A SYSTEMS STUDY OF WASTE PAPER RECOVERY AND RECYCLING

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ABSTRACT

This thesis investigated the technological economics of waste paper recovery and recycling in UK. The major problem in waste paper recycling is still the removal of contraries, although technological developments have so far been able to remove some of them. The costs incurred by the local authorities in recovering waste paper were investigated. Local authority costing was found to be inconsistent and many of them did not include all the relevant indirect costs and savings, so that many local authorities claimed to be making heavy losses in their operations. Full accounting incorporating all the relevant indirect costs and savings have shown that most local authorities incurred much smaller losses and in some cases profited from their waste paper recovery operations. A general computer model was developed to allow local authorities to check the viability of their on-going operations and another computer model was developed for an investment appraisal of a proposed waste paper recovery operation. Multiple regression models were developed to forecast the demand of waste paper in the short term and the long term. The cost to the mill in recycling waste paper was also examined. Waste paper recycling can only be increased by improving demand for waste paper based products. Various alternatives for diversifying the markets for waste paper were investigated, particularly those outside the paper and board industry. The government's role in helping to increase waste paper recovery and recycling was examined and some government actions that could be taken were proposed.

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1 - Introduction

1.1 Aim of this thesis

Disposal of domestic refuse, a major part of which is paper (29 percent by weight and 50 percent by volume) is becoming ever more difficult and costly. Yet only a fraction (about 30 percent) of the waste paper in UK is recovered in any form for recycling. The number of local authorities recovering waste paper has been decreasing mainly because of heavy loss in their operations and uncertainties caused by fluctuations in the waste paper market.

The paper and board mills in UK have traditionally been the only customers for waste paper. The potential supply of waste paper far exceeds its demand since there is a limit to the amount of waste paper which the paper and board mills can recycle. In order to absorb the excess waste paper the market for waste paper has to be diversified.

A systems study was performed to investigate the following areas :

a) The existing state of technology and the future technological requirements to improve waste paper recovery and processing.
b) The identification and evaluation of the true costs involved, both to the local authority and the industry.
c) The possible uses, market potential and economics of recycled waste paper in relation to its availability and cost.

1.2 The systems approach

Waste collection, disposal and secondary materials reclamation have very often been planned as separate and independent operations. In England waste collection is done by the district councils while waste disposal is carried out by the county councils. While integrated waste treatment and materials recovery plants are being planned and built by county councils, waste paper recovery is carried out sometimes by one or the other or both authorities. But in Scotland and Wales waste collection and disposal are done by the district councils.

There are numerous interdependencies among the functions of waste collection, disposal and secondary materials reclamation and these interdependencies are often very significant ones. Disposal methods can influence collection methods and collection systems will affect disposal practices. For example, salvaging huge amounts of waste paper has effect on tip life and on the performance of incinerators. The effect of collecting waste paper from trade premises on trade collection charges is another example. The response of householders in saving waste paper for separate collection and the demand of the recycling industry will influence waste collection and disposal management. If these interdependencies are ignored, the cost of refuse collection, refuse disposal and waste paper collection will probably become much too high and will not reflect the true cost of the operations. Satisfactory solutions to solid waste management and secondary material reclamation cannot be obtained by treating each operation within the processes of refuse collection as an independent unrelated function. To achieve efficient solutions to these problems, the problem must be viewed in its entirety as an interconnected system of component operations and functions. In short, a systems approach is required to consider all the social, commercial, technological and economics aspects of waste paper recovery and recycling in relation to waste management and to the recycling industry.

1.3 Definition of terms and units used

'Re-use' is a term used to describe the return of an item into the material stream for use in exactly the same type of application as before, without any change in its identity. One common example of re-use is the returnable milk-bottle which is collected, washed and refilled for the next delivery. In terms of waste paper, the term 're-use' has very limited use. For example, a piece of computer printout with one side blank is often reused by students for scratch notes before the paper is finally disposed into the dustbin.

'Recovery' is used in this study to describe either the collection of waste paper which has been source separated or the retrieval of waste paper through a mechanical sorting process at an integrated recovery plant. 'Reclamation' and 'salvage' are used synonymously with 'recovery' here.

'Recycling' is looked at from two angles - direct and indirect. Direct recycling refers to the use of recovered waste paper for the manufacture of paper and boards. In direct recycling, recovered waste paper after being cleaned, washed and repulped becomes 'secondary fibres' ready for the paper or board making machine. Indirect recycling refers to the recycling of waste paper into other forms of materials other than paper and board. For example, the incineration of waste paper for heat recovery, or the recycling of waste paper with other combustible components of refuse into waste derived fuel, or the conversion of the cellulose in the waste paper to a combustible gas by pyrolysis.

'Solid waste' is used generally to describe soiled material discarded because consumers no longer envisage any further use for them. They are therefore generally of no economic value unless regarded as a potential source of secondary materials or energy. 'Solid waste' in this study refers to the domestic and trade refuse collected by the local authorities.

The generic term 'paper' includes both paper and board. Board has been defined as 'stiff and thick paper'. International specification requires paper above 250 g/m^2 to be classified as 'board'. Although the UK recognises this classification for international trade purposes, the UK Customs regard all paper above 220 g/m^2 as boards. In certain sectors of the industry, multiply paper with thickness of at least 0.3 mm (0.25 mm in UK) is also called paper board.

SI units have been used throughout this study and where necessary data from earlier years have been so converted for easier comparison.

1.4 Subject area

This study deals with waste paper recovery and recycling in UK only, since a major work on the EEC (Massus,1974) and some work on the OECD countries (OECD,1979) have been done.

This study requires data which are difficult to come by and which are collected in few countries. Even in UK, very few systematic attempts have been made at the local authority level to estimate what tonnage of waste is generated locally and what percentage is recoverable. DOE(1976A) is the first publication where UK figures on waste disposal authorities are presented. But the information covers only waste disposal activities of England in 1974/75 and even this information is qualified by various small prints, which show that the information is far from complete and the accuracy of some of the returns is questionable. Turner(1978) felt that an evaluation of any waste paper recycling scheme operated by the local authorities is not really possible, given the limited amount of empirical evidence available.

Official information on prices of waste paper is basically non existent. The <u>Trade and Industry</u> used to publish waste paper price index and even this information was stopped after September 1978. All the waste paper prices reported in this study have to be compiled from trade sources.

Good quality waste paper is always in demand because of their high quality and limited supply. The lower grades of waste paper, the mixed waste and the container waste, are those recovered mainly by the local authorities. There is a huge potential supply for these grades but they have rather limited use. These grades are badly affected by price and market fluctuations. This study has therefore concentrated on the lower grades of waste paper.

1.5 Organisation of the report

Chapter 2 is a review of some areas of relevant literature so as to put the current study into context with other works which have been done. Some consideration of the present stage of recycling technology in Chapter 3 helps to clarify the terminology and sets the technical background for later discussions. The economics of waste paper recovery begins at Chapter 4 with the supply and suppliers of waste paper. Chapter 5 looks in detail at some of the local authorities waste paper recovery operations and what they regarded as the cost of recovering waste paper. The costs computed by the local authorities are then compared to what they should be in a uniform accounting system where all relevant costs and savings are included. Although cost is the major factor affecting the viability of a local authority recovery operation, there are other factors which have bearings on their operations as well. These factors are discussed in Chapter 6. Computer facilities are easily within reach of most local authorities and to help them to get a computerised costing system which could be used to check the viability of the operation, a viability model is developed in Chapter 7. An investment appraisal model is also developed in the same chapter for the local authority to evaluate the profitability of a proposed salvage scheme. Sample inputs and outputs with sensitivity analysis are used to emphasize the importance of full costing with all the relevant costs and savings included. Chapter 8 looks into the demand side of waste paper and the possible uses for waste paper. Models are also developed in this chapter to forecast the future demand for waste paper in both the short and the long term. Waste paper recycling is known to give cost savings to the mills. What sort of savings and how much can actually be saved by using waste paper is discussed in Chapter 9.

Waste paper demand from the mills is not enough to recycle the potential supply of waste paper. Alternative products outside the paper and board industry, which can use waste paper as a raw material have to be identified. Chapter 10 looks at some alternatives available at present and what impact they have on the rate of recycling. The rate of recycling at present is limited by the existing technology. Chapter 11 looks at some future technological developments which are required to improve recovery and recycling of waste paper. The Green Paper-War on Waste gives the impression that the government is committed to recycling. Chapter 12 reviews the role of the government to investigate how constructive it has been and then proposes some measures which could be taken by the government. The conclusions and recommendations are discussed in Chapter 13 where certain areas which may have impact on waste paper recycling in the future are also mentioned for further research.

2 - A review of earlier works

This chapter reviews certain areas of literature which are relevant to the main study since it helps to put the current study into context with other works that have been done.

2.1 Waste paper recovery

One of the earlier comprehensive account of the problems and hopes for the waste paper industry is found in the supplement 'Waste Paper Recovery' of Municipal Engineering (February 1967). One article examined the problems of waste paper collection from the local authority viewpoint and discussed changes which were needed if the service was to survive. The second article gave the factors influencing the decision whether to save waste paper, also from a local authority viewpoint. The British Waste Paper Association (BWPA) talked of their problems in the third article. However, not all the articles in this supplement gave a gloomy picture. There were two more encouraging articles, one described how 'The lucrative results of Bristol's waste paper collection scheme', maintained a profit margin and the other gave the experience of Kingswood District Council where they were 'making fortnightly collection pay in a small authority'.

'Waste Recycling - the next steps for local authorities', an article in the Surveyor(November 1978) discussed waste recycling from both the district view and the county view; and warned that although the government was eager for local authorities to carry out their statutory duty and reclaim as much as was practicable, reclamation was a commercial operation with attendent risks and must therefore be approached with caution.

2.2 Waste paper recycling

Perry(1971) discussed the problems involved in recycling waste paper in the USA and pointed out some of the problems facing the American mills, which were not uncommon to British mills. He pointed out that the manufacturing facilities which could increase the consumption of waste papers were limited and any major increase in consumption of waste paper would require new mills specifically built to use secondary fibre and must be located near the major collection areas. In order that waste paper could meet price competition and quality requirements of the users, there was a need for research and development into new methods of collection, handling and cleaning the waste papers.

The problems of removal of contraries from waste paper, of separation techniques and of secondary fibre processing methods were emphasized by Carr(1971). Although the energy required to recycle secondary fibre is less than that needed to process wood into pulp, yet the use of secondary fibre is limited. He felt that other factors which outweighed the benefits and which needed consideration would be the accessibility of waste paper, the availability of the waste paper and the user's ability to predict the volume composition and quality in comparison with wood pulp, and the number of alternative uses of waste paper. He regarded recycling of waste paper as a means of solid waste disposal and thought that revenue from recycling waste paper could make significant reductions in landfill requirements and costs.

Carter(1976) summarised the state of commodities recycling and the government involvement up to then. He believed that the impetus for recycling was growing slowly and held that "recycling research and processes must expand and the finance be made available in the short term for the ultimate benefit of the financial, commercial, national economic and ecological situation of the future."

Bidweel(1977) looked at recycling policy from an international viewpoint and wrote on the rationale for action and measure to promote recycling. He stressed the need for increased demand for recovered materials, without which, action to improve supply will not result in an overall increase in recycling activity.

Woldbeck(1977) gave three conditions necessary for expanded utilisation of secondary materials - development of new production techniques, new products and marketing potentials, and changes of requirement on products quality requirements. He encouraged a basic change on consumer thinking - the elimination of prejudice and impediments to products manufactured from secondary raw materials.

Porteous(1977) did not accept the axiom that 'recycling is a good thing', and discussed both the technological and economical limitations and how time will alter them. Besides direct recycling he also recommended indirect recycling such as using waste paper in the process of hydrolysis, to produce ethanol for powering internal combustion engines and in the production of protein for animal feeding.

Linear programming can be used in many situations to examine the consequence of choosing between different strategies related to activities such as cost, manufacturing, marketing and transportation. McRoberts et al(1978) applied linear programming to the paper industry as an aid to recycling decisions, a continuing research programme at the Queen Mary College Wolfson Recycle Unit. In their model they optimised minimum overall cost of the industry with many variables describing the paper industry, production, population, activities and products. Constraints are imposed by availabilities and markets for products, by yields and capacities of unit and for transport among internal districts and between internal and external districts. The model is particularly valuable in sensitivity analysis, dealing with the effect due to changes on pay, capacities, costs, markets and technical innovation etc. The limitation to the model however, is that total costs cannot be expected to emerge in every case because of estimates of costs used in certain cases.

Very little has been published on the recycling technology used in British mills. Most of the writings on recycling technology have been based on American technology. Some rather detailed work have been done by Higham(1968,1970). Forbes(1973) was one of the earlier to share his experience of producing waste-based fluting,homogeneous liner and chipboard. A comprehensive account of waste paper recycling technology is found in Minshall(1978). A solution to the practical problem of extracting the maximum fibre content from a continuous extraction waste hydrapulper was given by Ward(1979). A new method to measure cellulosic fibre properties was developed by Pycraft & Howarth(1980) using enzymatic degradation technique. Laboratory results showed that wet pressing primarily affects the fibre as a whole while dryer temperatures affect the fibre surface.

2.3 Economics of waste paper recovery and recycling

One of the earliest attempts to try to analyse the profitability of a local authority waste paper collection from domestic premises was made by Freeman(1975). He concluded that :

> "....... it is difficult to foresee a sharp fall in prices, due to the activities of local authorities. Viewed in the context of a world shortage of wood pulp, the indications are that a waste paper collection scheme which is profitable now will not cease to be so because of a sudden collapse in the waste paper market."

But the collapse actually took place rather suddenly, later in 1975 and average prices of waste paper (mixed waste) dropped from £26.25 per tonne in October 1974 to £19.25 per tonne in May 1975, a drop of 27 percent within half a year.

Quimby(1975) did a case study of the potential for increased recycling of newspapers and corrugated containers in the Washington Metropolitan area, when 'recycling' was just becoming a popular term. At that time little or no empirical studies has yet been done on the economics of recycling.

LAMSAC(1975) provided a guideline to UK local authorities on the economic evaluation of a waste paper salvage scheme. Local authorities were advised to maintain long term contracts with waste paper merchants or mills so as to try to level out the fluctuation in the demand of waste paper. Five main items, a 5 year period for the contract, a datum tonnage (ie the total tonnage to be bought by the mill during the year), a quota tonnage, a starting price to be agreed annually and a guaranteed minimum price for the datum tonnage fixed for the period of the contract, were among the essential items recommended to be included in the contracts. (A more detailed discussion on the LAMSAC model is given in para 5.1.1)

An economic evaluation of a local authority waste paper recovery and baling system was carried out by Taylor(1977) where he showed that the operation could have profits which vary from £6.17 to £9.20 per tonne of recovered waste paper.

Wray & Nation(1977) investigated the demand for waste paper from the paper and board industry and its supply from the reclamation activities of merchants and local authorities in England and felt a growing need for the maintenance and expansion of waste paper reclamation. Although they analysed the operation costs of eight English local authorities, the data used was not primary data which they collected themselves. The information was secondary data obtained from an earlier Department of Environment survey on local authority waste paper recovery operations.

2.4 Economic models

The use of excess stock schemes or buffer stock schemes to reduce the cyclical fluctuation of the waste paper market has been advocated by the British paper and board industry. But simulation exercise by Dyer, et al(1975) showed that the suppliers could easily make less revenue over the whole trade cycle in a market with stock support scheme than they would have if they were operating in a free market. Pearce & Grace(1978) using a simulation exercise for a stock holding agency whose sole objective was to reduce price fluctuations during the 1970 to 1974 period, showed that a stock support scheme could lose tremendously.

Butlin(1977) stressed the need to know price elasticities of supply and demand both for raw scrap and for reprocessed secondary materials. Though he felt that intervention and regulation of the market price could be one approach to reduce uncertainty in secondary materials, he did not advocate the use of buffer stocks for stabilising the secondary material market unless the elasticity was known.

The question of whether buffer stock agencies would have any associated external benefits was examined by Hallwood(1977). He argued that though benefits were positive, they were not of the magnitude implied in earlier studies.

Turner et al(1977) considered the extent to which waste paper recycling actually took place, the desirability of increasing that recycling rate and by which mechanism that could be brought about. Their findings showed that future demand would not reach the exaggerated levels of forecast in some official UK documents, and again cautioned the adoption of stock piling schemes.

Turner & Grace(1976) showed that the demand for waste paper was strongly correlated with the Gross Domestic Product. Since the only source of waste paper not fully exploited were the household and small trader source whose waste paper was generally of low grade, they argued that government grants for development of technology for de-contaminating and upgrading waste paper was far more logical than government assistance to support a buffer stock scheme which could loose large sums of money.

A two part forecast for waste paper demand was developed by Turner & Grace(1977), a long term forecast extrapolates the past growth rate to aid investment decisions, and a short term forecast to predict the deviations from the long run growth path. They projected a demand for waste paper by 1980 to reach 2.4 million tonnes, a more cautious projection compared to the

BPBIF's estimate of 3.2 million tonnes.

Price has been most commonly seen as the main manipulating factor in recycling policy. Deadman et al(1978) revealed that neither pulp prices nor waste paper prices appeared to have significant effect on waste paper demand. Imports of waste paper and stock levels appeared to be determined to some extent, rather by the gap between forthcoming domestic supplies and forecast usage requirements. In their re-appraisal of the UK waste paper market they constructed a new variable which was believed to have a major influence on the consumption of waste paper, something not considered earlier by Turner & Grace(1977). This variable consisted of the amalgamation of board products and packaging products other than food wrappings and was able to account for the very important role of the packaging industry in the utilisation of low grade waste paper.

Edwards & Pearce(1978) suggested that price oriented policies design to encourage recycling were in most cases doomed to failure except when prices were maintained very high. In their model, they explained the low price elasticity of supply in terms of an expectation hypothesis. Quoting the case of waste paper the elasticity implicit in the model was as low as 0.3 which means that a 10 percent expected price rise would raise supply by only 3 percent. The low elasticity casted doubts on the encouragement given to suppliers through campaigns which emphasised spiralling pulp costs. The pulps which waste paper could be a replacement, would need a very substantial price rise for expectations to be formed which would significantly increase waste paper supply. To encourage recycling, attention should be focused on re-designing products to make use of more waste paper, rather than on waste paper price manipulations.

The costs and benefits involved in a local authority salvaging waste paper were examined by Turner(1978). His study emphasized the importance of analysing waste management as a total system of interdependent activities. Costs and benefits involved in a waste paper recovery operation, however, could not be fully quantified without a comprehensive locally based information system. In the absence of such a system Turner examined what evidence there was concerning refuse generation functions and collection cost functions. After examining the market prospect for waste paper in UK from 1977 projected to 1990 and their significance for increased local authority involvement, he concluded that in general, there was unlikely to be any large scale increase in demand at the low grade end of the market, at least until 1980 but thereafter the demand for low grades may well increase substantially. Events in 1980/81, however, did not support this conclusion.

Grace et al(1978) concluded that international trade would tend to encourage waste paper recycling in some countries and discourage it in others but the overall volume of recycling would tend to be greater with international trade than without it and there would be some effects on price stabilization. In their model they assumed that the price of virgin pulp (the primary material) set the upper limit to the maximum price at which any waste paper (the secondary material) would be demanded. But Yohe(1979) disagreed with this point and citing USA data on waste paper and pulp prices showed that in the USA waste paper prices could exceed pulp price when output demand was high. Using a similar model as that of Grace, et al(1978) he went on to show that price instability was more acute than that Grace, et al(1978) have allowed and the stabilizing diversity offered by international trade would therefore assume greater importance than they claimed. Grace et al(1979) pointed out that Yohe's model was basically a USA model while Grace, et al(1978) used a general model which was applicable to a number of domestic markets in European countries such as UK, and has no specific reference to the USA market. In Britain waste paper prices were not market prices in the conventional sense, but demand controlled. Prices paid for waste paper in UK have not exceed pulp prices and the UK data offered some support for Grace, et al(1978)'s assumption that pulp prices set an upper limit for waste paper prices.

Deadman & Turner(1979) felt that the European initiative in the 70s on secondary materials recycling could only succeed if there was an adequate data base, with proper forecasts of future demand for secondary materials, something grossly neglected in the UK. Using waste paper as an example they forecast the demand using three methods, namely, the long or short term GDP forecasts, the basic or modified Holt-Winters Model and the input-output model which could incorporate various scenarios to allow for the effects of technical changes.

2.5 Waste paper recycling in the EEC and the OECD countries

Massus(1974) did a major work, a two volume unpublished report - 'Waste Paper in the EEC' which was much quoted in various forms by later writers although some of the data such as the utilisation coefficient tables for waste paper in production of paper and board products, have been disputed by some experts.

The OECD conducted a study of waste paper recycling for its member countries in 1976. The survey was carried out to determine whether any stimulus to policy was required to achieve the waste paper recovery and utilisation rates which have been projected and deemed desirable. The report also apportioned responsibility for various measures to be taken by the different parties involved in waste paper recovery, central and local government, paper and board industry, waste paper merchant and voluntary organisations. The lack of policy experience on which to draw from was also pointed out.

The Commission of European Communities Report(1978) on the economics of recycling examined reclamation in general to identify why materials were currently discarded and not reclaimed from waste and aimed to assist the EEC with the necessary policy decision. The report described in general the economics and principles of material recovery, the methods, the potential and the actions that might be taken to realise the potential, and summarised the information relevant to recycling in the EEC, the waste arisings, cost of recovery, values of recovered materials and actions currently being taken by the EEC to encourage further recovery. A shortage of reliable quantitive data was encountered in the study and so, a large number of estimates of quantities and costs had to be used. The EEC committee on Waste Management has realised the importance of waste paper recycling to give it top priority in its definition of Community Waste Management policy and a Working Party on Waste Paper was formed from government and industrial experts to give advise on community measures for encouraging increased waste paper collection and recycling.

In the EEC <u>State of the Environment 2nd Report 1979</u> , para 111.2 Re-utilisation of Waste Papers, it mentioned the setting up of a programme from 1978-1980 to look into the technical problems involved in waste paper recycling. Four areas would be dealt with,

" 1) the analysis of recycled fibres, their upgrading by means of a wide range of different process, and the effects of repeated recycling on fibres for paper manufacture;

2) the elimination of the detrimental effects of harmful substance in waste paper, including dispersion of thermo softening contaminants;

3) deinking, including the relationships between different types of colorant and deinking, and the treatment of liquid effluent from waste paper recycling plants; and

4) the use of municipal fibres from mechanised waste sorting systems, including technological analysis of solid municipal refuse and health problems caused by the use of recycled fibres. "

By 1980 this programme was extended one more year into 1981. Pearce in his report to the OECD(OECD,1979) concentrated on low grade waste papers and their traditional and potential uses. He outlined briefly the historical, current and future trends of waste paper recovery and examined the economics of waste paper recovery in a wider social cost and benefit framework, with special reference to pollution and energy impacts. He urged that recovery of waste paper be increased and that recycling should be done up to the point where the social cost of an extra amount of recycling just equals the extra social benefit received. He questioned 'consumer acceptance', an obstacle to increased waste paper recycling and suggested investigation into the lowering of non-essential standards of paper product specification.

2.6 Comments on the literature survey

Very few in-depth studies have been done on the technological economics of waste paper recovery and recycling, although various articles have been written on different aspects at various times. There is lack of accurate and meaningful cost data from both the local authorities and the waste paper industry and practically no cost information on the recycling of waste paper has been published by the British paper and board mills. One of the aims of the research is therefore to close the gap in this area of knowledge.

3 - Fibres, pulps, waste papers and recycling technology

Paper was invented in China in AD 105 by Cai Lun who made paper from barks, fish nets, hemps and rags. The fibres from these raw materials had first to be macerated until each individual filament was a separate unit. The fibres were then intermixed with water. With a sieve-like screen, the fibres were lifted from the water in the form of a thin stratum, with the water draining through the small openings of the screen to leave a sheet of matted fibre upon the screen's surface. The thin layer of intertwined fibre was paper.

Although the Egyptians had used papyrus as a writing material, it was not formed from macerated fibres and was therefore not paper as we know it today. Papyrus was a laminated material formed by cutting or slicing the stalks of the plant from end to end and then putting them together in about the same way a sheet of laminated wood board was formed.

The traditional process of making paper as devised by Cai Lun was eventually transferred to Europe through the Middle East. Up till today the basic principle of fibre formation of paper has undergone no change. Prior to the introduction of paper into Europe parchment and vellum made from animal skins had been in used. Although paper had been in use in Britain since 1309, the process of making paper by hand was not introduced into Britain until 1494.

By 1591 Scotland was also making its own paper. The raw materials then used were waste products like cordage, linens, rags and torn sails. The development of printing in Europe in the fifteenth century increased the demand for paper. The invention of the Fourdrinier paper machine in the late eighteenth century allowed paper to be made much easier and faster. By the 1860s Britain was importing rags from a large number of countries. With increasing demand for paper and paper products and the shortage of the raw materials in mid-nineteenth century, there was a need for alternative raw materials.

3.1 Fibres and pulps

The shortage of waste linen and cotton rags turned the attention of paper makers to grass and cereal fibres such as esparto. Esparto grass is strong and quickly amenable to cleaning and bleaching. Its fibre length is comparatively uniform, and high quality printing paper can be produced. Later wood pulp was also substituted as a raw material for making paper. By using wood pulp instead of rags, thinner, stronger and more attractive sheets of wrapping paper were produced.

Theoretically all plants contain cellulose fibres but only a relatively small number of plants are suitable for making paper. This is because in some plants the cellulose content is too little to be worth extracting while in others the cellulose is too firmly bond to be extracted without causing damage to the fibres themselves. In some plants the fibres may be too short and are not suitable for making good paper. Trees, in particular coniferous trees, yield the highest proportion of their weight as fibres which are particularly suitable for paper making. But the cellulose in trees is always heavily encrusted with lignin, a non-cellulose material which has no fibre forming properties. The lignin and other non-cellulose materials in the plant such as resin have to be removed to free the cellulose fibres for paper making.

The quality of paper is determined to a considerable extent by the type of fibre employed in its manufacture and to a lesser extent, the production process. For many centuries the raw materials for paper making was waste linen and rags made from cotton. Cotton and linen fibres make the most durable papers because of their purity and stability and they are among the strongest since both are relatively long, narrow fibres with lengths varying from 10 to 60 mm for cotton and 25 to 40 mm for linen.

The technology that can be used to refine wood and other raw materials into pulp depends on the type of raw materials used and the qualities such as strength or brightness required in the final product. Of the four basic ways of doing this, the most widespread is the kraft chemical or sulphate process which produces pulp that has long fibres and considerable structural strength. Kraft pulp is therefore used for making strong, brown wrapping paper and paper bag.

The sulphite process, an older chemical pulping method, is used mainly with pulpwoods of little resin content. The chief advantage of this process is its ability to produce a relatively bright pulp without using bleach and when bleach is used, a pulp of higher brightness is obtained. The sulphite pulp is generally of long fibre, and is soft and flexible. It is used for making fine writing papers and tissue.

The major proportion of chemical wood pulp is processed from pine, fir and other coniferous woods with an average fibre length of 3.5 to 5 mm which can produce papers of good strength and reasonable durability.

The semi-chemical process or neutral sulphite semi-chemical pulping process(NSSC) uses chemical cooking to start the separation of fibres followed by mechanical separation. Semi-chemical is a fairly recently developed process capable of producing a range of pulps of intermediate quality between the chemical and the mechanical pulp. Semi-chemical pulps are used mainly in corrugating medium, the centre ply of a double wall corrugated cardboard.

The mechanical process for making groundwood pulp uses a mechanical grinder to grind the wood logs under a stream of water. The resulting pulp therefore contains much fibre debris together with bunches of fibre fragments. This process does not aim at separating the fibres in a very pure state, but rather to obtain the maximum yield of pulp, with minimum physical damage to the fibres. However, mechanical grinding tends to bruise and rupture the fibres and does not remove the lignin, so that paper made from mechanical pulp is brittle and non-durable. The lignin present will cause rapid decoloration of the paper when it comes into contact with sunlight and air. A familiar example is the old newspapers which turns yellowish after some time. Paper made from mechanical pulp has a high opacity and is printable. It is therefore suitable for making cheap papers particularly newsprints and cheaper grades of wrappings and printings.

Figure 3.1 shows a summary of various types of wood pulp suitable for manufacturing different types of paper and board. The paper made by fibres alone are rather transparent and therefore in the manufacture of printings and writings, additives such as china clay are added to improve opacity.

3.2 Waste paper generation

Figure 3.2 shows the various stages of the production-consumption sequence of paper and board, where waste paper is generated.

While the paper is being produced at the mills, waste paper is also being generated. At various parts of the paper making process and at the final stage where the continuous web of paper is reeled into jumbo rolls, paper may be torn off and cut off. 'Broke' also includes waste paper generated when the output did not meet customer specifications and has been rejected.

The jumbo rolls of finished paper have to be sent to convertors where they are cut into smaller sizes or made into other stationery such as paper bags, envelopes, filing folders, paper board boxes, cardboard tubes, etc. Newspaper printers generate waste papers such as newsprint mill wrappers and unprinted newsprint. Convertors and printers have various types of unprinted cut-offs and trimmings and they are good sources of homogeneous, high grade, clean waste paper which are deinking grades of waste papers capable of being used as pulp substitutes. But at times these waste papers can be specifically contaminated by wax, glue or ink which have been added in during the conversion process and these additives have to be removed before the waste paper is suitable for recycling.

The distributors do not generate much waste paper since they perform mainly warehousing and distributing functions.

Figure 3.1 - Various paper and paper board products made from the different wood pulps

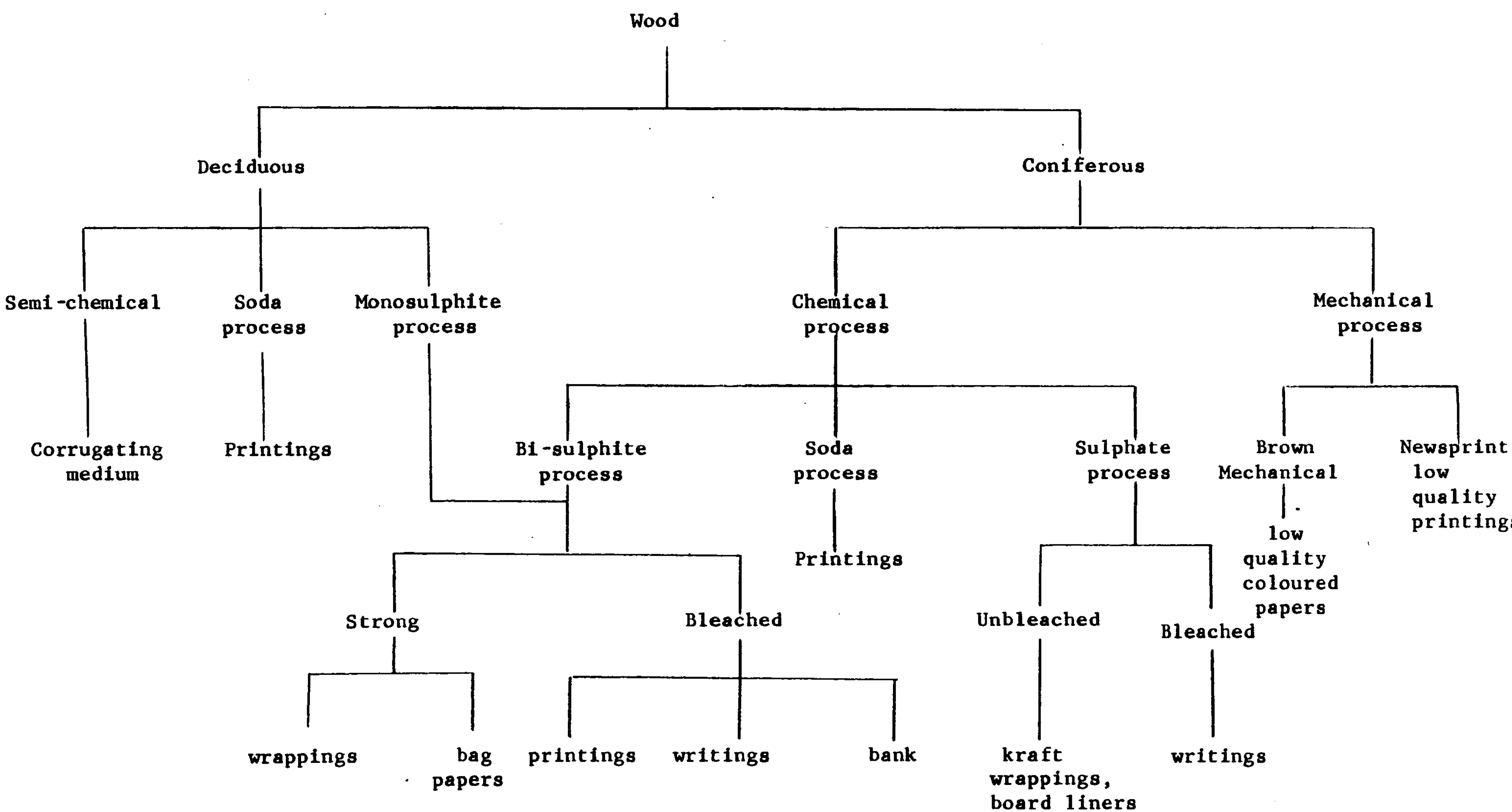
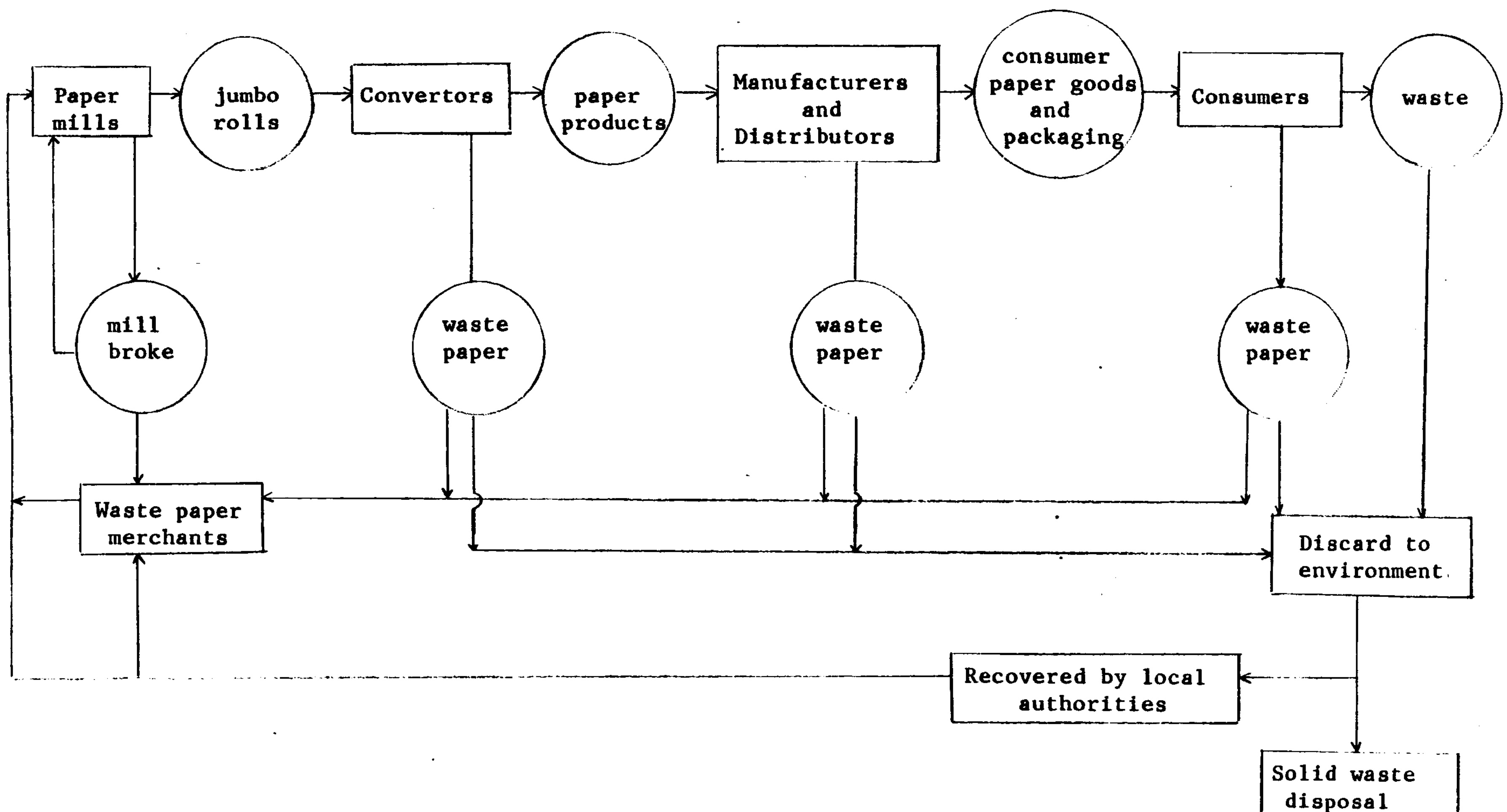


Figure 3.2 - System flow of waste paper in the production-consumption sequence of paper and board



Usually the packaging and shipping containers are passed intact to the retailers. One exception however, is the distributors of newsprints, where over-issue news not sold are collected as waste paper which have substantial recycling value.

Retail shops usually receive their supply of goods in corrugated containers and carton boxes and therefore they generate large quantities of container waste. Liquor shops and supermarkets in particular generate much container waste. Big supermarkets like Boots and Marks & Spencer even bale their own container waste so as to cut down on-premise storage space.

The type of waste paper generated in office buildings varies with the nature of operations going on in the building. Shredded writing and printing papers may be produced at various times, but generally, office waste is broadly classified as mixed waste paper, being paper collected from the many waste paper bins in the office. Such waste paper may contain paper clips, staple wires, rubber bands and carbon paper, substance which must be removed before the waste paper can be recycled. One particular type of waste paper generated in the office is computer printout papers and computer punch cards. These are high quality waste papers in great demand. In recent years with the introduction of video monitors computer punch cards are becoming more difficult to find.

In the household only two categories of waste papers are usually generated, newsprints and mixed waste. Newsprints refer to newspapers, magazines, comics and periodicals. It is a very common misconception of many people to refer to old newspapers when they hear the words 'waste paper'. Old newspapers are relatively easy to segregate and stacked separately, hence large amounts of old newspapers are usually collected from households. But newspaper is made from groundwood pulp with a high lignin content, which limits its use in recycling. Magazines usually have coatings of china clay and layers of adhesives used in the binding which, together with the high groundwood content of the paper, generally do not give it a high value for recycling.

Mixed waste paper generated in the households generally consists of packaging materials for consumer goods, such as folding cartons used for various food products, cosmetics, toilet articles, beverage containers, medical products and various appliances. The difference in types of paper board, coatings and inner liners used in the production of these cartons complicates their sorting and segregation into the different categories of fibre types. Some cartons like beverage containers are heavily coated with plastic which makes the separation of the paper portion difficult. Grocery bags and other kraft wrappings are usually collected by the households and re-used as containers for household refuse, making it difficult to recycle the paper because of the heavy contamination. Mixed waste paper disposed together with other refuse is dirty and difficult to recover for recycling. However, if the waste paper has been segregated at the source of generation from other refuse by the householders, then the possibility of recovering and recycling them is good. Other grades like stationery, books, printing and writing papers are generated in the household in small quantities and their frequency and volume movement of generation is rather unpredictable. Old box boards, corrugated containers are also generated in rather insignificant amounts.

3.3 Grades of waste paper

Waste paper used in the British mills is categorised into 42 different grades by the British Paper and Board Industry Federation(BPBIF) jointly with the British Waste Paper Association(BWPA). (Appendix 1) But for statistical purposes 8 groups are used by the UK Customs and Excise (Table 3.1). Group 1 is the best grade of waste paper, consisting of white printing paper cuttings while group 7b consists of the lowest grade called mixed waste papers which covers any grade of paper or board that can be pulped with

Table 3.1 - Waste paper groupings for statistical purposes

Old Groupings up to December 1976

1) Cream shavings, fine shavings, white paper, doyley cuttings, second shavings or white printing shavings, best white shavings

2) White woody seconds, white coated shavings, white woody shavings, unprinted white card cuttings, egg flats, best one-cuts, woody one-cuts, printed woody one-cuts, white and light toned shavings, white and coloured shavings

3) Buff manilla shavings, buff tabulating cards, coloured tabulating cards, light browns or buffs

4) Ledgers, white heavy letter, heavy letter, light letter, light paper, quire, best white pams, continuous stationery

5) Over-issue news, flat read news, crushed news, wood pams, over-issue white woody pams, over issue coloured woody pams, telephone directories with soft covers

6) Coloured manilla, kraft browns, coloured kraft, mixed browns, kraft sacks, new KLS, old KLS (Kraft lined strawboard)

7a) Coloured card, container waste, strawboards, chipboards

7b) Mixed papers

8) All other types

Groupings used for the exchange of statistics on an international basis :-

1) Old and over-issue newspapers and magazines, telephone directories, brochures, etc.

2) Corrugated and solid container waste (old and new)

3) Wood-free printing and writing papers, punch cards and other high grade qualities

4) All other types of waste paper

cold water in the mills. These groupings were modified into 10 groups after January 1977 (Table 3.2). In this study reference is made to the pre-1977 groupings since most published statistics follow this list and it is easier to join the new groupings of 6 and 7 into the old group 6 for comparison purposes.

The high quality waste papers are those in groups 1 to 4 and group 6. They come in the form of cuttings and trimmings of high quality printing and writing papers from printers and convertors. Printers and convertors obviously make every effort to minimise their waste and so cut-offs and trimmings are generally limited in supply. Because these grades are generally pulp substitutes, they are always in demand and are therefore more expensive than other grades (Table 3.3). The supply of these grades of waste paper is mostly inelastic and even in times of general recession which affects the waste paper market, they are little affected. The supply is made even more inelastic by the fact that it finds a ready market abroad and tends therefore to be exported more easily than the low grades. The high grade waste papers are generally collected by merchants under contract with the generators.

Waste paper collected by the local authority consists mainly of two main grades - container waste and mixed waste (group 7a,7b). Used newsprints collected by local authorities used to be separated into a different category for pricing purposes but has recently been baled together and priced together with mixed waste. Because of the high quantity of newsprints collected, mills buying mixed waste from local authorities usually put a limit to the amount of newsprint that can be mixed with the mixed waste and this limit may fluctuate from 5 percent to 20 percent depending on the market conditions. Newsprints collected by local authorities are different from over-issue news. Over-issue news have not been circulated and are therefore cleaner and more homogeneous in quality. It is therefore suitable for recycling into newsprints or tissues after deinking.

Table 3.2 - New Groupings from January 1977

Following the recommendation of the Waste Paper Committee, the Customs and Excise approved certain amendments to the Waste Paper Groupings as from the 1st January 1977. The opportunity was taken to improve and update terminology and also to isolate new kraft lined corrugated waste from Group 6. This new Group will be numbered '7', the old Group 7a will be re-numbered '8' and the old Group 7b will be re-numbered '9'.

1) Best white shavings, fine shavings, white and cream shavings, white coated shavings
2) White unprinted, white duplex and other mechanical wood pulp cuttings, slightly printed white card cuttings, best one-cuts, printed woody one-cuts, white and light toned shavings, white and coloured shavings
3) Buff envelope cuttings, buff tabulating cards, coloured tabulating cards, light browns and buffs
4) Ledgers, white heavy letter, coloured heavy letter, white continuous stationery waste, coloured continuous stationery waste, white carbonless copy paper waste, coloured carbonless copy paper waste, quire, best white pams
5) Over-issued news, once-read news, over-issue white woody pams, over-issue coloured woody pams, news and pams, telephone directories with soft covers, once-read woody pams
6) Coloured manilla, used brown kraft, new brown kraft, coloured kraft, new wet strength kraft, used multiple ply feed flour and starch sacks
7) New kraft lined corrugated waste (No.1 & No.2)
8) Container waste
9) Mixed paper and coloured card
10) All other types

Table 3.3 - Mill price paid to merchants for various groups of waste paper
Source : Trade sources

Main groups of waste paper	A	B	Prices at July 1979 per tonne
Best white shavings,etc	1	1	£ 144.00
White unprinted,etc	2	2	£ 114.00
Buff envelope,etc	3	3	£ 163.00
Ledgers,etc	4	4	£ 95.00
Over-issued news,etc	5	5	£ 45.00
Coloured manilla,etc	6	6	£ 131.00
New Kraft,etc	7		£ 52.00
Container waste	8	7a	£ 47.64
Mixed waste	9	7b	£ 31.87
All other types	10	8	£ 31.87

B - Groupings used before 1977

A - Groupings with effect from January 1977

3.4 Differentiating the various grades of waste paper

Waste paper is hand sorted and tested to differentiate them into different grades by waste paper merchants. Since each grade gets a different price waste paper merchants will try to sort out as much of the higher grades as possible for separate baling. Various methods are used. Experienced sorters are able to tell the grade of a paper by using their hands. By handling and rubbing a sheet of paper between the fingers and thumbs they can judge the grammage and thickness. By tearing the paper and recognising the sound and the feel of the tear they can infer the type of fibres in the paper (Table 3.4). A piece of paper made from recycled waste paper is soft and bulky. Ledger paper made from cotton fibres is crisp while those made from wood pulp is soft. Rubbing a piece of bank or bond paper will get a good 'rattle'. A piece of good coated paper will not give any appreciable change when rubbed, but when the entire coating comes off it means that the paper has a weak base.

Paper by itself will absorb water and solvent like a blotting paper, and must be 'sized' with starch to prevent it from doing so. As paper is sold by weight, it is common for paper makers to add more starch than fibres to make up the paper to the required weight since starch is obviously much cheaper than fibre. Applying the tongue to one side of the paper and watching the ease with which the saliva spreads on the paper will give some idea of the degree of 'size' used on the paper. Alternatively one can write on the paper to see how the ink spreads.

Various chemical tests can also be applied to identify the type of paper and its fibre composition (Table 3.4). At times mixtures of fibres have been used to blend a particular type of paper. The fibres have first to be extracted by boiling the paper in water and if necessary with a little sodium hydroxide, to get a very dilute suspension of the fibre in water. A drop of this dilute suspension is put on a

Table 3.4 - Some physical and chemical tests to identify the type of paper and its fibres

Test	Result	Inference
By tearing	tears softly and rather easily	paper made from esparto fibres
	strong resistance	paper made from cotton fibres
	difficult to tear	paper made from manilla fibres
By rubbing with silver	gives a black mark on the paper	coated art paper
By adding a drop of dilute nitric acid	gives a brown spot	mechanical pulp paper
By adding a drop of aniline (acidified with dilute sulphuric acid)	gives a yellow spot (dark)	groundwood paper
	gives a light yellow spot	unbleached sulphite and sulphate paper
By adding a drop of p-p' azodimethyl aniline (acidified with glacial acetic acid)	gives a red spot	unbleached sulphite paper
By testing with Herzberg stain (saturated solution of zinc chloride with potassium iodide and a little iodine)	turns red	cotton fibres, linen and hemp
	turns yellow	mechanical pulp and jute

microscope slide and dried. The dried fibres can then be identified by chemical test or by its fibre length and width. For example, cotton fibres are long, between 10 to 60 mm with a width of 0.02 mm. Softwood fibres are shorter, about 3.5 to 5.0 mm in length with a width of 0.025 mm and hardwood fibres are much shorter, about 1.0 to 1.8 mm with a width of 0.03 mm (Higham,1968).

3.5 Historical perspective of waste paper recycling

Recycling of waste paper had been carried out in China and Japan as early as 1031, but the first recorded recycling of printed paper was in Europe, at Denmark in 1695 (Hunter,1947). In Britain, Matthias Koops was granted a patent in April,1800 covering the're-use'of printed papers. By the middle of the nineteenth century waste paper was being used widely in commercial qualities of paper and board in Europe. The earliest statistics available in UK for the amount of waste paper consumed was published in 1948 which gave a total consumption of 665.6 thousand tons (676 thousand tonnes) in 1939. By 1950 waste paper consumption had increased to 902 thousand tonnes.

The development of faster paper making machine resulted in increased demand for waste papers which reached its peak during the 1939-45 war, when the situation was aggravated by the restriction on imports of wood pulps and esparto. Waste paper was in great demand to supplement the meagre supplies of raw wood pulp. The normal supplies from the newspaper merchants were inadequate to satisfy the demand. A national campaign was mounted in 1940 to collect every scrap of recoverable waste paper. The Ministry of Supply encouraged local authorities to launch special salvage weeks for the war effort. The week included press and school publicity and the film "Raw Material is War Material" was shown at all the town cinemas. The public response was good and nearly a million tonne was collected. After the war, although waste paper recovery was continued there were not much incentives and tonnages recovered gradually declined until the early 1960s when waste paper was recycled in great amount again, initially to reduce the use of wood pulp, cut imports and production costs and later also as a natural resources conservation measure. Waste paper consumption by 1965 reached 1.63 million tonnes. By the mid-70s, pressure groups of ecologists, environmentalists focused the attention of the public on the exploitation of the much needed natural resources, including trees, and the need to recover and recycle the huge amounts of 'cheap, readily available and acceptable substitute raw material' such as waste paper which were being buried in landfill sites or burned in incinerators. Waste paper is again an important indigeneous raw material, a source of secondary fibres.

3.6 Contraries in waste paper

The main problem in recycling waste paper is the presence of contaminations, known as 'contraries' in the trade. The content of contraries in mixed waste paper has to be less than 10 percent to be acceptable for recycling as current processing equipment cannot cope with a higher content of contraries. This is very difficult to achieve if the waste paper has not been previously source-separated from the other refuse. A group of 3 London Boroughs sorting waste papers collected from households and trade premises reported 14 percent of contraries by weight, with surprisingly highest figures from the waste paper collected from trade premises, about 20 to 25 percent in one analysis (Hall,1981).

Only the easily identified contraries such as rubber bands, spring clips, paper clips, plastic bags and cups can be removed in the initial hand sorting process. But certain additives to the paper and board during manufacture and conversion cannot be easily removed by hand picking. Paper manufacturers put in various additives to meet customer requirements and to enhance the properties and for appearance of the end product. Multi-wall sacks may have bitumen or polythene liners added in to make it water proof. Tissues may be treated with resins to increase their 'wet strength'. Polythene films and metallic foil laminates are added to paper used for various packaging purposes. Self-stick adhesive are added to envelopes and labels for consumer convenience. All the additives become contraries in waste paper and if not removed can seriously affect and interfere with production and cause stoppages during the production run or cause damage to the final product. These contraries are classified as 'pernicious', because even in a very small quantity they can do harm which is disproportionate to the value of the material being recycled. One mill claimed that the presence of just half a kilogram of carbon paper could ruin a tonne of finished product. Mills therefore will not take in mixed waste with more than 5 percent content of NCR paper. (carbonless copy paper)

Up to the early 1950s, recycling of waste paper and the removal of contraries were relatively simple and straight forward. But new developments and products after that have introduced new contraries and removal problems. One mill estimated that the amount of pernicious contraries in the lower grades of waste paper is increasing at about 10 percent per year.

There are three ways to handle these contraries. The easiest way is not to introduce them in the first place. But the fact that they have been introduced and their extent increasing is a reflection of the consumers' demand for convenience and so this approach will not be effective. The second method is to discard the paper with such contraries. But first such paper products have to be identified and sorted. Attempts were made in 1967 by the waste paper industry to introduce a system of codes to label and identify all paper and board products which contain pernicious contraries. One method used a labelling scheme where all paper and board products containing the pernicious contraries were labelled with the letters NEP (Not Easily Pulpable). It was agreed then that all mills should use these letters to label the appropriate products. The second system was to print a bar broken into three parts on multi-wall kraft sacks which were free of pernicious contraries. Although the two codes were accepted internationally in principle, they were not completely effective because the scheme was not universally implemented. The third method is to develop new instruments with greater efficiency for cleaning and re-pulping the waste paper.

Many cleaning and washing systems for removing pernicious contraries during re-pulping have been developed within the last ten years and by 1980 some of the pernicious contraries can be removed to a certain extent. Even plastics in certain forms can now be satisfactorily removed. In fact one mill in Scotland which uses almost entirely waste paper is experimenting with the recycling of the plastics that have been removed as pernicious contraries.

There are currently four main groups of pernicious contraries which are still difficult to remove.

Group 1 : Soft non-emulsifiable thermoplastics which includes latex and laminates, rubber derivatives, adhesives on self-adhesive envelopes and tapes and plastic ink

Group 2 : Mechanically separables by screening and centrifugal cleaners, which includes brittle plastics such as polystyrene foam and polystyrene drinking cups

Group 3 : Mechanically non-separables or removable by density differences

Group 4 : Chemically dispersables such as wet strength resin in paper and board and carbonless copy paper (NCR)

Of the four groups, the first two are the most troublesome, because they cannot be satisfactorily removed by the usual cleaning systems. If high pressure and temperatures are used to disperse them, the quality of the stock deteriorates. Drainage of the water during the production process could be slowed down, and the burst and tensile strengths of the finished product will be reduced.

3.7 Waste paper processing at the mills

Waste paper, whether they are mixed waste paper and container waste purchased from local authorities or pulp substitute higher grades of waste paper, on arrival at the mill has to be re-pulped, cleaned and washed and may be deinked. The only difference is in the degree of cleaning and washing that needs to be done, and this depends on the extent of contraries in the waste paper. In theory, the re-pulping should be easier since the waste paper contains fibres which have been processed in its earlier production and all that is needed to be done is to break up the bonded fibres in the waste paper into its individual fibres again.

The principle behind waste paper processing is simply to break up the used paper into its individual fibres and then re-form them together in a web to give a new sheet of paper. The chief disadvantage is the presence of ink and dirt making the new paper slightly greyish. Hence it is frequently used for wrapping paper and for paper board. In all the years of waste paper recycling, all the machinery used has been designed first to clean and then to process the fibres into a condition which can be used on a paper making machine. An early process used a Kollergang which was basically a pan in which two stone rolls revolved to macerate the waste paper into pulp. Since then many machines have been developed to treat and clean waste paper. By the early 1950s there were twenty or more different types of equipment that could be used in various combinations to process waste paper for various end uses. Although there is a wide variety of designs in waste paper re-pulping systems, each custom built to a mill's particular requirement, it is possible to generalise the basic processes which are virtually used in all systems.

The equipment used to process waste paper depends on two factors :-

(i) the grade of waste paper being processed, and

(ii) the specification of the final product to be made from the secondary fibres.

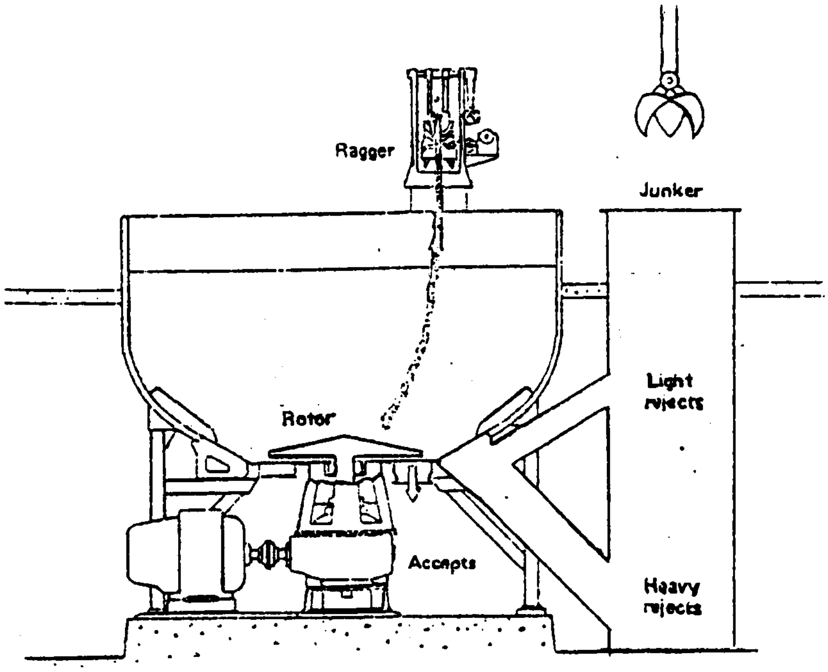
To get the individual fibres in the waste paper back into a clean state, free of all contraries, the waste paper undergoes two basic stages, de-fibering and cleaning in the re-pulping systems.

3.7.1 De-fibering

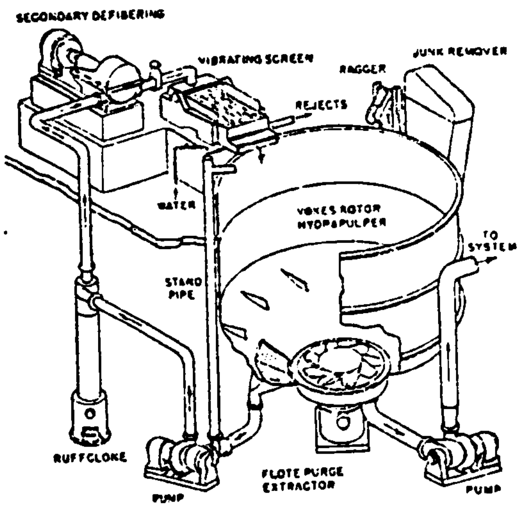
The easiest way to separate the bonded fibres in the waste paper is by wetting followed by mechanical action. All conventional waste paper processes start this way. There are various designs of pulpers available but the most common one in use today is still the hydrapulper (Figure 3.3). It is basically a large cylindrical tank (varying in diameter between 1 to 6 m with an average depth of 3 m), open at the top and having a bowl-shaped bottom with blades fixed on the side. At the bottom of the bowl is the Vokes rotor, a large propellor carrying another set of rotable blades. A perforated plate at the base enables stuff which has been fully de-fibered and pulped to pass through continuously to the other stages of the processing system. The temperature of the operation depends on the type of waste paper in use and the end product in mind. If mixed waste or container waste is re-pulped for making boards, cold water is used. If higher grades of waste paper are re-pulped for making some sort of paper product, hot water is used.

The mixture of water and waste paper is churned by vortex action caused by the Vokes rotor's rotation. The mass of water and waste paper is thrown by centrifugal force towards the fixed blades at the side of the hydrapulper and when they drop down the centre of the swirling mass they land on the rotor blades again. The combined violent swirling and rubbing of the waste papers against the blades

<u>Figure 3.3</u> - Hydrapulper with ragger and junker
Source : Koffinke(1980)



<u>Figure 3.4</u> - Flote purge system for removing low density contraries
Source : Felton(1970)



disintegrate them very rapidly into their individual fibres. The ragger is a rope with a length of barbed wire tied to the end and is allowed to stay in suspension in the swirling mass in the hydrapulper. Centrifugal action which forces the contraries away from the lighter paper pulp will be caught on the barbed wire and thus removed. Contraries such as rags, strings and wire are among the rejects.
A 'junk remover' or 'junker' may also be incorporated. The junker is actually a vertical bucker elevator connected to the base of the pulper through which heavy rejects and solid objects present in the waste paper are removed.

Since re-pulping directly is not the most economical way of de-fibering because of the high energy consumption, it is now rather common to first breakdown in-coming waste paper bales into small pieces of paper or clumps of fibre by the pulper and then pass the broken clumps of fibres on to more economical secondary de-fibering equipment such as 'deflakers', 'defiberers', 'disintegrators' or 'dispersors'. These machines use shear forces to break up the fibre clumps and the contraries such as coating flakes, wax globules, etc. to produce a more homogeneous, de-fibered, 'speck-free' pulp.

The hydrapulper with the ragger and the junker is not sufficient to remove all the contraries. Light materials break up into small irregular pieces and float on the surface of the stock being slushed in the hydrapulper.
A combination of cyclone cleaner, deflaker and vibrating screen forms what is called the 'flote-purge' system which is generally added to the hydrapulper to get rid of the light contraries (Figure 3.4).

3.7.2 Cleaning

Cleaning removes some of the contraries and converts the others into an acceptable form. Contraries of different densities are usually removed by centrifugal means.

When a mixture of particles of different densities is rotated rapidly, all the particles tend to move away from the axis of rotation and the heavier the particle the greater is this tendency. In this way the heavy particles may be received in a receptacle around the circumference of the machine, where they accumulate and can be removed when desired.

Contraries with density and size comparable with cellulose fibres are the most difficult to remove, and gravitational method is ineffective. If the contraries have a different shape from those of cellulose fibres, they may be separated by screening. There is a wide variety of screens for this purpose, with plates having holes 1.0 to 3.0 mm in diameter to plates with slots of width 0.2 to 1.5 mm. Screening removes over-size pieces such as bark, knots and weeds, particularly uncooked bundles of fibres. Otherwise these particles would break up in the stock preparation and give rise to long, narrow brown specks in the paper produced.

Contraries such as bitumen and wax are normally not removed during the re-pulping cleaning process. Bitumen is commonly used as a laminating adhesive and as a water vapour barrier in sack papers and fibre-board containers and it is therefore often found in mixed waste paper and in container waste. Bitumen is often used by paper makers themselves as protective wrappers to protect newsprint and other papers during transportation. If not removed or dispersed it gives rise to black spots which mar the appearance of certain grades of boards and prevent them from being used as containers for consumer goods. Bitumen can be dispersed after being softened by heat, into a fine form so that it is not visible in the finished product.

3.7.3 Deinking

Printed papers and boards mixed with other waste papers are recycled without deinking into boards and corrugating grades. The ink after being dispersed will give the familiar grey colour of box boards. But good white paper, lightly printed can be recycled with deinking into most grades of papers except 'high white' papers. Deinking is therefore a way of improving the quality of printed waste.

Newsprint waste when bleached and blended with about 10 percent wood pulp can be recycled back into newsprint. It is the use of recycled fibre that makes newsprint manufacture viable. Of the national newspapers, Daily Mirror and Daily Telegraph are consumers of newsprint which contains about 70 percent secondary fibres.

Printing grades represent a high proportion of waste paper available for recycling and consequently deinking is an important aspect of secondary fibre usage. Deinked waste paper is largely used as a general replacement for groundwood, especially in paper board manufacture, in the manufacture of the middle and back liners of multi-ply boards. Deinked waste paper is also used as a fibre component in some packaging papers and boards.

Deinking has been used in various forms for the removal of coating and ink from waste paper since 1795. The many types and methods of applying ink, colour and coating by modern technology have widened the meaning of the term 'deinking'. Today, it encompasses the much wider concept of the process for recovering usable fibre from printed and coated waste paper.

Deinking by flotating and by washing differs with respect to the physical principle of separation, the chemicals involved and the chemical process used, the separating equipment and the properties of the end product. Figure 3.5 gives their schematic procedures to allow comparison of the two processes. Since pre-cleaning and fine cleaning are more dependent on the type of waste paper and less on the deinking method used, re-pulping and pre-cleaning as well as fine cleaning after deinking are about identical for the two processes. The removal of ink first

Figure 3.5 - Schematic diagram of deinking processes
Source : Pfalzer(1980)

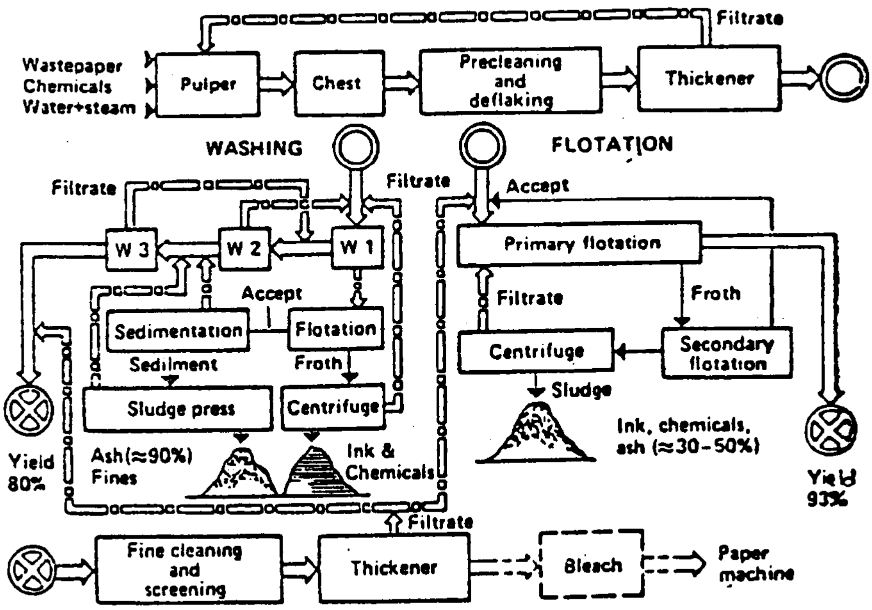
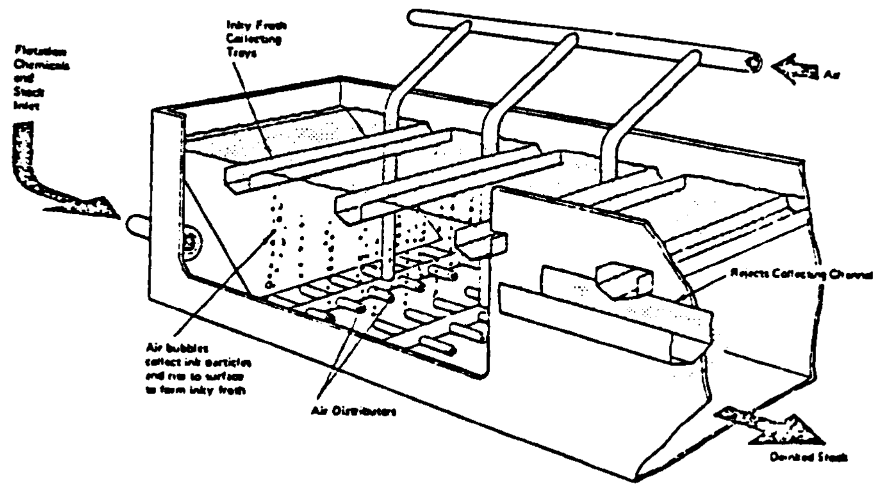


Figure 3.6 - Flotation deinking principle of
Escher-Wyss Unicell
Source : Minshall(1978)



chemically in the pulper and then mechanically in the deflaker depends on the type of ink that needs to be removed and will dictate the type of chemicals required for its separation from the fibre. Washing can only be used if the ink particles has been reduced to a size smaller than 25 µm and this requires very careful re-pulping and dispersion. Flotation however, is not sensitive to ink particle size and the process can work with particle size in the range of 2 to 10 µm and certain adaptations allow the size to go up to 160 µm. Flotation can therefore be used for waste paper like paper board (cigarette and food cartons), copier paper, advertising supplement and glossy brochure.

The choice of deinking chemicals depends on the type of waste paper under treatment, but sodium hydroxide and sodium carbonate are generally used. Alkali is used for the detachment of ink from the fibres since it weakens the majority of the ink binders. At the same time the swelling of the fibres will weaken the ink-fibre structure to such an extent that mechanical forces can separate the ink from the fibre.

For effective deinking, the ink once separated from the fibres has to be made into a stable dispersion so as to prevent the agglomerated ink particles from being re-deposited on the fibres. Ink particles once separated from the fibres can be removed either by flotation or by washing. Flotation deinking uses air bubbles to absorb the removed ink and float it to the surface where it is skimmed off (Figure 3.6). Ink removal by washing is done by repeated de-watering and dilution of the stock. The use of secondary fibres for newsprint production has very fierce competition and the high yield characteristic of the flotation process is one of the reasons for its preference in Europe. Waste effluent and environmental protection regulations also favour this method over washing.

For paper and paper board which is heavily printed with high-gloss polymeric inks or overprint varnish such as magazine cover, frozen food carton, advertising and sales brochure, conventional deinking methods will leave unsightly dark or coloured flakes in the recycled pulp. These waste papers are therefore considered as un-usables which have to be separated from the usable grades. Not only has this reduced the percentage of waste paper that can be economically recycled but the cost of sorting out the un-usable grades from the usable has contributed substantially to the high cost of waste paper recycling. Dispersion of high gloss inks and overprint varnishes by ultrasonically induced cavitation was explored by Turai & Teng(1978). By impinging a thin stream of the slushed waste paper slurry onto the edge of a flexible metal blade so designed that its natural vibration frequency was in the ultrasonic range of 16 to 22 KHz, they were able to reduce ink particles remaining on the waste paper to a size (of the order of a few hundreths of a millimetre) small enough to be removed by simply passing it through a centrifugal cleaner. Pilot plant study was ready by early 1979. By the end of 1980 developments have improved to the stage where a two-minute ultrasonic process was able to produce secondary fibres capable of making sheets of paper with better properties than those made from secondary fibres obtained after 60 minutes of mechanical deinking action.

3.7.4 Limitations of secondary fibre pulping systems

Each end product is controlled by eight main quality factors of the paper products : basic weight, caliper (or thickness), colour, moisture, porosity, opaqueness, printability and strength. The qualities of the finished paper or board as controlled by these factors determine the mixture of waste paper and upgrading raw pulp required in the furnish to the paper or board machine. Therefore a mill using waste paper must be able to define the quality of waste paper which could produce the secondary fibres required to satisfy the final product specifications, and then design the re-pulping system to process these grades of waste papers. Various pulping systems have been designed and some of the more common systems have been described by Minshall(1978) and Felton(1980). However, it does not mean that the different systems are interchangeable to process different grades of waste paper for making different types of paper and board. A mill which uses secondary fibre does so on a set of equipment designed to re-pulp, clean and refine specific grades of waste paper. For example, a mill which deinks ledger, wet-strength and other stocks free from groundwood for making fine paper will not be able to recycle high groundwood content newsprint, telephone directory and publications paper. This is because the latter grades of waste paper cannot be bleached to the desired whiteness and they cause shrinkage losses and will increase the cost of operation. Conversely, a paper mill producing newsprint from waste paper grades of high groundwood content cannot use old corrugated cartons or many other grades of waste papers to manufacture a satisfactory newsprint sheet. In short, there is no mill presently using secondary fibres that can use any and every grade of waste paper economically. Each operation needs a certain grade of waste paper suitable for recycling to the end product being produced.

3.8 In-plant recycling

Whereas not all mills recycle externally purchased waste paper, all mills try to recycle as much as possible all the in-plant generated waste paper or 'mill broke', which includes part of the web that is washed off during the production. The wet broke has to be broken up and diluted before being pumped back to the stock preparation stage. The mill will try to recover the maximum amount of broke for recycling. Such recovery and recycling of broke not only help to reduce production cost but also help to reduce the amount of waste generated. The amount of broke produced can vary over a wide range and a major production control in all mills is to minimise the amount of broke generated during production. No actual figure for the amount of broke produced per tonne of finished product is available, partly because this value is regarded as confidential costing information and partly because it is difficult to measure since broke can occur at different stages of the production process. According to trade sources a satisfactory amount of broke coming off the production line should be less than 10 percent of production and a 40 percent broke creation would indicate production problems.

Although broke is best recycled back into the same grade of paper as that from which it originated, it may sometimes be difficult to do so because of certain additives introduced. The broke has then to be recycled into a different grade. For example, dry broke after re-pulping will not produce a stock with the same properties as it originally had, it is generally freer (that is to say the pulp has a greater readiness to lose water by drainage) and it is therefore weaker in strength. Certain additives used in the converting operation, such as plastic film or metallic foil, will become contraries and such dry broke will need special re-pulping processes to recycle them, usually to a lower grade of paper or board.

3.9 Effects of recycling on the fibre and paper properties

When the wood pulp is first beaten, the beating process caused internal de-lamination and opened up the structure of the fibre walls. After the fibres have been formed into a web of paper it undergoes a drying process which partially reverses the effects of the beating process causing the opened fibre walls to shrink and internal bonding to take place within the fibre itself. But when the paper is re-welted, the internal bonding produced by drying is not broken up again. However, when the waste paper is subject to beating, the fibre structure can be re-opened to a degree, partially restoring the condition of the beaten pulp from which the paper was originally made from. Recycling reduces fibre bondage probably as a result of the decrease in fibre flexibility and conformability. This in turn reduces bursting and tensile strength, folding endurance and decreases density.

A major problem with recycling waste paper is the loss of fibre strength. When the wood fibres are separated during initial pulping the cellulose swells. The extent of the swelling and to what degree the fibres shrink and bond together during the drying stage will determine the final paper strength. Secondary fibres will be weaker after pulping and the degree of weakness depends on the number of times the fibres have been pulped before. On the average, secondary fibres are shorter than virgin fibres and less swelling takes place with weaker fibre bonding and hence reduced paper strength (Pycraft & Howarth,1980) . A disadvantage of recycling is the need for a higher tonnage input of waste paper to obtain a given output of finished paper or the need of blending in higher grades of waste paper or virgin pulp with longer fibres to make up for the loss in paper strength. Corte(1980) concluded that on the whole secondary fibres produce weaker papers and any recovery of the strength loss is accompanied by an increase in the drainage resistance.

But recycling will increase the paper's tearing strength, its opacity and stiffness, making it suitable for use in making corrugating medium. Although paper and board produced from secondary fibres may not be as strong as that produced from virgin pulp, there are many advantages in using secondary fibres in the manufacture of certain types of paper and board products, for example household tissues, blotting paper, wall paper and even some grades of printing paper. The reason is, as the number of re-pulping of the fibrous material increases the caliper (or thickness) of the finished product will also increase and the product becomes less dense and more porous. These are exactly the properties required for blotting paper, toilet and household tissues. This is also true to some extent for printing papers because if they are porous they absorb printing ink more easily.

3.10 Energy savings in recycling waste paper

The paper and board mills are heavy users of energy. The industry is the sixth largest energy consuming group in Britain and the second largest self-generator of electricity. The energy consumption of this industry in UK in 1979 was of the order of 103.5 million GJ *(BPBIF Facts,1980). The mills generate much of their own electrical power from steam driven turbines, at the same time using the steam from the turbine to heat the drying cylinders. A paper mill can therefore achieve up to 70 percent efficiency in its use of energy compared to only about 35 percent for a 'public' electricity generating station. Energy in the form of process steam is required mostly for drying the wet paper web. Energy requirement consists of heat for the air being supplied to the paper or board machine, heat for conditioning the air in the machine house to maintain a satisfactory ambient condition, direct steam heating of the stock in preparation if necessary.

Energy costs of the industry are about £210 million (1980 prices) which is about 15 percent of total manufacturing costs. This has in fact increased from about 7 percent since 1977 and is still increasing. Energy cost is fast replacing labour cost as the second biggest cost of production, next to raw materials. One study in 1980 compared the energy costs for a typical small UK mill with that of its overseas competitors (Table 3.5). For oil, UK prices are more than double those of the USA; for gas, the UK price is highest; for electricity, UK prices are more than 150 percent of those charged in Germany. The government defends it by saying that there is a 'free market' in fuel pricing, but at the same time

* Primary energy input

Table 3.5 - Comparing energy costs for a typical small UK mill with those of its overseas competitors
Source : Editorial, Paper Technology & Industry July/August 1980

	Gas (£'000)	Electricity (£'000)	Oil (£'000)	Total (£'000)	Cost £/tonne
UK	1300	416	123	1839	49.7
Germany	942	266	109	1317	35.6
France	837	300	93	1230	33.2
USA	666	157	60	883	23.9
Canada	397	92	60	549	14.8

Table 3.6 - Energy inputs & production of some paper products in UK in 1976
Source : Palmer(1977)

Product	Energy input (GJ/tonne) Pulp manufacture	Primary fuel process	Electrical process (expressed as primary fuel equivalent)	Total input
Fluting (using 100% secondary fibres)	0.2	10.0	3.8	14.0
Liner	2.4	7.0	12.6	22.0
Board	2.5	16.0	8.5	27.0
Printing & writing paper	11.0	18.5	7.0	36.5
Soft tissue	9.0	13.0	16.0	38.0

argues that high prices should be encouraged to 'regulate' energy consumption. The BPBIF feels that while the lower energy prices in the foreign countries is a result of a deliberate subsidy policy to improve industrial performance, the UK government has kept energy prices high to increase its revenue. Although British mills are blessed with a national source of energy, yet the high energy price maintained by the government has forced them to pay for this energy at the international market price.

Palmer(1977) analysed the energy consumption in the production of five paper products in UK (Table 3.6). In the production of fluting, liner and board, recycled waste paper is used as raw material, while in the production of printing and production of printing and writing paper and soft tissue nearly 100 percent of virgin wood pulp is used as raw materials. The energy input varies from 14.0 GJ/tonne for fluting using 100 percent recycled waste paper to 38 GJ/tonne for soft tissues where production speed is high and drying has to be rapid thus resulting in higher energy consumption. In another UK survey, fluting medium made from 100 percent mixed waste used only 88 percent of the equivalent energy required to make a tonne of saleable output of the same product from NSSC pulp (Cummings,1978A).

Table 3.7 compares the energy consumption in the production of newsprint at three different pulp and paper mills. In the first mill only virgin pulp was used, in the second mill a blend of 67% virgin pulp and 33% recycled waste paper was used and in the third mill only recycled waste paper was used. Both steam consumption and electrical energy consumption for pulping were highest in the mill using only virgin pulp and lowest in the mill using only waste paper. Steam savings for Mill III was 74% of that used in the first mill, while electrical energy savings was 66% of that used in the first mill. But deinking waste paper introduced more effluent problem and so Mill III consumed more energy in effluent treatment, which was about two and a half times more than in Mill I and

Table 3.7 - Energy consumption per tonne of output of newsprint from three different pulp and paper mills
Source : Anon(1976A)

Fibre combination :-	Mill I using 100% virgin pulp	Mill II using 67% virgin pulp + 33% recycled waste paper	Mill III using 100% recycled waste paper
Stages of production			
1) Pulping & deinking			
tonnes of steam	1.90	1.45	0.50
electrical energy (Kwh)	1130	760	380
2) Paper making			
tonnes of steam	2.70	2.70	2.70
electrical energy (Kwh)	180	180	180
3) Effluent treatment			
tonnes of steam	-	-	-
electrical energy (Kwh)	14	14	36
4) Miscellaneous including auxi-llaries, tonnes of steam	0.45	0.53	0.60
electrical energy (Kwh)	14	14	36
Total :			
Tonnes of steam	5.05	4.68	3.80
Electrical energy	1338	968	632

and in Mill II. Once the pulp had been cleaned and washed and sent to the paper machine, the paper making process was basically the same for all three mills, hence the energy consumption at this stage was the same for all three mills. The net energy consumption of steam per tonne of output in Mill III was 3.80 tonnes, the lowest among the three mills, offering a saving of 25% of that used in Mill I and 19% of that used in Mill II. Electricity energy consumption in Mill III was also lowest being only 632 kwh per tonne of output, which offered a savings of 53% of that used in Mill I and 35% of that used in Mill II.

Liner board can be produced from a 100% virgin fibre or a 100% secondary fibre. An integrated mill compared the energy consumption used in producing a tonne of liner board in both cases (Table 3.8). Pulping of the waste paper again used less steam giving a 69% savings, but electrical energy was slightly higher by 23%. Since deinking was not done, the energy consumption for effluent treatment was the same. In this example, the integrated mill also produced the pulp itself from its own timber, hence another 90 kwh per tonne was used in the wood preparation stage. With or without this amount of energy included, the production of liner board from wood pulp used more energy than its production from recycled waste paper.

Thomas(1977) argued that to compare the energy cost of recycling with production from virgin pulp, account must be taken of the full cycle of events involved, beginning with the cutting of the trees and ending with their residual disposal, including all processing steps en route, such as waste paper recovery, baling and recycling. To carry out such an analysis would need to follow the entire cycle from the tree to the final recycling in an integrated mill which also recycles waste papers. No such analysis has been done in UK, mainly because UK mills are generally not integrated and they usually either recycle lower grades of waste paper as a raw material for board production or use imported virgin pulp supplemented by higher grades of pulp substitute waste paper. But in the

Table 3.8 - Energy consumption per tonne of output in the production of liner board in an integrated pulp and paper mill
Source : Anon(1976B)

Stages of production	Mill I 100% virgin fibre	Mill II 100% secondary fibre
1) Pulping (without deinking)		
tonnes of steam	3.2	1.0
electrical energy (Kwh)	240	295
2) Board making		
tonnes of steam	4.0	4.0
electrical energy (Kwh)	327	72
3) Effluent treatment		
tonnes of steam	-	-
electrical energy (Kwh)	27	27
4) Miscellaneous & auxillary		
tonnes of steam	0.8	1.0
electrical energy (Kwh)	86	195
Total :		
tonnes of steam	8.0	6.0
electrical energy (Kwh)	680	589
	770	589
if include wood preparation	90	-

USA, Berry & Makino(1974) have compared in a somewhat similar manner, the energy consumption of production using virgin fibre with productions using secondary fibre. Their energy costs for virgin fibre included felling, de-barking, chipping, transportation and pulping operations, while for secondary fibre they included recovery, baling and handling of waste papers, transportation and secondary pulping. They concluded that a 50 percent saving in energy was possible in the production of pulp from recovered waste paper, which required an equivalent of 1086 kwh of electrical energy per tonne compared to 2206 kwh electrical energy per tonne for producing pulp from virgin fibre.

Love(1978) surveyed fourteen pulp and paper mills in Canada to study the energy savings involved in production using secondary fibres. Mills were selected so that they were illustrative of the differences in energy requirements in producing functionally similiar paper products using primarily virgin fibre and using a maximum amount of waste paper. Table 3.9 shows the total energy required to produce one tonne of output. For each of the products considered, the use of secondary fibre instead of virgin fibre has allowed energy savings, ranging from 5.4 GJ to 24.2 GJ per tonne of output.

Cummings(1978A) argued that energy has already been expended in the initial production of paper and board. If the waste paper is now discarded instead of being recycled, so is this energy input. When waste paper is recycled, the only extra energy required will be for slushing, cleaning and re-pulping the fibre (plus collection and baling energy). Therefore from a national point of view, the greater the waste paper utilisation rate the bigger the energy savings and the lower the paper and board industry's energy bill.

3.11 Reduction in pollution as a result of recycling waste paper

The UK paper and board industry in general uses 3,000 million litres of water per day (BPBIF Facts,1980).

Table 3.9 - Energy savings in productions using secondary fibres
Source : Love(1978)

Product*	Total energy required per tonne output (GJ)	Savings per tonne output (GJ) as a result of using secondary fibres	Secondary fibres recycled per tonne output (tonne)	Savings per tonne secondary fibres recycled (GJ)
Printing & writing paper				
100% virgin fibres	51.1	-	-	-
34% secondary fibres	45.7	5.4	0.338	16.0
83% secondary fibres	34.0	17.0	0.940	18.1
Newsprint				
100% virgin fibres	30.9	-	-	-
100% secondary fibres	20.5	10.6	1.120	9.5
Tissue & sanitary paper				
100% virgin fibres	50.8	-	-	-
100% secondary fibres	23.3	24.2	1.116	21.7
Corrugated containerboard				
92% virgin fibres	27.5	-	0.08L	-
100% secondary fibres	21.0	6.5	1.124	5.8

* All products except corrugated container board were in the final form

But it recycles much of the water and in general 1,200 million litres per day is circulated for process and cooling purposes. The production of a tonne of paper or board requires an average of 4,500 litres of circulating water. Not only must the water input to the mill be pure in the sense that it should be free from suspended matter, iron, magnesium, slica and dissolved minerals in general, have neutral hardness and be of uniform temperature, the water leaving the mill should also be clean. Effluent from the mills may contain cellulose fibre fines, process chemicals and organic matters absorbed from the waste papers. Regional Water Authority standards have therefore necessitated effluent treatment plants for water treatment in the mills.

The major sources of water pollution in the paper industry comes from the various pulping processes. The pollutants are caused mainly by wood components and process chemicals. The waste effluent contains suspended solids which are mainly fibres lost during processing, bark and wood fragments and other dissolved compounds. Chlorine from bleaching, resins and fatty acid soaps derived from extractives in the wood are found in the effluent from chemical and mechanical pulping. Sulphate pulping mills also emit air pollution, particularly sulphur dioxide and some chlorine from the bleaching process. In general the amount and type of pollutants emitted during the manufacture of a paper product vary considerably according to the pulp manufacturing process involved. Since the pulping of virgin fibre involves the removal of those parts of the wood not suitable for paper making, pulping mills are responsible for most of the polluting effluent generated by paper making. Hence the manufacture of paper products from recycled waste paper, where pulping of virgin fibre is not necessary, will reduce the amount of pollutants emitted to the environment.

When waste paper is recycled, effluent problem is caused mainly by deinking. Love(1978) found that deinking tissue and sanitary paper mills using 'exemplary' deinking processes need not increase water pollution, especially if proper effluent treatment equipment is installed and operated properly. With an ink-dispersion process the pollution problem is reduced significantly. Once the waste paper has been re-pulped, it is used for making paper products in the same way as virgin fibre pulp and pollution problem during the paper making stage is relatively insignificant.

3.11.1 BOD and SS content

The extent of pollution in water is measured by two factors, the biochemical oxygen demand (BOD) and the suspended solids content (SS). The BOD is a measure of the potential of an effluent to remove oxygen from rivers or bodies of water from the oxidation of its organic contaminants. It can be measured in terms of the quantity of oxygen in kilograms or grams that a newly released organic substance demands from its environment under specific conditions (for example, the first five days), or it can be related to pulp production, via effluent volume, expressed as kilogram dissolved oxygen consumed/tonne of pulp produced. If oxygen is plentiful in the environment, such as an un-polluted stream, most organic substances will oxidize to a stable state within five days. A high BOD can therefore remove all the oxygen from a stream thus heavily polluting it.

The importance of the BOD measurement can be seen by comparing human and industrial discharges. An estimated 77 gram of oxygen is required by bacteria to decompose a daily human discharge of waste, while nearly 447,389 gram of oxygen is required for the decomposition of untreated waste from one tonne of bleached sulphate pulp. Thus an average size sulphate pulp mill which produces about 200 tonnes of pulp each day can create a BOD load equivalent to that of human waste from a million people (Allan et al,1972).

SS content is a measure of the minute solids and fibres in suspension, which clog water courses and interfere with both aquatic plant and animal life. It is measured in kilograms or grams per tonne of pulp produced.

Table 3.10 shows some typical BOD and SS loads for waste paper deinking plants in USA. Recycling of paper board released the least pollutants since deinking was not used, while recycling of magazines gave the most pollutants. The much higher SS loads in magazines were due to the large quantity of washed-out clay and other fillers used in their manufacture. The principal waste constituents found in magazine re-pulping included coarse and fine fibres, adhesive, sizing, coating materials and various fillers and pigment, substances which formed a messy sludge which has to be disposed by landfill. On the average 15 to 20 percent of the input fibre to deinking plants may be washed out as ink, clay, fibre fines and fine dirt and this figure could go up to as high as 50 percent (Porteous,1977). Therefore high BOD and SS content in the effluent will result in very expensive effluent treatment, thereby increasing the cost of using secondary fibres in the mills.

Table 3.11 shows the effluent loads per tonne of product from pulp mills in the USA. Comparing Tables 3.10 and 3.11 shows that wood pulp production gives a much higher level of BOD and SS loads than re-pulping waste paper. Only mechanical pulping gives effluent loads comparable to that of paper board pulping. Pulping of news even with deinking will still give less effluent loadings than all the other methods of producing pulp. But re-pulping of magazines with deinking will produce effluent loadings higher than all the wood pulping processes except sulphite pulping. Except for re-pulping of magazines with deinking, re-pulping of waste paper will generally cause less pollution than producing virgin pulp from wood.

Table 3.10 - Initial effluent loads per tonne of pulp from waste paper pulping mills
Source : Kenworthy(1973)

Waste paper grade	Deinking plant	BOD load (kg)	SS load (kg)	Effluent (m^3)
Magazine	Washing	50 - 68	270 - 410	135
News	Washing	18	50	135
Magazine	Flotation	40	270	90
News	Flotation	18	50	90
Paperboard	-	9	18	40

Table 3.11 - Water-borne wastes per tonne of product from pulp mills
Source : Porteous(1977)

Type of pulping	BOD load (kg)	SS load (kg)	Effluent (m^3)
Kraft pulp - bleached	36.3	63.6	170.0
unbleached	22.7	22.7	83.2
Mechanical pulp	10.0	11.3	38.0
NSSC pulp	50.0	22.7	52.0
Sulphite pulp	272.0	28.0	181.0

But in UK wood pulp is imported so that the pollution due to pulping wood is not a major concern to British mills. However when deinking is used in UK, there will be a net increase in pollution, consider from the point of view of the UK compared to recycling waste paper without deinking.

4 - Supply of waste paper

4.1 Suppliers of waste paper

There are four main categories of waste paper suppliers, of which the merchant processor group is the biggest. Together they supply about 75 percent of all the waste paper consumed in UK, while the paper and board convertors and the local authorities each supplied about 10 percent. The remaining 5 percent of waste paper consumed is supplied by the various voluntary organisations throughout the country.

4.1.1 Local authorities

Under the Public Health Act,1936, and the Control of Pollution Act,1974 local authorities in UK have a statutory duty to collect and dispose domestic waste, but there is no legal requirement for local authorities to collect commercial waste or to collect waste paper separately from domestic waste. However, many local authorities operate separate waste paper salvage alongside the normal waste collection and disposal services. In 1965 there were 744 local authorities collecting waste paper in UK, but this number dropped to 451 by 1971 (Kenworthy,1973B). In 1974 the local government re-organisation in England reduced considerably the number of local authorities. In early 1975, there were 40 local authorities in England operating trial schemes for waste paper recovery while just under 200 authorities had already made arrangements for separate collection of waste paper (Materials Reclamation Weekly, Vol 126 No.3, January 25,1975). By 1980 there were only 134 local authorities collecting waste paper in England and 168 local authorities in the whole of England, Wales and Scotland. Today local authority collection contributes about 10 to 12 percent of the total waste paper consumed in UK, mainly in newsprint, container waste and mixed wastes.

Many local authorities have stopped salvaging waste paper because of financial losses. The recession in 1975 added to the disenchantment of many waste disposal officers so that between June and October 1975 thirteen local authority waste paper recovery schemes were abandoned as uneconomical (Taylor,1977). Some local authorities have been reluctant in the past to start collecting waste paper because of the cyclical nature of the market and those local authorities who have stopped their waste paper salvage during the slumps in the waste paper market were reluctant to start again. The fact that it can take up to two years to really put a new collection system into smooth operation also helps to discourage some local authorities from getting involved in waste paper salvage.

The two sources of waste paper available to the local authority are,

a) domestic premises which contribute newspapers, magazines, paper board containers and mixed waste papers, and

b) trade premises, offices, warehouses and factories which contribute fibreboard containers and mixed waste papers.

Methods of collection and processing vary greatly between the different local authorities. In the past, a common method was to use trailers on refuse collection vehicles or putting roof racks on refuse collection vehicles to collect the separated waste papers. One advantage of using a trailer or a rack system was that householders do not have to remember which day was paper collection day. The separate sacks or bundles of waste paper could be placed at the curb-side on any normal refuse collection day. Prior to 1976 over 70 percent of local authorities used trailers (Taylor,1977). By the mid-1970s, the refuse collection vehicles have been changed to much bigger ones, with holding capacity about 4 times that of earlier vehicles, so that the area covered by each collection vehicle increased four fold. But the size of the trailers has not been increased, so that trailers became filled much faster than the refuse collection vehicles. Returning to depot just to change the trailer when it was filled up would increase the cost of collection. If the trailer was increased in size, they became too big to be practical. Trailers gradually began to be phased out. There were other factors that supported the replacement of trailers by separate collection vehicles. There were problems of loose papers being blown about causing further environment pollution. Trailer collection required the addition of a draw bar hopper to a modern refuse collection vehicle which was rear loading and this became a burden to the refuse collectors and a source of potential danger. Circuitous roads and cul-de-sacs also caused manoeuvre and operational difficulties when trailers were in used.The Health and Safety at Work Act, 1974 also gave rise to representations by collectors claiming that trailers on vehicles constituted dangerous working conditions. Local authorities began collecting waste paper separately using a separate collection vehicle and crew on certain days of the week. Such arrangement obviously increased the cost of operation because of additional labour cost as well as higher capital investment. Since waste paper would be collected only on certain days householders have to be constantly reminded of the collection day. A complication also arose in connection with the existing refuse collection bonus schemes with waste paper taken out of the normal dustbins. The employees and their unions required refuse collection rounds to be adjusted with regard to work load content and some form of bonus scheme for the men engaged in waste paper collection had to be worked out. Bonus of up to 33.3 percent of basic wages have been paid to waste paper collectors in some local authorities.

Baling of the waste paper requires capital investment in conveyors and baling equipments. At boom periods it would be worthwhile to sort the waste paper collected into different grades, such as mixed waste paper, newsprint, kraft paper and paper boards, before baling since the different grades fetch different prices. But hand sorting ceased in recent years because of the expensive labour involved and all local authority waste papers are now baled either as mixed waste papers or container wastes for which they are paid different prices by the mills.

4.1.2 Merchants

4.1.2.1 Organisation of merchants

The most notable trend in the waste paper industry has been the increase in vertical integration of merchants in recent years. As paper and board mills make more use of secondary fibre, they acquire the control of various merchants to ensure a continuous supply of their own grades of waste papers. Many of these merchants in turn buy up smaller firms upon whom they rely on for their supply. In 1974 mill-owned merchants supplied nearly 70 percent of the tonnage recovered by the British waste paper industry (Anon,1975A).

A number of the non-mill-owned waste paper merchants formed the Independent Waste Paper Processors' Association(IWPPA) in January 1975. The objective is to provide a forum for the independent merchants to seek representation within the waste paper industry and to organise a supply group that could offer regular bulk tonnages of all grades direct to the consuming mills, particularly the independent mills of UK. This will reduce the dependence of the non-mill-owned merchants on having to sell individual loads to mill-owned merchants or agents. The IWPPA is also trying to give the independent mills a further option when looking for large tonnages. The weekly average production of all grades of waste paper by the independent merchants is about 6,000 tonnes. The IWPPA claims that they have been rather successful in their objective, although by 1980 they have only 36 full members with a total of 52 production plants, all fully integrated for sorting and baling the full spectrum of board and pulp substitute grades. The recession in 1980/81 subjected the independent merchants to very great economic pressure. Some of them were either forced to close down or sell out to the mills. By early 1981 there were only about 20 merchant processors in Britain who remain independent of the mills, out of a total of some 150 establishments (Anon,1981A).

There is however, another group of merchant suppliers of waste papers - secondary material dealers who do not specialise in waste paper merchanting, but at times of peak waste paper demand they can, at short notice, provide transport and labour and assist merchanting activity on a sub-contract basis to increase supplies to meet mill requirements. When the waste paper market recedes they will stop collecting waste paper and continue with other types of secondary materials recovery. The dealers have the advantage of being able to adjust their activity to meet the changing requirements without affecting their capital holding and manpower levels. The dealers also serve a geographical role. While waste paper production is fairly evenly generated throughout Britain, the mills tend to be rather concentrated. Certain mills and merchants therefore have contracts with dealers in areas where they themselves are not established. The contracted dealers will then serve as collecting agents as well as provide transport for the bulk movement of the waste paper to the mills. Whilst some dealers have been known to be honest and to provide some essential services, some dealers have also been known as fringe operators. These fringe operators usually have no professional expertise in waste paper merchanting and they enter the market at peak demand and withdraw as quickly when demand falls. Their usual preys are the voluntary organisations who do not have any expertise in waste paper recovery operations. These fringe operators compete directly or indirectly against local authorities and merchants. Prices are quote short as these are the prices they have negotiated with a merchant or a mill and which only hold-good as long as they receive their percentage. Collections are irregular and collections are made only when they are assured of an outlet for each load. Every effort is made to pass on inferior quality material to obtain optimum prices and immediate payment is required for each load as they are not certain of their period of activity. By going from mill to mill and from merchant to merchant bartering in search of higher prices, they cause confusion over the actual tonnage required in the market as well as market prices, and create mistrust and uncertainty in the industry.

4.1.2.2 Collection and sorting

It is economical for merchants to collect only from industrial, commercial and business premises which can offer them sufficient tonnages to be worth their while. For mixed waste papers, they will normally not collect anything less than two tonnes from a source. If there are high grade papers such as computer printouts, they will even collect as little as 50 kg from a source.

Industrial and commercial business organisations generate sufficient waste paper to be worth selling the waste paper to the merchants. The fact that they are getting paid for their waste paper is an incentive for them to keep certain types of waste paper into separate sacks and to keep contraries out of the sacks. They also use the waste paper merchants to help them clear their huge amounts of waste paper constantly, so that the contract is to collect the waste paper on a regular basis no matter what the state of the waste paper market is. Waste paper is being generated on their premises continuously and if collection is not made regularly by the waste paper merchants they will have a waste disposal problem on their hands.

The nature of the paper making industry is such that each mill has a different waste paper requirement. Merchants therefore sort their waste paper to the specific requirements of mills. Sorting and grading of waste paper is a labour intensive task because there is as yet no machinery available for the entire process, although certain equipment like rotating sorting tables, conveyor belts, agitating screens have eased the problem to some extent. It is a manual operation which requires a degree of skill and a sharp eye by the operator. Sorting today is done by women. The merchants claim that women workers have a greater dexterity than men and more often possess more sensitive fingers and they accept the working routine better than men. The work needs practice and training before the paper sorter can acquire the skill of 'touch' to differentiate the various grades of papers. Training of the operator may vary from two weeks to a month depending on the operator's aptitude.

There are two basic stages to a sorting process. First, the dirt, dust and bigger contraries such as plastic bag pieces, strings, metal clips, carbon papers, wood stripes, remnants of polystyrene cups, etc. have to be removed. The paper is then sorted into easily recognised grades.

In a big factory, conveyor belts will be used to take the waste paper up to the sorting table and in the early stages of the conveyor belt there may be vibrating sections which will shake off some small contraries and dust. At the latter stage of the conveyor belt may be electro-magnets to get rid of the ferrous metals while operators will hand-pick out the bigger contraries. As the conveyor belt moves along other operators will pick out the easily identifiable grades of papers into separate bins. The contents of these bins may later be finer sorted or packed as a grade. The residues left on the conveyor belt will then be sent to a baling press and baled as mixed waste paper.

The waste paper is baled to conserve storage space, for easier and better stacking up, and particularly for reducing the cost of carriage and to improve convenience of transport. Uniform bales of paper will occupy a known area of space which allows easier stock-taking. Properly baled waste paper will also allow it to be stored longer without deteriorating.

Mixed waste paper bought from merchants has been sorted to such a fine extend that not much paper of long fibres is left in it. Mills therefore prefer to buy mixed waste papers from local authorities where the mixed wastes have not been sorted so thoroughly and therefore contain a higher proportion of paper with longer fibres in them.

While majority of hard covered books and ledgers are printed in good quality paper they have to be sorted out for further processing before the mills will accept them. Hard covered books are bound by strings and glue and their covers are printed. The pages have to be removed from the hard cover and backing as the glued parts of the book are pernicious contraries to recycling. Each book has therefore to be guillotined to remove all traces of glue, textile and leather bounding. Not only is this a time consuming process, a loss in weight, sometimes up to 30 percent, could result. This means that only about 70 percent of the book could be sold as group 4 waste paper to the mill.

In recent years many magazines have free gifts attached to them. These free gifts may be a small plastic screw driver, a small plastic bag of shampoo, and even a free cassette stuck on to the cover of the magazine. Any waste paper merchant buying large stocks of such over-issued magazines from the publishers may get practically clean waste papers, but the 'free gifts' which remained stuck on the magazine covers become pernicious contraries during recycling and each piece has to be removed by hand from the magazine, which is both time-consuming and labour intensive.

4.1.2.3 Operating costs

The only report in which some mention of waste paper merchant operating costs is made in DOI/DOE(1980), where the Touche Ross report investigated three independent and three mill-owned merchants. Table 4.1 shows the financial results of the 6 merchants. Sales has been based on 100 to preserve confidentiality of the merchant's identity and adjustments have been made. For example, depreciation has been adjusted on a replacement basis and similar groups of assets have been adjusted to have the same working life (ie 40 years for buildings and 7 years for plants). Returns on assets employed are positive for four of the merchants, ranging from 1 percent to 15 percent. Touche Ross considered the merchants to be operating fairly efficiently but there appeared to be scope for reducing unit costs by increasing plant utilisation. Based on the this report, the Committee on Waste Paper Supply concluded that merchants were doing reasonably well compared to the mills and the local authorities.

Waste paper merchants are reluctant to reveal their actual collection cost and baling cost. According to trade sources, collection cost is roughly twice the baling cost.

Table 4.1 - Waste paper merchants - adjusted financial returns for year ending in 1978 (based on sales = 100)
Source : DOI/DOE(1980)

Merchants	MA	MB	IC	ID	IE	MF
Sales	100	100	100	100	100	100
Costs -						
Paper & Board	74	70	51	63	66	63
Transport	14	9	11	13	12	11
Processing	5	14	22	15	16	14
Buying, Finance, Admin etc.	4	6	11	10	10	8
Total :	97	99	95	101	104	96
Pre-tax Profit/ (Loss)	3	1	5	(1)	(4)	4
Return on assets employed (Net Replacement cost) %	15	1	7	-ve	-ve	11

M indicates mill-owned merchants

I indicates independent merchants

4.1.3 Voluntary organisations

Voluntary organisations such as churches, schools, scout troops, Boys Brigade and environmental groups like Friends of the Earth, are involved in the collection of waste paper. Their aims vary, the environmental groups express concern over the waste of the resource of paper making fibre, while the other organisations use waste paper collection to raise funds for their communal activities.

Waste paper collected is mainly in the newspaper and magazine grades, since they are collected from private households where such grades are largest and most easily sorted out. These grades are harder to sell than other grades especially during a recession.

Most of the voluntary organisations sell their papers to merchants rather than direct to the mills, while some sell them to the local authorities. DOI/DOE(1980) found that in areas where voluntary organisations were active and the local authority in the area also operated a collection scheme then the local authority lost out as a result of the competition and duplication. But in areas where local authorities have stopped salvaging waste paper, collections by voluntary organisations could be useful as a supplementary source of supply, especially during the 'boom' periods. Voluntary organisations are particularly active in areas where local authorities are not salvaging waste paper, for example in Wales.

Waste paper merchants regard voluntary organisations as the source where there is flexibility in supply, although it takes some time for these organisations to react to the changing situation, to start or stop their waste paper collection. Some local authorities regard voluntary collectors as a nuisance especially in times when the waste paper markets is just beginning to decline and everyone is left with huge tonnage of collected waste papers. While the local authority has to deal with the disposal of its own waste paper, it has also to help the voluntary organisations to dispose their waste papers.

The environmental groups will most probably continue salvaging paper even during a slump but for the community groups aiming to raise funds through waste paper salvage fall in prices will disheartened their efforts and dissuade them from further participation. Their major complaint is that price fluctuations occur without warning. But the dispersed nature of voluntary organisations makes it difficult for any information on price changes to be conveyed to them and even the waste paper merchants who purchase from them are unable to forecast the timing or changes in future prices.

In recent years several voluntary organisations have emerged to salvage not just waste paper but a number of secondary materials as well. One which was formed earliest and has been most publicised is of course the Oxfam 'Wastesaver' scheme. This scheme was started by Oxfam in early 1975, supported by the Kirkless Metro-politan Council. The area of operation was broadly defined by the old Huddersfield Borough. Although the Kirkless Metropolitan Council supported the venture it assumed no financial responsibility. But it expected to get a 10 percent share of the net revenue.

When the scheme started, about 6,000 housewives were approached to participate. Each household was given a 'Dumpy', a stand with holders to contain four plastic sacks. Each sack was colour coded to receive a specific type of material. One sack was for newspapers and magazines, another was for plastics, tins and bottles, the third was for mixed waste paper and the last for discarded garments, rags and items that could be resold through Oxfam shops. The remaining refuse was deposited by the householder in the usual dustbin which was collected by the local authority. Oxfam leased a 4 storey building with about 4,650 m^2 of floor space in Huddersfield. The premise was the sorting centre and was also used for the sale of furniture, domestic appliances and clothing collected and re-furbished under the same scheme.

Initial investment for the programme was £150,000 (1975 prices). The Department of Environment(DOE) provided publicity aids costing over £5,000, which included 30,000 colour-coded adhesive labels and easy-to-follow instructions to help housewives sort and separate materials from their domestic waste. The DOE provided the backing because they believed that the project would yield valuable information on the public attitude to separating refuse at source and the information gathered would be useful in developing future policies. Various industry and organisations provided some support and donations were made by the National Westminister Bank, the textile organisation and some waste paper processors.

Reclaimed materials were sold through normal trade channels. J & J Maybank waste paper processors, contracted to buy all the waste paper collected and Redfearn National Glass contracted to buy 500 tonnes of cullet a year for recycling in its York and Barnsley glass works. Of the 80 or so employees, 50 had been recruited under the Government's Job Creation Scheme which means that they were paid by the State (Gooding,1976A). Many volunteers also assisted the scheme by providing free labour.

Of the initial households approached less than half participated (2,500 approximately). But the 'Wastesavers' organisers felt that even at this participation level the programme was worthwhile. Although the 'dumpy' was sound in theory, it is a lengthy operation to remove and replace the sacks. Within two years, the dumpy was replaced by a single main sack in a bright green standard dustbin.

Although there was great hopes for the Oxfam 'Wastesaver' scheme initially, later results suggested that the scheme could not operate other than at a loss for the collection of waste paper from households. Pearce in OECD(1979) extracted relevant data from Blackmore & Turner(1978) to cost the 'Wastesaver' waste paper processing operation and found that the waste paper collection scheme as a whole made a distinct loss (Table 4.2). Of a total expected revenue of £26,403 from waste paper, about £17,011 or 64.4 percent of it goes into direct costs and a further £14,848 or 56.2 percent of it goes into collection costs under 'payments to transport department'. There is an average loss of £5.88 per tonne of waste paper salvaged. Based on strict accounting terms the scheme is uneconomic at least as far as waste paper collection is concerned. Blackmore & Turner (1978) however, argued that it is socially beneficial when all social costs and benefits are accounted for. They argued that manpower used would otherwise have been unemployed and hence its 'shadow price' is zero or near zero. This is not strictly correct as the State will still have to pay the unemployed social benefit costs, so that the 'shadow price' should be the wages minus social benefit costs and not zero. In table 4.2, both the savings in waste collection costs and disposal costs which would have been incurred by the Kirkless Metropolitan District Council had not been considered. If the average savings equal or exceed £5.88 per tonne, then the 'Wastesaver' is socially beneficial even though it is not profitable privately.

'Wastesaver' could not have been worse timed from the point of view of the national economy (Holmes,1981). From 1975-1977 transport costs, wages and costs of running the centre rose sharply while revenue obtained from sales of reclaimed materials remained static. By 1977 'Wastesaver' decided to concentrate on its most successful products and dropped the reclamation of furnitures, tin, glass, plastics and ultimately paper. Currently only textiles and aluminium are reclaimed by 'Wastesaver' and there are plans to relocate the centre to a smaller modern factory so as to reduce overheads.

The Friends of the Earth have also a long history of involvement in waste paper recovery activities. The Camden Friends of the Earth in early 1974 published a report

Table 4.2 - Oxfam 'Wastesaver' Project (Annual waste paper recovery cost)
Source : OECD(1979)

Processing Costs	£	£
Leasing of equipment	5882	
Maintenance	600	
Processing expense[1]	1130	
Wages & National Insurance	3601	
Total		11213
Administration & Overhead charges		
By space utilisation	4656	
By wage bill	1142	
Total		5798
Total processing cost		17011
Payment to Transport Department for operations		14848
Total operating cost		31859
Revenue		
772 tonnes mixed waste paper @ £26.31/tonne	20338	
156 tonnes KLS @ £38.88/tonne	6065	
Total revenue		26403
Net revenue		(5456)
Average loss per tonne of recovered paper		£5.88

Note :

1 Costs of consumable goods and general expenses (£2597) minus internal credits from other departments for use of machinery

Waste Not to encourage and urge the Camden Council to recycle waste paper. The analysis at that time concluded that waste paper recovery would be profitable to the Council. Another group of The Friends of the Earth was recovering waste paper in Edinburgh and was supported by the Manpower Services Commission.

A more recent organiser in which the local authority participated actively with the public in organising waste recovery scheme is the SWAP programme in Leeds, (see para 5.6.12) and the Teeside Wastesavers in Middlesborough which have taken over waste paper collection in two districts of the borough.

4.2 Tonnage recovered

4.2.1 Tonnage recovered by local authorities

Table 4.3 shows some sample analysis of the composition of waste paper collected by local authorities. Mixed waste paper is the dominant grade for both collections from trade premises and domestic premises, while domestic sources give more newspaper than container waste.

No figures on the waste paper recovered for UK as a whole has been published. Value and tonnage of waste paper recovered by English local authorities were however, published in DOE(1967) and DOE(1971) (Figures 4.1, 4.2). Statistics of waste paper recovered in England and Wales were published jointly by the Society of County Treasurers and the County Surveyors' Society from 1974, but this work was taken over by the Chartered Institute of Public Financial Accountants(CIPFA) since 1976. Similiar statistics for Scottish local authorities have not been published at all. Between 1967 and 1974, no published statistics for waste paper recovered exists, even for English local authorities.

Local government re-organisation in 1974/75 has shifted the boundaries of some districts and absorbed some

Table 4.3 - Composition of waste paper collected by local authorities
(Percentage by weight)

Grade	Trade & domestic collections			Trade collections	Domestic collections	
	1972 (1)	1974/75 (2)	1979/80 (3)	1980/81 (4)	1972 (1)	1978 (5)
Mixed waste	64	81	54	83	45	45
Container waste	26	16	15	16	10	16
Newspaper	10	2	31	1	45	39
Others	-	1	-	-	-	-
	100	100	100	100	100	100

Note :

(1) Whiting(1972) for an English local authority

(2) Scottish Development Department Survey on 31 Scottish local authorities(Appendix II)

(3) Case Study EB

(4) Case Study ED

(5) Minshall(1978) for Harley, England

Figure 4.1 Value of waste paper recovered in England and Wales by local authorities from 1955 - 1966 (unadjusted)

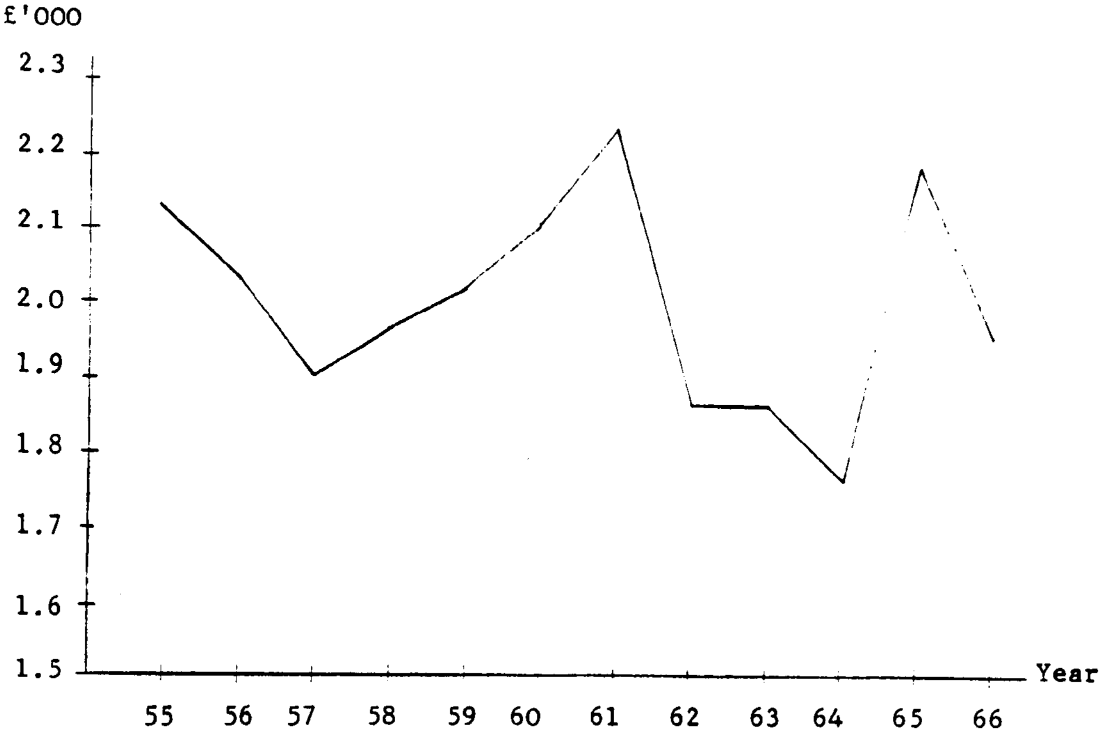
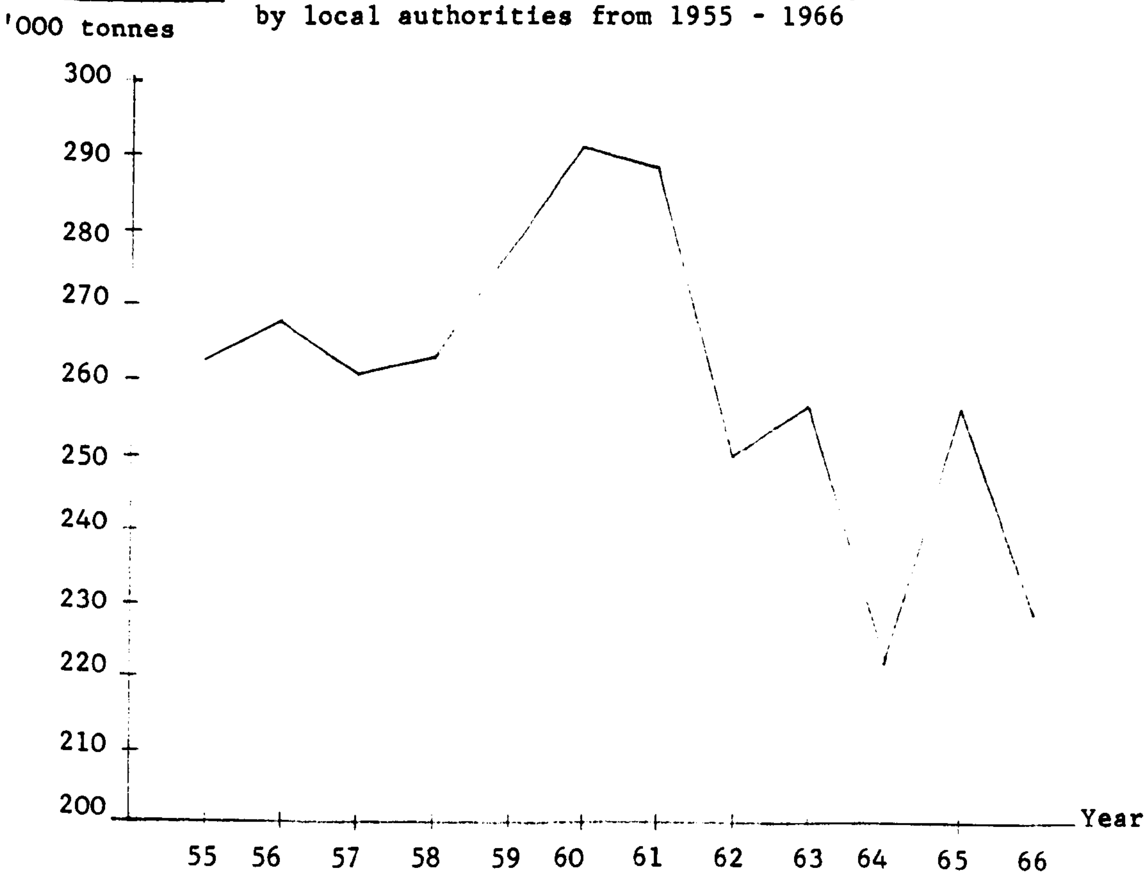


Figure 4.2 Tonnage of waste paper recovered in England and Wales by local authorities from 1955 - 1966



of the smaller burghs. It is therefore not meaningful to compare waste paper recovery activities and statistics before 1974/75 and after because of the different responsibilities and areas of management.

Just prior to local government re-organisation in Scotland, a survey on local authority waste paper recovery operation was conducted by the Scottish Development Office. But the returns from this survey were never analysed. The survey returns were only analysed in 1981 by this author during the course of this research. (Details of the analysis is at Appendix II) A total of 31 local authorities were collecting waste paper then. 3 cities collected a total of 22,120 tonnes of waste paper, 9 counties collected 5,301 tonnes while 19 large boroughs collected 13,730 tonnes. Total income derived from the sale of waste paper was however not reported. During the period of April 1974 to March 1975, mixed waste paper fluctuated from £21.50 per tonne in April to £26.25 per tonne in October and it was difficult to estimate the actual total value of the waste paper. Working on the average price for the year, the total value of the waste paper recovered could be around £1,000,000.

Just after local government re-organisation, a set of waste disposal statistics for England(1974/75) was collected and published by the Society of County Treasurers in conjunction with the County Surveyors' Society. Fourteen non-metropolitan counties recovered a total of 35,164 tonnes of waste paper, while 4 metropolitan counties recovered 19,035 tonnes, and the Greater London Council recovered 93 tonnes. The actual value of the total recovery was not reported since only 6 out of the 29 county councils reported the income derived from the sales of the paper. An estimate of the value of the recovered paper came to just over £1,000,000. Therefore in the 1974/75 period the local authorities in UK recovered 95,443 tonnes of waste paper with a market value of about £2,000,000.

Table 4.4 shows the extent of waste paper recovery activities in local authorities in England, Wales and Scotland from 1976 to 1981. The total number of local authorities involved has been on the decline due to a decline in the number of English local authorities collecting waste paper. From a supply of just over 262 thousand tonnes in 1955/56, the amount fell to only 135.8 thousand tonnes in 1976/77 and then to 114 thousand tonnes in 1978/79. English local authorities, both district and county councils, with 83 percent of the total UK population, accounted for about 75 percent of the total local authority waste paper collection. Scotland, with only 9 percent of the total UK population was able to recover about 25 percent of the total local authority collection in UK. In Scotland the number of local authorities collecting waste paper has been fairly consistent.

In the last few years only 2 Scottish local authorities have stopped salvaging waste paper. One reason to account for the more consistent contribution from the Scottish local authorities (Table 4.5) is that out of the 33 Scottish local authorities recovering waste paper, 31 of them have long term contracts to sell to one big board mill in Scotland, and all the Scottish local authorities get the same price for their waste paper. There is also very good and constant rapport between both suppliers and buyer. Whereas in England the local authorities are rather widespread and there are 3 big buyers and numerous merchants buying from the different English authorities. Prices paid to the English local authorities varied with mills and merchants and some local authorities get such low prices from the merchants, particularly during recessions in the markets, that it is impossible for them to subsidize the heavy losses incurred in the waste paper recovery operations.

Very few district councils in Wales salvage waste paper, together they supplied less than 1 percent of all local authority collection. By 1980 local authority waste

Table 4.4 - Waste paper recovery activity of local authorities
Source : CIPFA for England and Wales
Trade sources for Scotland

a) Number of local authority recovering waste paper

	1976/77	1977/78	1978/79	1979/80	1980/81
England					
WCA	153	No	132	120	N/A
WDA	11	survey	11	14	11
Wales	2		5	1	0
Scotland	35	34	33	33	33
Total	201	N/A	181	168	N/A

b) Recovered tonnage (tonnes)

	1976/77	1977/78	1978/79	1979/80	1980/81
England.					
WCA	127376	No	111230	120773	N/A
WDA	8431	survey	2935	25133	14795
Wales	644		831	170	0
Scotland	43066	36428*	36499*	42665*	41299*
Total	179517	N/A	151495	188741	N/A

c) Sale-Value of waste paper £'000

	1976/77	1977/78	1978/79	1979/80	1980/81
England					
WCA	2972.8	No	2890.5	3289.3	N/A
WDA	217.8	survey	171.5	211.4	150.2
Wales	17.1		22.2	2.89	0
Scotland	998.0	1074.6*	1076.7*	1269.3*	944.7*
Total	4205.7	N/A	4160.9	4772.9	N/A

WDC = waste collection authorities
WDA = waste disposal authorities

* two local authorities' statistics not known (in 1976, together they accounted for only 1.75% of all Scottish local authority recovered tonnage)

N/A Not available

Table 4.5 - Local authorities recovering waste papers in Scotland
Source : Trade sources

	1976/77		1977/78		1978/79		1979/80		1980/81	
	Tonne	£	Tonne	£	Tonne	£	Tonne	£	Tonne	£
BORDERS										
Ettrick & Lauderdale	630	16250	647	19086.50	720	21240.00	826	24573.50	615	14068.13
Roxburgh	465	12480	910	26845.00	1122	33099.00	1229	36562.75	1193	27289.88
CENTRAL										
Falkirk	2154	52790	2207	65106.50	2352	69384.00	3122	92879.50	2878	65834.25
Stirling	220	8785	437	12891.50	479	14130.50	572	17017.00	780	17842.50
DUMFRIES & GALLOWAY										
Annandale & Eskdale	114	5100	161	4749.50	86	2537.00	83	2469.25	108	2470.50
Nithsdale	361	6625	NK	-	NK	0	NK	0	NK	0
Wigtown	60	2460	75	2212.50	201	5929.50	118	3510.50	154	3522.75
FIFE										
Dunfermline	1938	44237	2025	59737.50	2108	62186.00	2089	62147.75	1989	45498.38
Kirkcaldy	1793	41239	426	12567.00	1920	56640.00	2788	82943.00	2754	62997.75
North East Fife	690	18170	939	27700.50	1213	35783.50	1312	39032.00	1385	31681.88

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	1976/77		1977/78		1978/79		1979/80		1980/81	
	Tonne	£	Tonne	£	Tonne	£	Tonne	£	Tonne	£
GRAMPIAN										
City of Aberdeen	3602	68761	2835	83632.50	2911	83587.50	3442	102399.50	2928	66978.00
Banff & Buchan	543	13439	256	7552.00	217	6401.50	263	7824.25	617	14413.88
Gordon	150	3500	127	3746.50	120	3540.00	280	8330.00	334	7640.25
Kincardine & Deeside	106	3177	84	2478.00	95	2802.50	58	1725.50	2	45.75
HIGHLAND										
Inverness	607	31500	838	24721.00	843	24868.50	1019	30315.25	1032	23607.00
Moray	300	5978	163	4808.50	14	413.00	0	0	0	0
Ross & Cromarty	140	3862	8	236.00	0	0	0	0	0	0
LOTHIAN										
City of Edinburgh	6491	157488	5469	161335.50	4517	133251.50	5735	170616.25	6086	139217.25
East Lothian	1576	34117	1709	50415.50	1725	50887.50	1857	55245.75	1694	38750.25
West Lothian	1508	37370	1445	42627.50	1510	44545.00	1908	56763.00	1718	39299.25
Midlothian	1039	26578	1215	35842.50	1015	29942.50	1449	43107.75	1441	32962.88
STRATHCLYDE										
Cunningham	62	2857	93	2743.50	96	2832.00	177	5265.75	235	5375.63
Dumbarton	50	530	0	0	0	0	21	624.75	6	137.25
East Kilbride	396	12198	NK	-	NK	0	NK	0	NK	0
City of Glasgow	10762	214095	7990	235705.00	6804	200718.00	7697	228985.75	6727	153880.13

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	1976/77		1977/78		1978/79		1979/80		1980/81	
	Tonne	£	Tonne	£	Tonne	£	Tonne	£	Tonne	£
STRATHCLYDE										
Hamilton	445	19824	803	23688.50	773	22803.50	466	13863.50	655	14983.13
Inverclyde	195	7265	38	1121.00	38	1121.00	66	1963.50	37	846.38
Kilmarnock & Loudoun	529	13923	505	14897.50	468	13806.00	451	13417.25	597	13656.38
Kyle & Carrick	467	13513	424	12508.00	358	10561.00	361	10739.75	404	9241.50
Monklande	50	1200	0	0	0	0	0	0	0	0
Motherwell	820	22000	654	19293.00	838	24721.00	995	27601.25	994	22737.75
Renfrew	1890	31000	802	23659.00	872	25724.00	1163	34599.25	1029	23538.38
TAYSIDE										
Angus	1040	27533	973	28703.50	983	28998.50	976	29036.00	994	22737.75
City of Dundee	1680	38280	2048	60416.00	2024	59708.00	2099	62445.25	1873	42844.88
Perth & Kinross	193	5472	122	3599.00	77	2271.50	43	1279.25	40	915.00
Scotland Total :	43066	997975.00	36428	1074626.00	36499	1076720.50	42665	1269283.80	41299	944714.63

paper collection in Wales was practically non-existent. One of the reasons for the lack of activity in Wales is because of the geographical terrian which makes waste paper recovery difficult and expensive. One waste paper merchant claimed that the lack of local authority participation in Wales is partly due to many small, part-time waste paper collectors who collect from various premises to sell to the small waste paper merchants who in turn sell them to the bigger waste paper merchants.

Local authority supply of waste paper on the whole, has been shrinking from some 40 percent of mill consumption in the early 1950s to 30 percent in the 1960s, to 18 percent in 1970s and to 10 percent in 1980 (Anon,1981A). Financial contraints, especially rising labour cost which is reflected in higher collection costs, is a major cause for the reduction, but not the only one. The uncertainty of future demand and fluctuating waste paper prices have also discouraged some local authorities from continuing their recovery operations. Cumming(1978B) felt that one of the reasons for the drop in local authority supply of waste paper could be attributed to low waste paper prices in the continent which could be half of UK prices in some countries, which at times allows mills to get cheaper waste paper through imports.

4.2.2 Tonnage recovered by merchants

Waste paper merchants supply the main bulk of mill requirements, being capable of supplying more than 90 percent of the mills demand. In 1978/79 they supplied 1,947.6 thousand tonnes of waste paper, 92.3 percent of the total 2,109.1 thousand tonnes consumed by the mills. In 1979/80 they supplied 2,001.9 thousand tonnes, 91.4 percent of the total 2,190.6 thousand tonnes recycled by the mills. Most of the mill requirements of the higher grades of waste paper also come from the merchants. BPBIF(1980) estimated that out of the two million odd tonnes supplied by merchant processors, about 10 percent of 200 thousand tonnès of the waste paper have been collected from convertors and such sources.

4.2.3 Tonnage recovered by voluntary organisations

Most of the voluntary organisations sell their waste paper to merchants and since most voluntary organisations operate on an 'on-and-off' basis, it is difficult to assess how much they actually supply. Besides they are rather dispersed throughout the country and their activities are not centrally co-ordinated, making it difficult to gather collection statistics from them. However, DOI/DOE(1980) estimated their combined collection to vary from 100,000 to 150,000 tonnes per annum, making up about 5 to 7 percent of mill consumption in 1979. In times of high demand voluntary organisations have been known to supply up to 10 percent of total waste paper consumption. In 1974 during the peak demand, voluntary organisations collected over 200,000 tonnes or 9.5 percent of the 2.1 million tonnes consumed in UK mills that year.

4.3 Waste paper recovery rate in UK

The amount of waste paper collected or recovered (WPCO) can be calculated from other published data, according to the relation,

$$WPCO = WPCS - WPIP + WPXP + CWPS$$

where
WPCS = waste paper consumed
WPIP = waste paper imported
WPXP = waste paper exported
CWPS = change in waste paper stock

Total tonnage of waste paper recovered in UK (Figure 4.3) has been on the increase since 1954 and the trend from 1954 to 1979 has an average rate of increase of 2.6 percent per annum. Highest tonnage of waste paper collected was 2,218.5 thousand tonnes in 1974, but in 1975 total collection dropped by 19 percent to

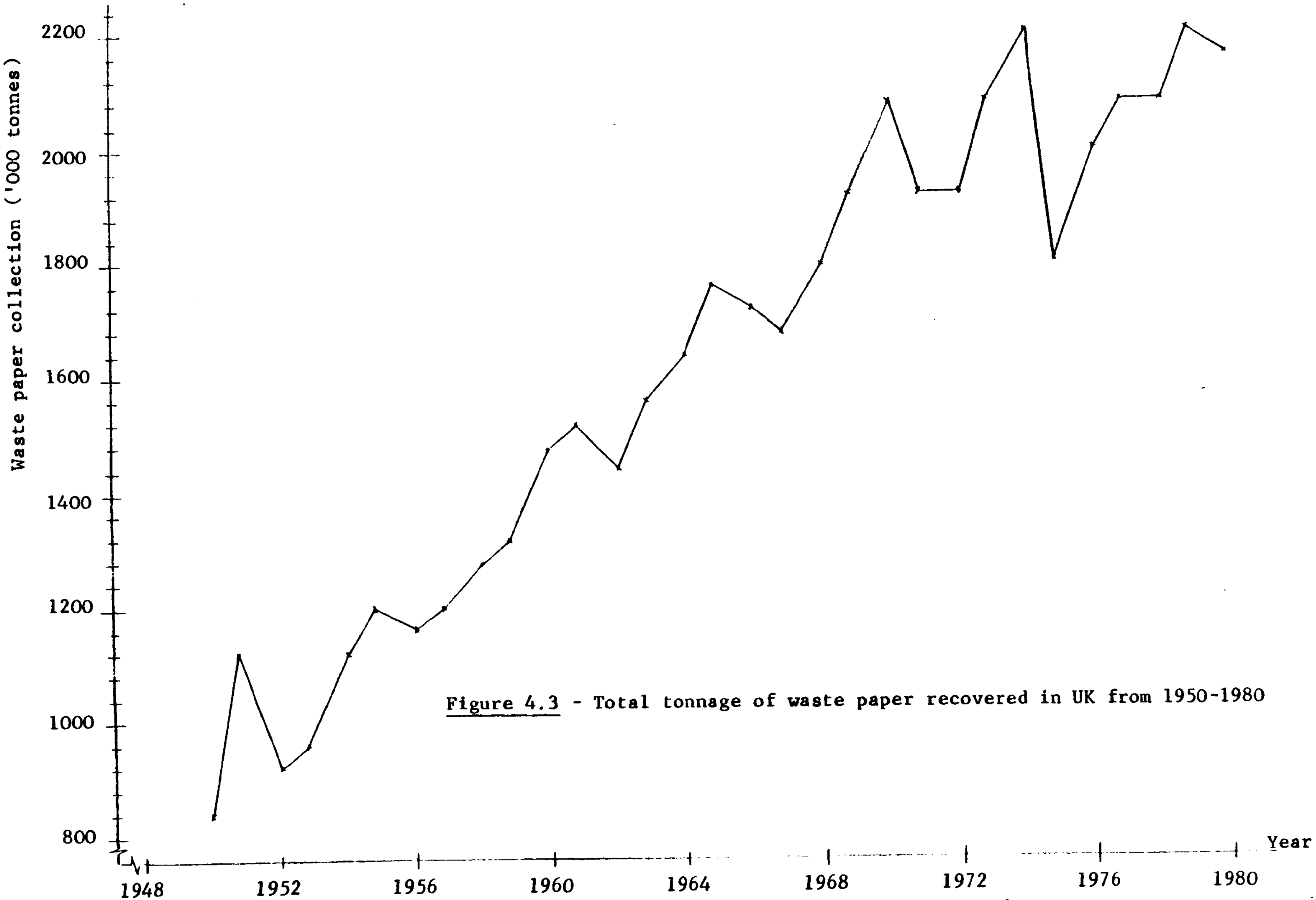


Figure 4.3 - Total tonnage of waste paper recovered in UK from 1950-1980

1,793 thousand tonnes.

Waste paper recovery rate (RCRATE) is defined as the ratio of waste paper collected to apparent paper and board consumption. Official statistics for waste paper recovery rate is not published. The recovery rate is therefore computed from other published data, using the relation,

$$RCRATE = \frac{\text{Waste paper collected}}{\text{Apparent paper \& board consumption}} \times 100$$

Waste paper recovery rate was highest in 1952 when 33.4 percent of the apparent paper and board consumption were recovered. Since then the recovery rate has been on the decline reaching the lowest rate of 26.4 percent in 1967. But after 1967 the recovery rate started increasing again to reach 31.5 percent by 1980 (Table 4.6) (Figure 4.4).

4.4 Elasticity of supply

Various models have been developed to study the response of waste paper supply to price changes. Miedema, et al(1976) showed that a very low generalised elasticity of supply exists for waste paper in the USA. The elasticity of supply at only 0.09 implies that a 10 percent increase in price would only cause about 1 percent increase in supply. Supply of waste paper in a given period has also been expressed as a function of current prices and prices in previous periods. Such 'distributed lag functions' have been explored by Anderson & Spiegelman(1977) for the USA waste paper supply and by Deadman, Grace & Turner(1978) for the UK waste paper supply. Anderson & Spiegelman(1977) found that supply responsed positively to current price, whose elasticity in the short run was estimated to be 0.53, but supply responsed negatively to previous prices so that long run price elasticity of supply was about 0.40. Deadman, et al(1978) also recorded low elasticity coefficients in respect of current prices, but negative coefficients for previous prices.

While all their models have showed the price elasticity

Table 4.6 - Waste paper recovery rate in UK
Source : Annual Abstract of Statistics, Business Monitor, P5 and PM 481, BPBIF Facts, BWPA Statistics (WPCS, WPIP, WPXP, CWPS, PBCS, WPCO in '000 tonnes)

Year	WPCS	WPIP	WPXP	CWPS	PBCS	WPCO	RCRATE
1950	901.3	0.0	10.1	-62.1	2978.3	849.3	28.5
1951	1014.0	0.0	6.3	79.7	3362.3	1100.0	32.7
1952	835.4	0.0	15.4	70.0	2755.1	920.8	33.4
1953	927.8	1.9	52.2	-34.2	3092.8	943.0	30.5
1954	1060.5	2.5	55.1	-5.0	3763.5	1108.1	29.4
1955	1114.1	4.4	61.1	36.5	4158.3	1207.3	29.0
1956	1078.9	0.9	84.2	10.6	4080.8	1172.8	28.7
1957	1113.3	0.4	96.5	-4.2	4291.1	1205.2	28.1
1958	1188.1	0.5	91.1	-7.9	4451.9	1270.8	28.5
1959	1245,8	7.0	75.2	-12.8	4687.9	1301.2	27.8
1960	1361.2	2.3	101.2	19.4	5311.9	1479.5	27.9
1961	1376.0	0.5	118.4	25.8	5326.2	1519.7	28.5
1962	1371.6	1.1	107.7	-20.7	5319.0	1457.5	27.4
1963	1442.7	0.9	109.8	-10.3	5600.9	1541.3	27.5
1964	1538.1	2.2	114.5	-16.3	6096.9	1634.1	26.8
1965	1624.7	22.8	98.2	40.8	6112.0	1740.9	28.5
1966	1592.1	4.2	93.9	20.0	6280.0	1701.8	27.1
1967	1593.1	2.3	106.6	-13.2	6370.5	1684.2	26.4
1968	1793.2	16.8	99.7	-63.3	6752.8	1812.8	26.8
1969	1855.8	53.7	93.9	23.9	7124.5	1919.9	26.9
1970	1946.5	26.5	101.1	39.2	7179.4	2060.3	28.7
1971	1835.2	13.3	77.3	36.4	6754.2	1935.6	28.7
1972	1881.1	11.8	74.2	-11.9	7114.9	1931.6	27.1
1973	2069.8	28.9	102.2	-44.0	7595.2	2099.1	27.6
1974	2121.8	107.4	143.3	60.8	7974.0	2218.5	27.8
1975	1703.8	23.8	66.8	46.2	6040.0	1793.0	29.7
1976	2056.6	100.6	54.9	-13.3	6933.0	1997.6	28.8
1977	2114.7	123.9	44.5	33.9	6913.0	2069.2	29.9
1978	2109.1	50.8	40.2	-9.5	7263.0	2089.0	28.8
1979	2190.6	50.2	116.8	-49.0	7495.0	2208.2	29.5
1980	2014.5	31.7	210.5	-38.0	6837.0	2155.3	31.5

* WPCS=Waste paper consumption, WPIP=Waste paper import, WPXP=Waste paper export, CWPS=Change in stock, PBCS=Apparent paper & board consumption, WPCO=Waste paper collected, RCRATE=Recovery rate.

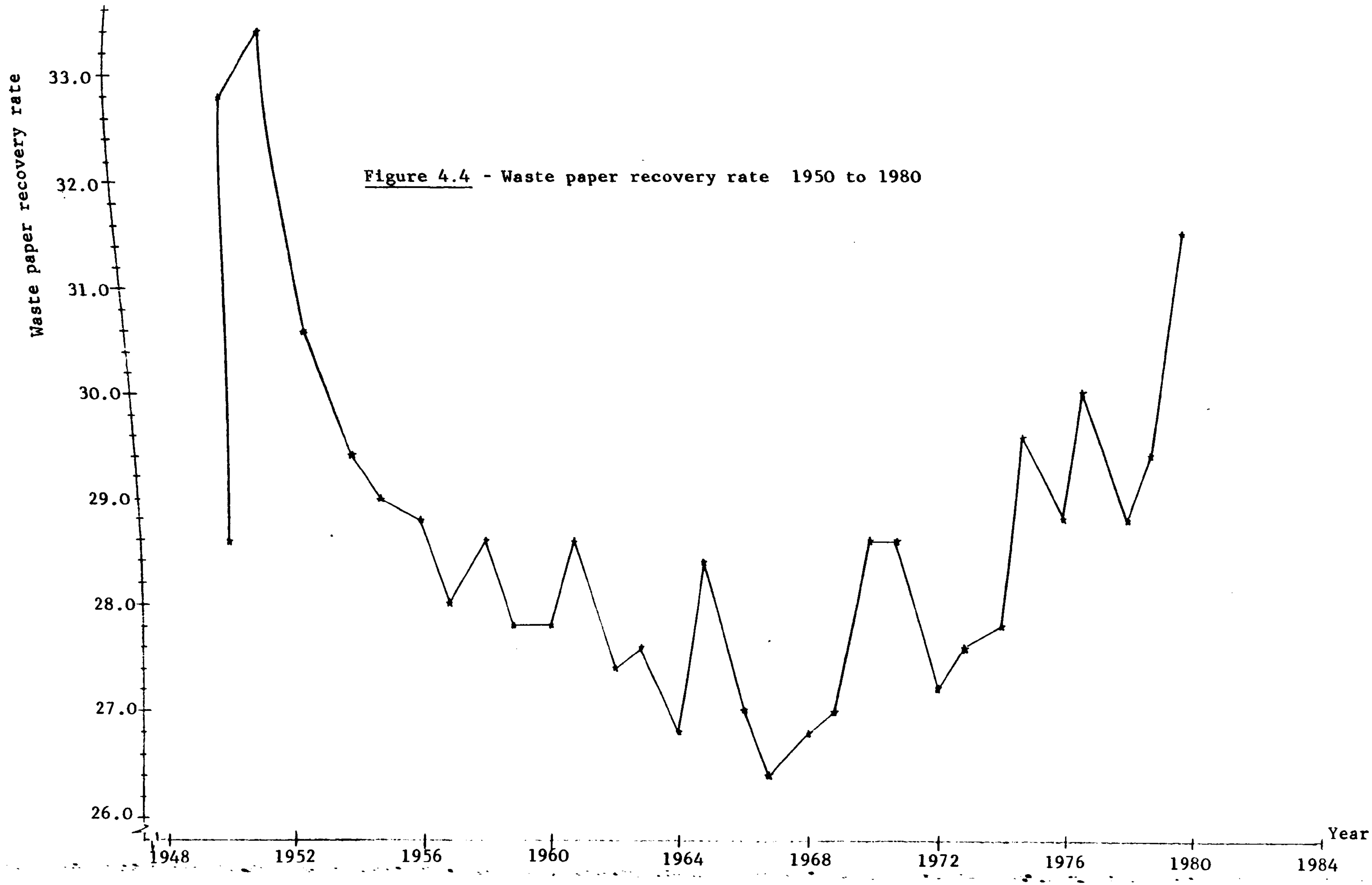


Figure 4.4 - Waste paper recovery rate 1950 to 1980

of waste paper supply to be low, none has successfully explained the phenomena. Edwards(1979) explained the low elasticity in terms of an expectation hypothesis. That means the supplier will make his quantity decision at the start of each period on the basis of the price he expects to prevail in that period as well as taking into consideration other factors such as costs and availability of waste paper. Using USA data he arrived at an elasticity of supply of 0.3 in respect of expected price, which implies that a 10 percent expected price increase would tend to increase supply by only 3 percent. This means that very substantial price changes have to be forecast to induce sufficient response from suppliers. Edward(1979)'s findings supported the view that purely price-based policies are unlikely to be effective in stimulating waste paper recovery. Another factor in support of this view is that waste paper supply takes time to be collected and supplier with experience of a volatile waste paper market would wait and see if any price increase is 'permanent' before they commit their investment to search for new sources of waste paper and arrange to collect from them. Meanwhile. suppliers' response to actual changes is sluggish and weak.

5 - The local authority's cost of recovering waste paper

5.1 Earlier attempts to assess the profitability of local authority waste paper recovery schemes

1974/75 was a period of extremes for waste paper demand. Demand was so high in the beginning of the year that mixed waste paper price increased by 24 percent between January and March and in April increased by another 37 percent. But within six months after reaching the peak price of £26.25 per tonne price fell by 27 percent in October. Many local authorities were badly affected by the drop in prices and lost money in the operations. The Local Authorities Management Services and Computer Committee (LAMSAC) subsequently developed a model in 1975, with the objective of helping local authorities to cost waste paper salvage operations and to check their viability.

5.1.1 The LAMSAC model

The model was in fact for calculating the break even price of a waste paper collection. Although LAMSAC claimed that there was such a wide variation in techniques and the system was so sensitive to local factors that generalisation was difficult, they gave rather broad guides in terms of simple equations for three different methods of salvage, domestic salvage collection using trailers, trade salvage collection using separate vehicles and a combination of the two methods.

The models were not of much use because they required local authorities to know a number of inputs for example, the total tonnage of domestic refuse collected and the fraction by weight of the total domestic refuse that is recoverable as paper salvage. These values are only estimates to the local authorities since very few actually analyse or weigh their refuse. The models have also been built up from information based on very small samples. For example, collection cost was based on the experience supplied by only one county borough in 1970 and the value has been updated by price index to January 1975. The equation for computing the purchase and operating cost of a baling press was derived from the actual costs in 1970 of only four local authorities, and the figures have been updated to January 1975 by using the Retail Price Index and the Industrial Wage Index. The element of labour cost, which was increasing at rather rapid rates, was not included in the equations. None of the indirect costs and savings as a result of separate waste paper collection was considered in their model.

5.1.2 Local authority surveys

The Department of the Environment(DOE) and the Welsh Office in 1974 conducted a survey on waste paper salvage by local authorities. Of the 403 collection authorities approached, 397 completed and returned the questionnaire. Response was very good, of the order of 98.3 percent. A similiar survey was conducted by the Scottish Development Department(SDD), involving counties, cities and large burghs only. Completed returns were received from 31 local authorities operating waste paper recovery schemes, while another 27 local authorities submitted nil returns (Appendix II).

Both the DOE and the SDD used the same survey forms where local authorities were asked to give an indication of the viability of their operation by giving a tick in one of the five columns :

Very profitable
Marginally profitable
Breaks even
Marginally unprofitable
Very unprofitable

without any guidelines as to how to judge each of the descriptions. Information obtained by this relatively simplistic criterion of profitability as seen by respondents themselves did not allow any firm conclusions to be drawn, particularly when each respondent has a different costing system. While almost all the authorities responding to the questionnaire offered some views on the degree of profitability of their schemes, in many cases no realistic costing had been undertaken and in others there was a marked variation between authorities in the items taken into account and the costs attributed to them (WMAC,1976). Some uniform accounting system would have to be devised to allow the local authority to assess its waste paper operation and to allow decision makers to make sensible decisions. Following the survey a team from the Advisory Group on Waste Paper Recycling visited 11 of the respondents, and all the local authorities visited welcome the idea of a uniform accounting system.

A working party was subsequently set up by the Advisory Group on Waste Paper Recycling in October 1975 to devise a uniform accounting system for waste paper recovery by local authorities, with the intention of enabling local authorities to make realistic assessment of the costs and benefits involved. In August 1976 the Report on Uniform Accounting for Local Authority Waste Paper Salvage Schemes was published by the DOE and given wide circulation to all local authorities.

5.2 The Report on Uniform Accounting for Local Authority Waste Paper Salvage Schemes

This report outlined which factors should be considered in periodic reviews of local authority waste paper salvage operations and provided a format for a cost and a feasibility statement for the purpose (Table 5.1). Although the details of the components making up the cost and feasibility statements were not explicitly given in the Report itself, they were discussed in WMAC(1976) where references were made.

Table 5.1 - Waste paper salvage; periodic review of existing schemes

(A) Cost Statement

Collection of waste paper salvage	Current year ACTUAL £	Coming year EST £	Coming year TARGET £
Employees -			
Salaries etc Cleasing Dept.			
Wages, Bonuses of collectors, drivers			
Supplies and Services -			
Equipment, tools, materials including sacks			
Transport and Trailers -			
Operating costs			
Repair and maintenance			
Loan charges(or Renewals Fund contribution)			
Premises			
Establishment expenses -			
Depot charges			
Central & Departmental charges			
Publicity and education			
Gross Expenditure on Paper Collection			
Sorting & Baling of waste paper salvage			
Employees -			
Salaries etc Cleansing Dept.			
Wages etc Paper baling			
Supplies and Services -			
Equipment, tools, materials including baling wire			
Baling Plant -			
Use of fork lift truck, plant etc			
Electric power			
Repairs and maintenance			
Loan charges(or Renewals Fund contribution)			
Premises			
Establishment expenses -			
Depot charges			
Central & Departmental charges			
Gross Expenditure on Waste Paper Baling			
GROSS EXPENDITURE			
Income			
Sale of Salvaged paper			
Associated salvage income (rags, woollens etc)			
Contribution by County Council to reflect disposal savings			
GROSS INCOME			
NET EXPENDITURE/INCOME			

Table 5.1 - Continuation

(B) Feasibility Statement	Current year ACTUAL £	Coming year EST £	Coming year TARGET £
Gross Expenditure as per Cost Statement			
Indirect Costs and Savings			
(i) Costs			
(1) Additional cost of operation, eg repairs,maintenance of refuse collection vehicles as a result of towing trailers, cost of additional time, labour.			
(2) Loss of income from trade collection.			
(3) Ad hoc provision (where applicable) if debt charges do not accurately reflect current rate of depreciation of plant.			
Total Costs			
(ii) Savings			
(1) Savings in refuse collection costs that results from smaller quantity of domestic refuse when waste paper salvage removed.			
(2) Savings in refuse storage costs (where local authority provides free bags or bins) that result from smaller quantity of domestic refuse.			
Total Savings			
Notional Gross Expenditure			
Gross Income, as per Cost Statement			
Notional Profit/Loss			

Local authorities were advised to separate the collection and the baling costs so as to provide a clearer picture of the cost involved at each stage and also to allow comparison of alternative methods of operation. For example, would a local authority buying loose waste paper from either neighbouring authorities or local voluntary groups for baling be more viable than one collecting and baling their own waste paper ?

Collection costs were to be considered under five categories :

a) Direct costs - which included labour, transport, plant, land and materials. Transport cost was operation expense, vehicle maintenance, fuel, insurance, road tax and drivers' wages. A provision for depreciation of the vehicle was regarded important to reflect the loss in value of the vehicle due to its use in waste paper salvage. An alternative to a depreciation provision suggested was the use of loan charges on money used for the purchase of vehicles.

   The Report made a distinction between labour cost associated with trailer collection and labour cost associated with separate vehicle collection. If trailers were used instead of separate waste paper collection vehicles, the labour cost was to be the salvage bonus paid to collectors rather than their basic wages. The plant cost for waste paper salvage included the depreciation and maintenance of the trailers and any marginal garaging and workshop costs involved. When both refuse vehicles and trailers were used, the running cost of the vehicle was to be charged to refuse collection service and only the costs of the trailers, their maintenance and the additional taxation of the towing vehicles were charged to waste paper salvage.

b) Overheads - The overheads were to include a proportion of the salaries of supervisory staff and certain central establishment charges.

c) Hidden savings on refuse and collection - The Report claimed that waste paper content generally being 60 percent by volume would allow waste paper salvage to reduce significantly the number of households requiring a second refuse receptacle or a larger refuse receptacle. The savings would occur from the fewer receptacles either in the form of sacks or bins provided free of charge by the local authority and also from the smaller volume of refuse that would need to be collected. In certain cases the reduced volume of refuse would allow refuse collection rounds to be re-organised enabling the same number of households to be covered by fewer vehicles or, with the same number of rounds the number of journeys back to the depot could be reduced thus cutting down both labour and running costs.

d) Hidden costs of refuse collection - The use of trailers, besides having difficulties in operation would involve certain hidden costs. For example, a trailer could get filled up much more quickly than the refuse vehicle. When the refuse vehicle returned more frequently to the depot because the trailer was full, extra collection cost would be incurred. Such hidden costs in refuse vehicle and labour, if occurred, were to be attributed to waste paper salvage. The operation of a waste paper salvage for commercial premises could result in some loss of income where charges were made for the collection of trade waste. A provision for this loss was to be made where this was not adequately compensated by the reduction in the cost of trade waste collection.

Baling costs were to include :

a) Direct costs - The direct labour cost was again the wages and bonus. Since the baling plant was often located on a site in the refuse depot it was to be apportioned cost according to the real opportunity cost. Valuation of plant use would include power, maintenance and depreciation of baling equipment, while material cost would relate mainly to baling wires.

b) Overheads - Again this was to be apportioned between the different services where central facilities and labour were shared.

The main source of revenue was to be derived from the sale of waste paper and any associated salvage income from items like rags, woollens etc. collected at the same time. The Report recommended local authorities to negotiate with disposal authorities for a contribution to reflect disposal savings resulting from salvage of waste paper and local authorities doing their own collection and disposal functions should include some provisions for their own savings in disposal cost.

Local authorities were recommended to seriously consider terminating any scheme that was predicted to operate with a perpetual loss except in circumstances where certain non-pecuniary advantages of operating the scheme fully compensate for any anticipated loss. The Report made references to WMAC (1976) which described some of these non-pecuniary advantages as, using the baling plants to provide employment for elderly or injured refuse collectors, or employing their reserve refuse collectors in the plant when they were not required on collection rounds, or using the waste paper salvage as a training ground for youths who would later become refuse collectors. In areas of high unemployment the few extra jobs created by collection, sorting and baling waste paper were considered important, whereas in areas of low unemployment, an attractive bonus for waste paper salvage could help with the recruitment of refuse collectors. Since such benefits were hard to assess,the local authorities were advised to weigh these factors in the context of the local situation.

5.2.1 Periodic review of existing salvage schemes

The Report advised local authorities to undertake periodic reviews of existing schemes at least every 12 months to determine their financial viability. To do this, the recommended cost and feasibility statements (Table 5.1) were to be prepared. The cost statement would give the tangible costs and income due to collection and baling of waste paper while the feasibility statement would bring in the indirect costs and savings resulting from the salvage scheme, thus modifying the cost statement in order to ascertain the notional net income to the local authority from its scheme. Local authorities following this system would have to do their sums three times, once for actual spending of the current year, once from estimates for the coming year and again for the target values of the coming year.

5.2.2 Economic evaluation of proposed waste paper salvage scheme

For local authorities considering whether to start a waste paper salvage operation, the Report advised them to evaluate whether the anticipated profits from the scheme in future years would justify the capital investment on collection and baling plant at the outset. The same costing components were to be used in the investment appraisal by discounted cash flow technique.

To avoid the problem of forecasting inflation, the Report recommended local authority to evaluate their schemes in constant price terms so that local authorities would only need to incorporate into their estimates any anticipated relative price changes that would affect the scheme, rather than changes in current money prices which incorporate the general rate of inflation.

For the real discount rate, the Report recommended local authorities to use the Treasury Test Discount Rate (TDR). The use of the TDR would help to appraise not only the viability of the proposed scheme from the national economic resource view point, but also the impact on the local authority's cash flow position.

Local authorities were advised to test a range of forecasts to examine the sensitivity of their results. Fluctuations in the major items of income and expenditure such as receipts from the sale of waste paper and wages paid to collectors and operatives may, in particular, have a significant effect on the profitability of the scheme. The Report therefore warned local authorities that they have to be confident on the proposed scheme's viability over a range of foreseeable circumstances before launching it, since the heavy capital commitment would make it difficult for the local authority to terminate the project once it has been started.

5.3 Critique of the Report on Uniform Accounting for Local Authority Waste Paper Salvage Schemes

In spite of the wide circulation given to the Report, it has not been widely accepted by the local authorities. Bagley & Dunn(1977) found many local authorities continued to present salvaging accounts in various ways. Local authorities' main excuse was that 'local pressures' (whatever they might be) made it necessary for them to continue with their existing total accounts rather than changing to the uniform accounting method. The Touche Ross Report in DOI/DOE(1980) after pointing out that local authorities were able to achieve break even only by taking into account not only the direct costs of the waste paper scheme but also the additional waste collection and disposal costs which would be incurred if there are no scheme, again urged them to take all costs and savings into account when appraising salvage schemes. DOI/DOE(1980) therefore again recommended that local authorities engaged in waste paper collection schemes should use the standard accounting procedue contained in the Report on Uniform Accounting for Local Authority Waste Paper Salvage Schemes .

Several reasons have been offered by the local authorities for not adopting the accounting system recommended by the Report. Most of them feel that this accounting system is meant to reduce all local authority accounts on waste paper salvage to a set scale for comparison purposes. The question they ask is, "who would want to make this comparison ?" and the answer seems to point to the Central Government. As far as they are concerned, their accounting system have been done along lines laid down by their Council and none of the officers spoken to during the course of the study expressed any willingness to alter their existing accounts or draw up a separate account along the lines of the recommended system for the waste paper salvage operation. The government public spending cuts have created a shortage in manpower, they claim, and there is a great deal of concern over who will do the special account and for what specific purpose ? Until the Councils are convinced of the usefulness and the contributions the recommended accounting system would bring to them, or until some new legal requirements make it mandatory for them to do so, few local authorities will adopt the recommended uniform accounting system. From the implementation point of view, the uniform accounting system as described by the Report will require the support of a very detailed and complicated data collection network. In summary, the uniform accounting system is a rag-tag of non-sensible assumptions and very few local authorities could have used it.

In this research, the importance of a uniform accounting system for the local authority waste paper recovery operation is recognised and the uniform accounting system as described by the Report could be accepted provided the following changes are made.

Trailers have been gradually phased out since 1974 and is today seldom used. The section on labour cost for trailers is therefore no longer essential. With each separate collection team, labour cost will be the direct cost associated with the driver, the collection crew and the baling crew.

Waste paper recovery is mainly a marginal activity to the local authority and if the waste paper operation is abandoned it will not in general reduce the salaries of the officers in the cleansing department or change the depot charges. For overheads, such as salaries of cleansing department, premises, establishment expenses such as depot charges, central and departmental charges, instead of apportioning them in various proportions as suggested by the Report, these items should be included on the basis of the answer to the question : "Would this item of expense be incurred if there was no waste paper salvage ?" If the answer is "yes", then it should be included and not otherwise.

Land used for the depot was recommended to be valued at the market rate of its best alternative use. For example, where the site could be easily re-developed for residential use the market rent per acre would be high. The Report also recommended for a separate collection service, the depot facilities to the vehicles to be evaluated in a similar manner. But this is unrealistic, because unless there is a requirement for the piece of land to be developed for residential or other use, a high rent allocated to it will be artificial. Therefore, when the site used for the depot is not required for any development and is just left vacant if not use, then even though it has the potential of being developed, its real opportunity cost should be regarded as zero. However, if the operation of the recovery scheme requires the renting of extra land or the operation displaces an on-going operation which has to use some other land where rent is required, only then will the depot charges for waste paper recovery be the value of that rent.

As far as income is concerned only two items needed to be considered, the revenue obtained directly from the sale of salvaged paper and a contribution to reflect the disposal savings. This is justified on the grounds that whatever is recycled will not enter the waste stream and hence will not require to be disposed, thus reducing disposal cost. The third type of income 'Associated salvage income (rags, woollen, etc)' has to be omitted since this is negligible in a separate waste paper collection operation. No sorting of this nature has been in use in recent years because of the high labour cost required.

Under indirect cost only the loss of income from trade collection where charges are made for the collection of trade waste, needed to be reflected.

As a result of a separate collection for waste paper, there is a smaller quantity of domestic refuse which will be collected by the domestic waste collection vehicles. Only the savings in refuse collection costs that results has to be reflected under 'indirect savings'.

Two other items under indirect costs and savings, 'Additional cost of operation' and 'Savings in refuse storage costs' are difficult to assess without a detailed system of sub-accounting which requires immense labour and time. Most, if not all the local authorities, will not have data on such costs and savings. They should best be omitted from the uniform accounting system.

The net indirect cost/savings added to the net expenditure or income derived from the direct cost and revenue will give a notional profit or loss to the operation.

Non-pecuniary advantages of a waste paper operation scheme are very difficult to consider since they are rather subjective and localised factors and will be difficult to quantify. They should best be omitted in the accounting system.

5.4 Local authority expenditure

The powers of a local authority to spend money to finance the wide range of public services are prescribed by statute and, in general, local authorities are permitted to spend money only on activities which are within their statutory powers, except for a small rate to be spent for the benefit of their areas and inhabitants generally.

Expenditure is subdivided under capital and revenue. Capital expenditure involves the purchase of an asset such as a refuse vehicle or a baling machine, which gives service over a considerable period of time. Local authorities usually borrow money to finance capital projects and the loan period varies with the type of asset, for example, it may be sixty years for buildings, twenty years for machinery and plant and ten years for vehicles. This means that the financial appraisal of a local authority investment in say, a refuse treatment and material recovery plant, may amortise different parts of the capital over periods from 10 to 60 years. Capital expenditure is sanctioned by the central government and the annual budget has to be presented to the appropriate Minister for approval or loan sanction. The Minister will ensure that the total capital expenditure budgeted for falls within the total allowed for that year.

Revenue expenditure includes staff salaries, operative services, etc. These costs are met out of rates and other sources of income. Rates which constitute large part of local finance, is a local tax levied on occupiers of property in the area. The cost of loan repayments or debt charges will also be included in revenue expenditure. Small items of capital expenditure can be charged to the revenue account. Revenue expenditure is financed partly by rates, partly by central government through the rate support grant and partly by charges levied such as for collection and disposal of commercial and industrial waste. Although the central government does not control budget directly, it can use the rate support grant to influence and sanction local government expenditures as a whole, if recommended spending levels are exceeded. Waste disposal and separate waste paper collection services therefore have to compete with other services for its share of the budget.

Local authorities borrow to finance capital expenditure and in anticipation of revenue to smooth their cash flow, which is limited by statute to the amount of outstanding revenue receivable. Local authorities can borrow only for purposes which have been authorised by Acts of Parliament and within the limits of loan sanctions issued by the central government. Under the Local Government Act 1972, local authorities are allowed to borrow by means of temporary loans, bank over-drafts, foreign currency, capital and revenue bills, mortgages, stock issues, bonds and through the Public Works Loan Board(PWLB). Almost all borrowing to finance capital expenditure are borrowed through the PWLB. Local authorities borrow from the PWLB at an interest rate fixed for the length of the loan, and the repayment of the sum may be made in half-yearly instalments or in full on maturity. If a local authority borrows above a certain annual quota it is charged a higher interest rate. (Appendix III shows some of the interest rates)

Instead of borrowing money for each project directly from the PWLB many local authorities operate a central loans pool which borrows money each year to the maximum allowed and from which each service borrows the capital it requires. The loans pool in turn may borrow from the PWLB or in the open market. The loans pool will therefore help to average out fluctuations in interest rates. The average rate charged to the borrowing service is calculated annually so as to protect individual projects which might otherwise borrow from the PWLB when rates are high and continue to pay that rate even when current rates are much lower.

5.5 Preamble to case studies

Case studies have been used to compile some costing data for the local authority waste paper recovery operations. In an ideal situation case studies should be made for local authorities of similiar size, using similiar types of vehicles to collect waste paper, baling them with similiar balers and keeping the accounts in similiar ways. While such local authorities are difficult to identify and even if they can be identified, it does not necessarily means that the information needed is available. Therefore in the case studies, a sample of local authorities who were known to be keen on waste paper salvage and who were operating a waste paper recovery operation was approached. Even then, only a few were willing to divulge their waste paper data and accounts. Some were unable to assist because they did not have the information while some were unable to spare the manpower to extract the information.

Each local authority was given a questionnaire (Appendix V) and a costing format to complete and follow up visits were made to those local authorities who returned the completed questionnaire and costing formats. The costing format used has been modified from the cost and feasibility statement of Table 5.1, based on changes discussed earlier in paragraph 5.3. As very few local authorities kept any cost information of such nature, very few case studies were available. From a total of 13 Scottish local authorities approached, only 5 could provide some cost information. From a total of 16 English local authorities approached, only 7 could provide some cost information. The few local authorities in Wales who were salvaging waste paper have stopped their operation since 1976, and so no case study from Wales was available. Although only 12 case studies were available these are 12 more than anyone else has collected on the costing of local authority waste paper recovery operation in UK, they are unique in this sense.

Although a number of local authorities were prepared to talk about their waste paper recovery operations, they tended to give the general public relation type of statements and hesitated to go into specific details of the operation. A problem with case studies of such nature is that usually it is one of the more senior officers and not the officer who actually supervises the recovery operation, that answers the interview. In the course of the interviews, one cannot help but felt that such senior officers did not know as much about the entire waste paper operation. Very often when details were asked for, information has to be called up from their sub-ordinate officers. Once the discussion turned to the cost figures, many local authorities shied away from the topic and some were not prepared to discuss it at all, claiming that this was confidential accounting information and they were at no liberty to divulge them to the public. Those local authorities who provided the cost data in the case studies gave what they believed were the correct accounts.

In the following case studies, each of the local authority is represented by a code, instead of referring to them by their actual names so as not to reveal the actual local authority involved. Scottish district councils have the letter S preceding their code while English waste collection authorities have the letter E preceding their code.

Following the synopsis of the case studies, the findings of the case studies are discussed. The operating cost and revenue per tonne of waste paper salvaged, as perceived by each local authority is summarised in Table 5.2. The details of the raw data provided by each local authority is at Appendix IV. Table 5.2 is then modified to include all relevant indirect cost and savings (Table 5.4) so as to provide the true costs of the recovery operations.

5.6 Case studies

5.6.1 Case SA

Area of responsibility	:	18,447 hectares
Population density	:	11.3 per hectare
Collection covers	:	50,000 domestic premises and 4,500 commercial premises
Average collection	:	1.14 kg per premise per week

Collection :

Waste paper recovery is a permanent operation. Collection is made from domestic premises in part of the city and from commercial premises over the whole of the city.

The council provides a twice weekly curb-side refuse collection service, Monday and Thursday or Tuesday and Friday utilising all vehicles and labour available and the vehicle and men are deployed on Wednesday to collect waste paper.

Baling :

The Council has two refuse disposal works but only one has waste paper and tin reclamation facilities. The collected waste paper and the waste paper sent to the disposal works from warehouses and commercial companies are baled by a small baler installed in 1974, with a throughput of 15 tonnes per day of 8 hours operation. All the baled waste paper are sent to a nearby board mill which has a long-term 5 year contract with the local authority to purchase its baled waste papers. Since the mill is near the city, the Council sends the baled paper to the mill and the local authority is reimbursed for the transportation. In 1979/80 the tonnage baled was 441 tonnes of fibre-board and 2,800 tonnes of mixed waste totalling 3,241 tonnes.

Possibility of increasing collection :

The Council claimed that all that was possible to be collected from the commercial premises was being done, but should additional quantities of waste paper be needed, another 100 tonnes or so could be collected from another 2,000 domestic premises. This extra amount was not collected in 1979/80 because of shortage of collection vehicles and because these premises were high - rise flats which made collection difficult. Above all, the demand of the mill was not high enough to justify the extra collection.

View of operation :

This Council, in the 1974/75 Scottish Development Department survey on waste paper salvage, claimed that because of its unique employment of manpower and vehicles, waste paper collection was regarded as 'very profitable'. But in 1979/80 the Council described its salvage operation only as 'marginally profitable'.

The Council felt that for operation purposes the collection, extraction and processing of waste paper from refuse were incidental to refuse disposal and a separate account was not kept for the waste paper salvage operation. Since the Council did not provide the costing information required, the details of the direct costs and revenue have been computed from the general operating costs and other information provided by the Council. Comparing the direct cost with revenue, the Council could make £7.80 per tonne of waste paper recovered. (Appendix IV, Table AIV. 1b)

Other features :

The Council claimed that it was unique amongst the larger cities in that the same labour was used for both refuse collection and street sweeping. These men spent approximately 65 percent of the time on refuse collection and 35 percent of the time on street sweeping. If waste paper was not collected separately the two vehicles and six men currently used in refuse collection would be idle and would have to be deployed elsewhere. But the fact that this Council could collect all the refuse in four days with one day free means that there was a

20 percent excess capacity in terms of vehicles and men. If waste paper collection was not done, the Council could, in the long term, reduce the number of vehicles and men and make some savings. Bonus was not paid in relation to waste paper collection only, but on all duties done. Any reduction in manpower would reduce the overall operating cost of the department.

An interesting feature of this case study was that about 14 percent of the total tonnage baled need not be collected. They were instead sent directly to the baling depot by the warehouses and commercial companies in the city. Except for the baling cost, the collection cost for this portion of the waste paper was therefore zero.

5.6.2 Case SB

Area of responsibility	:	26,064 hectares
Population density	:	17.6 per hectare
Collection covers	:	15,000 commercial premises in the whole city. 55,000 domestic premises (35% in the city)
Average collection	:	1.79 kg per premise per week
Collection	:	

Collection is done on a permanent basis by a team of ten vehicles five days a week in different parts of the city. Each vehicle is manned by one driver and two collectors.

Waste paper is collected in sacks provided by the Council. Previously, paper sacks were used and they were baled together with the waste paper without first having to empty the waste paper out of the sacks. But cost of paper sacks was high, about £70 to £80 per thousand sacks, so that each collection would involve an extra 7p or 8p per trip. Hessian sacks are now provided at a cost of 25p per sack but each sack easily allows re-use over 10 trips so that each trip of collection requires only 2.5p of sack cost. Recently an experiment was carried out using polypropylene sack, each costing 19p allowing at least 10 trips, cutting sack cost down to only 1.9p. Unless waste papers are put out at the curb-side in the special sacks provided for the purpose they will not be collected by the waste paper collection team. Domestic waste paper is not collected from tenement properties and local authority housing since the amount of waste paper that can be collected is too little to justify a separate collection team. The small amount of waste paper from these properties is due to two main reasons. Tenement properties and local authority housing have little storage space for waste papers and certain premises have chute waste disposal system which makes it easier for householders to dispose waste paper together with refuse.

Baling :

Waste paper collected is sent to a waste treatment and materials reclamation complex officially opened for operation in 1980. The plant has refuse shredding and baling facilities with a treatment capacity of 44 tonnes per hour. Because of excess capacity, the refuse baler is also used to bale the 20 to 25 tonnes of waste paper collected each day. Since the tonnage can be put through the baler very fast, baling cost is therefore marginal if not negligible. It is currently not possible to estimate this marginal cost for baling, as the waste treatment plant is still legally owned by the contractors since the Council has not taken over the ownership of the plant. Accounts are therefore not available from the Council. Currently the baling cost is absorbed under refuse baling cost as the Council augues that waste paper is basically a component of refuse which has been collected in a separate run. Before this new waste treatment plant started operation, baling was done on an old baler which required a staff of 8 to do sorting and baling. Baling cost was about £45,000 per year. With the waste paper now baled at the materials reclamation complex, this £45,000 baling expense is saved. Since sorting is an expensive and labour intensive process, the waste paper is not sorted at the waste treatment plant. Instead they are all baled together as mixed waste paper. Another reason for not separating container waste from mixed waste is because the low price of waste papers at that period did not make it worthwhile. In 1980/81 the Council recovered around 6,500 tonnes of waste paper which is the datum tonnage specified in the buying mills' contract.

Possibility of increasing collection :

When the market requires additional waste papers, at least another 900 tonnes per year could be collected from another 5,000 domestic and 5,000 commercial premises. Expansion plans to collect this amount was suspended in 1980/81 because the mill with which it maintains a contract, was only taking the datum tonnage from the Council besides reducing the waste paper price.

View of operation : The Council viewed its waste paper collection not just as another alternative for waste disposal but also as another service to the city and to industry.

Currently waste paper is being collected by old vehicles which have been in operation for seven years. They have extended the operating life of the vehicle to ten years instead. Had new vehicles been used there would have been a loan charge of around £25,000 per annum added to the collection cost. The extra £25,000 would have cost the Council another £3.85 to recover a tonne of waste paper. The Council therefore described its waste paper operation as 'slightly unprofitable', when in fact it was breaking even in the operation. (Appendix IV, Table AIV.2)

Other features : The Council is so keen on waste paper recovery that it is the only place in Scotland where anyone with 1 or 2 tonnes of waste paper could ring up for a collection vehicle to get the waste paper taken away.

5.6.3 Case SC

Area of responsibility	:	37,342 hectares
Population density	:	2.2 per hectare
Collection covers	:	300 commercial premises (about 90%)
Average collection	:	33.3 kg per premise per week

Collection :

A permanent waste paper recovery scheme collecting only from the commercial premises is operated by separate vehicles and crew. Sacks are issued to the commercial premises. Annual collection of fibre-board containers in 1980/81 was about 520 tonnes.

Baling :

Baling is done in a baler which was installed in November 1979 at a cost of £20,695. The throughput of the baler could go up to 50 tonnes per week but only 15 tonnes per week are baled.

Possibility of increasing collection :

The Council projected a figure of 1,250 extra tonnes which could be collected from domestic premises and another 50 tonnes from the commercial premises if there is sufficient market demand for it. Even with this extra tonnage the total amount of waste paper that needs to be baled will come to 2,080 tonnes per annum which will require only a capacity of 40 tonnes per week, well within baling capacity.

View of operation :

The Council described its operation as 'marginally profitable'. Its accounts showed that it was making a profit of 4 pence per tonne of waste paper salvaged. (Appendix IV, Table AIV.3) Had the waste paper not been salvaged, it would have to be disposed with the other refuse by landfill at a cost, estimated by the Council, to be £10.94 per tonne. The high disposal cost was attributed to the far-off landfill site, which required hauling via a transfer station. The Council felt that waste paper recovery would help to solve the waste disposal problem even if no profit was made in the operation.

Other features :

If not for the special features of the District, collection of waste paper in a locality so sparsely populated would definitely have been costly and unprofitable. Although this Council collects from only a small number of premises, the amount of fibre-board containers collected is very high (67 percent). The main reason for this is the location of a big printing plant and a whisky plant in the area which together generate easily 30 kg per week. Because of the high percentage of container waste the mill is buying more than the datum tonnage of 500 tonnes specified on the contract.

The Council felt that it was not financially viable to collect waste papers from domestic premises because of their spread around the district. There were about 30 voluntary organisations, made up of Scout groups, Boys Brigade and school teams collecting waste papers on a continuing basis from the domestic premises. These organisations recovered about 260 tonnes of waste paper in 1980/81 and the collection was sold to the District Council. The voluntary organisations brought the waste paper to the Council's Cleansing Depot where it was weighed and a receipt issued to them. At the end of the month the Council sent a cheque for the amount of waste paper bought, to the voluntary organisations, paying out £15 (1980/81 price) for each tonne of waste paper received. The Council had to pay £15 per tonne out of the £22 per tonne received for the mixed waste paper so that the 260 tonnes of mixed waste paper received a net £7 per tonne only, giving a total income of £1,820. Baling cost per tonne of waste paper was given by the Council as about £15.38, so the Council made a loss of £8.38 for every tonne of waste paper bought from the voluntary organisations.

5.6.4 Case SD

Area of responsibility	:	216,989 hectares
Population density	:	0.4 per hectare
Collection covers	:	16,000 domestic premises 1,200 commercial premises
Average collection	:	1.06 kg per premise per week
Collection	:	

Collection is done on a permanent basis by a separate vehicle with a crew of one driver and two loaders. The team collects waste paper five days a week throughout the various parts of the district. Average collection in 1980/81 was 250 tonnes of container waste and 700 tonnes of mixed waste.

Sacks for waste paper collection are issued specially to commercial premises only, while domestic premises are requested to tie their waste papers into bundles. A short pilot scheme was introduced in September 1980 for about three months, during which red plastic bags were issued to households for separating waste paper. The scheme was dropped later as there was no appreciable increase in domestic waste paper collected and many of the households seemed to be losing their red bags. Hessian sacks are now issued to households for separating waste papers.

Baling :

An entirely new baler capable of baling 40 to 50 tonnes of waste paper per week was installed in July 1979 at a capital cost of £27,000. But present throughput of the baler is only 3 tonnes per day although the baling capacity could go up to 3 tonnes per hour. Baling is done by one chargehand assisted by one loader, both of whom are employed as full-time workers for the baling operation.

Possibility of increasing collection :

The Council claimed that if there was sufficient demand from the mill they could increase the tonnage collected by another 200 tonnes. The extra tonnage was not collected because of lack of vehicles, and the low price of the waste paper did not justify deploying another collection team.

View of operation :

The Council described its own salvage operation as 'marginally unprofitable'. Unfortunately, no separate costing had been kept for the waste paper salvage operation until 1981/82 when the Council planned to have a separate account for the waste paper salvage operation. It was therefore difficult to check on the validity of the Council's view of its own operation. However, the budget figures for 1981/82 showed a loss of £3.46 per tonne in the waste paper recovery operation. (Appendix IV, Table AIV.4)

Comparing this cost with those for collecting the waste paper as refuse (estimated by the Council as £17/tonne) and then disposing it by landfill (estimated by the Council as £5/tonne), the Council claimed that their waste paper salvage operation was still cheaper by about £18.54 per tonne. As far as the Council was concerned, their waste paper salvage operation was to provide a service to the community rather than to make money and hence there was no constraint placed on the waste paper salvage operation to be viable.

Other features :

There were some voluntary organisations, such as Boys Brigade, Scouts and Community Councils collecting waste paper. Their waste papers were sold to the Council at around £17 per tonne, delivered to the baling shed at the Cleansing Depot. The Council's budget estimated the mixed waste price at £29.25 per tonne, and with baling cost at £11.28 per tonne the Council could make 97p per tonne from the waste paper bought from voluntary organisations.

5.6.5 Case SE

Area of responsibility : 171,275 hectares

Population density : 0.2 per hectare

Collection covers : 2,000 commercial premises

Average collection : 1.39 kg per premise per week

Collection :

Separate collection of waste paper was concentrated on the commercial premises within the town area. Annual collection was not high. Collection in 1980/81 consisted of about 82 tonnes of fibre-board containers and 63 tonnes of mixed waste papers, which totalled 145 tonnes.

Baling :

At local government re-organisation in May 1975, waste paper was being salvaged by two of the former authorities which were combined into this District and waste paper baling has been continued in the two areas, each using a small 3 horse-power Dawson Mason baling press.

Possibility of increasing collection :

They regarded their waste paper salvage in itself as 'never commercially viable' and any expansion of separate waste paper collection service to the sparsely populated area and the widely spread domestic premises was considered totally impractical because of the high collection cost.

View of operation :

The Council viewed its operation as only 'marginally unprofitable' even though their accounts showed an average loss of £76.49 per tonne to salvage waste paper. (Appendix IV, Table AIV.5)

Other features :

In addition to the collecting cost and baling cost, this Council has to incur an extra cost paid to the workmen to load the baled waste paper on to the lorry for transportation to the mill. This extra cost was unique among all the case studies because the workmen's duties have been so clearly defined in their Union contract that loading waste paper was not regarded as part of their duties and the little extra work required additional part-time labour. Although waste paper salvage was not viable, the service was conducted for two main reasons,

a) the long distance of the refuse tips from the centres of population and the high cost and additional difficulty involved in transporting waste paper to the tips for disposal;

b) the flexibility of labour that salvage baling provided; the two baling operatives were also responsible for other duties within the cleansing department, example, refuse tip maintenance and public convenience attendant.

In 1981 waste paper prices dropped to such a low level, that the loss incurred by the Council was so high that they were forced to suspend the waste paper recovery operation. With baling in abeyance the waste paper was collected by means of a conventional refuse collection vehicle and dumped at the refuse tip.

5.6.6 Case EA

Area of responsibility	:	6,580 hectares
Population density	:	14.8 per hectare
Collection covers	:	37,945 domestic premises and 6,044 commercial premises
Average collection	:	0.98 kg per premise per week
Collection	:	

Waste paper collection from domestic premises has been operating since 1939. Trailers attached to the collection vehicles were used in the early days. With the introduction of larger collection vehicles and larger trailers, the use of trailers became more difficult and was finally abandoned.

Collection of waste papers using a separate vehicle and crew started in June 1977. At that time, waste paper was collected from about 20,000 premises in the southern half of the Borough. Collections were made fortnightly on a regular day. Householders were requested by letters to bundle or box their salvage paper and cardboard and to place it at the front of their premises where it could be easily seen from the roadway. Initial response was high, average contribution was about 2.0 kg per premise per week. But within twelve weeks the contribution dropped to around 1.15 kg per premise per week.

Several problems were encountered when separate waste paper collection runs were introduced. Certain drivers completed the rounds too quickly and made no allowance for people putting their waste paper out late in the day. Some households waited for the vehicle to pass through a road before putting their paper out. Others put the papers at places not seen by the collectors while yet others put out papers each week or on the wrong day.

With the help of the mill who bought the waste paper, new leaflets were then printed, giving the exact dates on which collection would be made for the next four months. Householders were requested to put out the papers for collection at 7.30 am whatever the weather. Response increased from 16.9 percent to 34.1 percent per week. Collection level of up to 1.73 kg per premise per week were obtained. Continuous publicity was maintained and re-publicity took place at three to four months intervals. Advertising materials were fixed to the collecting vehicles to help generate public awareness of the local authority's effort to recover and sell waste paper. By January 1978 collection was extended to cover the entire area.

Baling :

A new baling press, conveyor and clamp lift truck were purchased at a cost of £32,100 (1978 prices) for the baling plant. The system was capable of handling at least 60 tonnes of waste paper per week. A fire in 1979 caused baling operation to be suspended till July 1980. During that period, for the sake of continuity and the future of the operation of waste paper, collection service was maintained but the waste paper was sold to the mill unbaled. By July 1980 the baling shed was re-equipped and full operation started again. Unfortunately, the board mills were facing a recession and quotas were introduced on the amount bought from the local authority from September 1980 to April 1981. Just at the time when the Council needed to sell more waste paper to generate sufficient revenue to pay for the loan charges of the new equipment prices of waste paper dropped in 1981. While they could recover more waste paper, they were unable to sell the entire recovered tonnages. The tonnage baled during this period was only 1,030 tonnes, averaging around 0.98 kg per premise per week, about 57 percent of what was collected in autumn 1977.

Possibility of increasing collection :

The Council felt that when the demand and price for waste paper increase again, with renewed publicity they could increase their collection level by another 700 tonnes, to reach the 1977 level of collection.

View of operation :

The Council felt that if the paper was collected as refuse it would bear the cost of that service, estimated by them to be £20.85 per tonne, and the disposal cost, estimated by them to be £2.50 per tonne by tipping. Therefore to collect and tip 1,030 tonnes of waste paper as refuse would cost £23.35 x 1,030 = £24,050.50 against a loss of approximately £10,650.00 on the salvage scheme, at a time when conditions could hardly be worse. (Appendix IV, Table AIV.6)

Other features :

This English Council did not receive any contribution from its Waste Disposal Authority for the reduction in waste that needed disposal.

5.6.7 Case EB

Area of responsibility	:	5,427 hectares
Population density	:	28.2 per hectare
Collection covers	:	100 out of the 5,934 commercial premises and 26,000 out of the 52,543 domestic premises
Average collection	:	0.96 kg per premise per week
Collection	:	

The Council has been operating a separate waste paper collection scheme since August 1977, but decided to suspended this operation with effect from February 1982 due to heavy loss incurred in the operation. Trade collection covered about 1.7 percent of all the commercial premises and domestic collection covered only 50 percent of all the premises.

The total collection of 1,300 tonnes in 1979/80 was 87 percent of the datum tonnage of 1,500 tonnes. The breakdown of the waste paper collected, according to grades was :-

	Tonnes	Percent
Newspapers	400	31
Fibre-board containers	200	15
Mixed waste	700	54
Total	1,300	100

This Council issued orange mesh bags for waste paper collection and the bags were collected fortnightly. The Council claimed that the sacks would allow about 60 percent increase in waste paper collected. This Council was in fact the only one to have made such a claim, whereas all the other case studies indicated either that sacks did not increase the amount of waste paper collected or that the increase could not be determined.

Workers on waste paper collection were paid a bonus of 33.3 percent on basic wages, provided all properties were visited during the collection rounds. This was one of the reasons for the much higher cost of collection involved in this local authority compared to the other case studies.

Baling :

Baling was done by an old baler installed in 1975, with a throughput capacity of 2 tonnes per hour and the baler was expected to be replaced in 1982 had baling been continued. The baled waste paper was sold to a mill in England, with which it has a long-term 5 year contract. The contract guaranteed a minimum price of £22 per tonne for all waste papers.

Possibility of increasing collection :

In the event of an increase in demand in waste paper, the Council could increase their domestic collection by another 600 tonnes per annum, and commercial collection by another 200 tonnes per annum, to give an annual output of 2,100 tonnes per annum. This means that the annual output could be increased by about 70 percent.

View of operation :

The Council estimated an annual gross expenditure of £91,470 for the collection of 1,300 tonnes of waste paper. Income received was only £35,879 equivalent to £27.00 per tonne. There was a loss in the operation of £33,591 equivalent to £25.84 per tonne. (Appendix IV, Table AIV.7) This loss was described by the Council as 'very unprofitable and hence the suspension'.

Other features :

Besides the local authority, some Scout groups and charity organisations were also collecting waste paper on a continuing basis, and they sold their waste papers to local merchants.

The Council did not receive from its Waste Disposal Authority any contributions which reflected the smaller amount of waste sent for disposal.

5.6.8 Case EC

Area of responsibility	:	27,100 hectares
Population density	:	4.3 per hectare
Collection covers	:	43,000 domestic premises
		4,000 commercial premises
Average collection	:	0.88 kg per premise per week
Collection	:	

Waste paper recovery is operated on a permanent basis. Unlike all the other case studies this Council still uses trailers for waste paper collection from domestic premises and a combination of both trailers and separate vehicles from trade premises. Collection is done once a week from the whole of the area. But participation ratio is only 78 percent for the domestic premises and 47 percent for the commercial premises.

Since trailers are used, the collection crew is paid a bonus based on individual crew effort. Each trailer is weighted and the bonus is paid on a gradual scale of £75, £76, £77 and £78 per tonne, to be shared between members of the crew. This is one reason why such a high percentage of domestic premises is covered in the collection rounds. The Council regards the direct labour cost associated with waste paper recovery to be only the bonus paid, as the actual wage of the crew is paid under refuse collection.

In 1980/81 total tonnage of waste paper collected was 2,146 tonnes of which 463 tonnes (21.6 percent) was container waste and the rest consisted of 171 tonnes of newspapers and 1,512 tonnes of mixed waste papers. The total tonnage supplied to the mill was just 86 percent of what the mill was prepared to buy.

Baling :

Baling is done by two small balers, one with a throughput of 3 tonnes per day, installed in 1968 and another installed in 1973 with a throughput of 2 tonnes per day. The baled waste paper is sold to a mill with which a long term contract is maintained and this contract guaranteed a minimum price of £22.00 per tonne with a datum tonnage of 2,500 tonnes,

Possibility of increasing collection :

Since the Council's operation is already covering the entire area, the only possibility of increasing collection is to step up the publicity to encourage more participation from the public. No estimates as to how much more could be collected was available.

View of operation :

The Council regarded its own operation as 'marginally profitable' till 1980, when the installation of a new baling shed coupled with a downturn in waste paper price caused the Council to start losing money in its operation.

The Council's estimate gave a loss of £13.80 in recovering a tonne of waste paper. (Appendix IV, Table AIV.8) None of the indirect costs and savings were available from the Council's accounts. The Council felt that no saving was available to refuse collection cost as a result of recovering waste paper separately since their refuse vehicles have sufficient capacity to collect all the refuse including waste paper had it not been separately collected for recycling. This implied that the Council has actually over-invested in its collection vehicles, which in the long run could be trimmed down to a smaller capacity to meet collection requirements.

Other features :

Besides the Council's own waste paper recovery operation nine other voluntary and charitable organisations also collected waste paper intermittently and they sold the collected waste paper direct to the Council.

5.6.9 Case ED

Area of responsibility	:	11,622 hectares
Population density	:	40.8 per hectare
Collection covers	:	30.371 commercial premises
Average collection	:	1.97 kg per premise per week
Collection	:	

Waste paper collection from all the commercial premises in the city is by both trailers and separate vehicles on a permanent basis. All commercial premises in the city are offered a free waste paper collection service, provided the waste paper has been separated into bags specially provided for this purpose. In 1979/80 the City Council collected charges worth £320,315 imposed on the collection of commercial waste amounting to 25,000 tonnes. If the commercial premises do not separate out their waste paper for recovery collections, but discard their waste paper together with the other trade waste then they will have to pay on the average, £12.82 for every tonne of trade waste and waste paper carted away by the Council. Free collection of waste paper is therefore an incentive to the traders to separate out the waste paper.

Although the local authority issues sacks and plastic bags for waste paper collection, they are not able to commend if any increase in waste paper collection has been achieved.

Baling :

Recovered waste paper is baled in the Council's own baler, which has been installed in September 1978 and will be used until it is no longer viable, as the Council puts it, although the term 'viable' here is not clearly defined.

In 1980/81 the breakdown of the total collection baled was as follows :

	Tonnes	Percent
Newspapers	17	1
Fibre-board containers	515	16
Mixed waste papers	2,583	83
Total	3,115	100

Baled waste paper is sold to a mill with which the Council has a 5 year long term contract, which guarantees a minimum price of £22 per tonne, and specified a datum tonnage of 4,000 tonnes of waste paper. The Council has been supplying only 78 percent of the datum tonnage.

Possibility of increasing collection :

Waste paper is already being collected from all the commercial premises. The only possibility of increasing the tonnage is to encourage more households to salvage waste paper, and to step up the activities of the schools who are currently collecting from the domestic sources.

View of operation :

All collection and transport costs are absorbed under refuse collection, since they regard waste paper as refuse which needs to be collected anyway, and the cost of recovering waste paper is attributed to only the cost of baling. No allowance has been made for any savings in the refuse disposal costs and loss in trade collection income as a result of separate collection for waste paper. The Council estimated a loss of £33.78 per tonne of waste paper recovered. (Appendix IV, Table AIV.9) The Council therefore regard their waste paper operation as 'very unprofitable'. However, they claimed, if waste paper was not recovered but collected together with the other refuse it would cost more since there was no income from the sale of waste paper to subsidise the operating cost of collection and disposal.

Other features :

Workers in waste paper salvage are paid a bonus based on what is called the 'weekly standard minutes', which has been established through work study for each of the collection routes. Bonus payments are made based on the performance of each crew against the standard minutes of work.

The Council does not collect waste paper from any of the 171,381 domestic premises as earlier pilot schemes carried out for collection of waste paper from domestic premises have always proved uneconomical. However, they go round the problem of collecting waste paper from domestic premises by encouraging educational institutions to collect waste paper. Pupils are encouraged to bring in their waste paper to the schools. The waste papers are then stored until a certain amount can be delivered to the Council's Cleansing Department waste paper plant for baling. For each tonne of paper sent to the plant the school receives for its school fund a certain price (based on the prevailing market price of waste paper) from the local authority.

This Council did not receive from its Waste Disposal Authority any contributions which reflected the smaller amount of refuse that needed disposal.

5.6.10 Case EE

Area of responsibility	:	9,274 hectares
Population density	:	28.3 per hectare
Collection covers	:	14,000 domestic premises
		750 commercial premises
Average collection	:	2.35 kg per premises per week
Collection	:	

A permanent waste paper recovery scheme is in operation collecting waste paper in only parts of the area from both the domestic and the commercial premises. Domestic collection covers 14.6 percent of the domestic premises and only 6 percent of the commercial premises. Collection is presently done by separate vehicles and crew. The 1980/81 collection of 1,805 tonnes consisted of 540 tonnes of fibre-board containers and 1,265 tonnes of mixed waste. This case has one of the highest recovery rates among all the case studies. One reason for the good recovery rate is the selection of area for collection. Collection is made only from areas where there is a consistently high output. Another reason for the high output could be the bonus scheme which the Council pays the waste paper collection crew, based on the miles travelled and the weight of waste paper recovered.

Baling :

A baler is operated by the Council to bale the recovered waste papers. It is a rather old baler installed in 1975 and is expected to be written off in 1985. This baler has a throughput of 40 tonnes per week, more than enough capacity to handle the 35 tonnes of waste paper collected each week. Baled waste paper is sold to a mill with which the Council has a 5 year contract which guaranteed a minimum price of £22 per tonne and a datum tonnage of 2,600 tonnes. Collected tonnage was therefore only 69 percent of what the mill was prepared to buy. The datum tonnage therefore allows the Council to increase its output by another 31 percent.

Possibility of increasing collection :

Should there be a demand for more waste paper, the Council felt that another 40 tonnes or so can be collected from more domestic premises. This is a very small increase over the annual collection of around 1,800 tonnes, since the extra tonnages would be collected by the refuse collection teams using racks fitted to the refuse collection vehicles.

View of operation :

The Council's accounts showed that the waste paper recovery operation costed an average of £48.99 to recover a tonne of waste paper. (Appendix IV, Table AIV.10) The Council therefore regarded the operation as 'very unprofitable'. An overhead based on about 5 percent of the wages of the direct labour cost has been included under the labour cost of collection.

Other features :

No contribution to reflect waste disposal savings has been made by the Waste Disposal Authority.

The Council has so far retained their waste paper recovery service because of its concern about the redundancies which would be created if the waste paper collection was abandoned. They are currently conducting experiments to see if collection cost could be reduced by using a cheaper method of collection such as using the refuse collection teams instead of a separate waste paper collection team.

5.6.11 Case EF

Area of responsibility	:	17,615 hectares
Population density	:	9.5 per hectare
Collection covers	:	6,750 commercial premises
Average collection	:	0.54 kg per premise per week
Collection	:	

The Council has a long history of waste paper collection having started operation since 1936. Collection had been done by trailers until 1975, when the Council scrapped the trailer system and introduced separate collection vehicles. Till 1977 collection had been made from commercial premises only.

In late 1977 and early 1978 a scheme for a separate fortnightly collection of waste papers from part of the 58,560 domestic premises was introduced. This pilot scheme was for a period of 12 months. Response from the public was good and some 694 tonnes were recovered by the end of the 12 month period. In August 1979 the Council thought that they could make the waste paper collection viable by increasing tonnage through a second round of collection and using an incentive bonus based on tonnage recovered. With this re-organisation the Council also introduced a new separate system for the direct accounting of the waste paper operation. It is interesting to note at this point, that although the Waste Management Advisory Council recommended the use of a separate standard costing system for all local authorities in 1976 no action along this lines was taken by this Council until 1980. With effect from April 1980 the Council attributed all costs to waste paper recovery operation and baling under a separate account. The Council was trying to get a careful financial monitoring of the operation. The operation was found to be losing so much money that the Council has no choice but to cease waste paper recovery operation in April 1981.

Baling :

Waste paper recovered has been baled in the Council's own baler (Details of capacity and throughput were not available). Baled waste paper was sold to a mill under contract.

Possibility of increasing collection :

If the demand increased together with a higher price for waste paper, and the price of waste paper stayed high, the Council may be encouraged to resume waste paper collection from the commercial premises again.

View of operation :

The first half-yearly account from 1st April 1980 to 30th September 1980 showed a loss of £23,794 against an estimated loss of £8,730, 1.7 times in excess.(Appendix IV, Table AIV.11b) The Council estimated that the total loss by the end of the 1980/81 financial year would amount to £51,346. This means that the Council was losing about £1,000 per week on the waste paper recovery operation. The Council's subsequent investigation into the reasons for its loss revealed that,

a) the recovered tonnage was not as high as that estimated,
b) estimated income was based on the 1979 prices which dropped rather sharply in 1980 as a result of the recession, and
c) both fuel prices and labour costs have increased faster than waste paper prices thus adding to higher operating costs.

Although the Council tried to streamline and reduce manning levels to cut down the loss, an estimate of £20,000 loss in the operation each year was still projected.

Other features :

The Council's accounting system did not bring in all the indirect cost and savings related to the operation and has only consider the direct cost and revenue. (Appendix IV, Table AIV.11a)

5.6.12 Case EG

Area of responsibility : 51,215 hectares

Population density : 14.3 per hectare

Collection covers : Not applicable

Average collection : Not applicable

Collection :

The Council does not operate a separate waste paper collection as such. Instead, it assists a voluntary organisation under the name 'Save Waste and Prosper' (SWAP), whose basic aim is to encourage members of the public to separate waste paper, foil, textiles, cans, bottles and jars from their refuse and deliver these materials to skips located at various collecting points in the neighbourhood. Waste paper, foils and textiles may be sent on the first Saturday of each month to any of the 41 collection points strategically located throughout the city. No direct labour from the Council is involved, except some administrative assistance, since the charity organisations benefitting from the scheme are required to provide volunteers or manpower to man the collection points.

Baling :

No baling is done by the Council for the recovered materials. The waste paper is collected by the waste paper merchants on the same day to eliminate storage problems. The merchants provide the skip and the transport to move the waste paper.

Possibility of increasing collection :

Current participation from the residents is between 50,000 to 100,000 depending on the charity organisation and its followings. Based on previous experience, with increased publicity, the tonnage could be increased by about 15 percent.

View of operation :

As far as the Council is concerned, the SWAP programme is on-going. Even in the recession of

1980/81 with the slack in the secondary material markets, there was still a substantial amount of materials recovered and adequate contributions made to the local charities. In fact waste paper tonnage was highest in 1980/81 since 1978/79. There was an increase of 138.41 tonnes or 15.8 percent over collection in 1979/80. (Appendix IV, Table AIV. 12a) Although the total tonnage was higher in 1980/81 then 1979/80, yet net income obtained was lower because of the lower prices obtained in 1980/81 for the salvaged materials. (Appendix IV, Table AIV.12b)

Currently SWAP is recovering an average of 208 tonnes of secondary materials per month, nearly 2,500 tonnes per annum, which is about 1.5 percent of the city's total domestic refuse. Although this is a small figure, yet the operation is able to give a savings of £6.14 per tonne of salvaged material to the Council. (Appendix IV, Table AIV.12c and Table AIV.12d)

Other features :

A major difficulty involved in operating such a scheme is the removal of an average of 80 tonnes of waste paper which is dependent on voluntary effort and the weather. There is a need for close liaison with the merchants and their drivers and over the last few years of operation most of the co-ordinating work have been smoothed out. Collection on days when there are gale force winds and heavy rain has always been difficult.

The public have been known to bring along their empty bottles in cardboard boxes and after putting the bottles into the bottle skips left the cardboard boxes around, not remembering that collection for paper and board was open only on the first Saturday of each month. The paper became litter, causing inconvenience and giving bad publicity to the scheme. This problem has been reduced by the provision of containers (0.95 m^3 capacity) near the bottle skips and arrangements are made with the local shopkeepers or supermarket management to supervise the site, in return for a reduction on trade refuse charges.

In this City, the trade premises lose out unless they could accumulate all their waste papers and container waste and move them once a month to the waste paper collection points, otherwise they have to pay about £17.36 per tonne to have it taken away by the Council as trade waste.

This scheme is a very interesting example of how a local authority with proper coordination of the public's response and contribution could salvage valuable secondary materials, assist local charities in raising funds for themselves, promote a good public image and yet does all these at minimum cost to themselves. This may well be the beginning of a new trend in waste paper and secondary materials recovery.

5.7 The local authorities' views of their cost of recovering waste paper

The operating cost to recover a tonne of waste paper varies and according to the local authorities, could vary from a profit of £7.80 per tonne to a loss of £76.49 per tonne (Table 5.2).

Except for case SC, because of the special location of a printing factory and a whisky factory in its vicinity which generates a huge amount of container waste, the collection per premise per week varies from 0.54 kg to 2.35 kg. The highest contribution per premise per week is therefore about 73 percent of the waste paper content in the domestic waste stream, but this is an exception rather than the rule. On the average, the rest of the case studies recovered only about 41 percent of the waste paper in the refuse, less than half of what is in the refuse stream.

Case SA, because of its re-deployment of street orderlies to waste paper collection could cut down its labour cost for waste paper salvage and was able to profit from its operation.

Case SB has a high collection cost considering that it is a big city with a dense population. This is because of the big team of vehicles and crew maintained just to collect waste paper separately and the collected tonnage was not really high. High collection costs in EB, EE and EF were due to high bonus scheme paid out to the workmen.

Baling cost varied from 0 to £62.04 per tonne. Case SE has a very peculiar situation where their baling shed worker, due to some clauses in their trade union agreement, refused to load the baled waste paper for transportation to the mills. The Council has therefore to engage extra labour and thus the extra cost for just doing the loading.

For those case studies with known datum tonnage, one Scottish local authority recovered sufficient waste paper to match the datum tonnage, while two Scottish local authorities recovered much more than their datum tonnage (Case SC by

Table 5.2 - Operating cost & revenue per tonne of waste paper salvage as per case study (1980/81)

Case	SA	SB	SC	SD	SE	EA	EB	EC	ED	EE	EF	EG
Population density/hectare	11.3	17.6	2.2	0.4	0.2	14.8	28.2	4.3	40.8	28.3	9.5	14.3
Average waste paper collected per premise/week (kg)	1.14	1.79	33.33	1.06	1.39	0.98	0.96	0.88	1.97	2.35	0.54	NA
Datum tonnage in contract	?	6,500	500	840	?	?	1,500	2,500	4,000	2,500	?	NA
Tonnage of waste paper salvaged pa (tonnes)	3,241	6,500	780	1,440	145	1,030	1,300	2,146	3,115	1,805	918 (6)	2,448 (5)
Collection cost:												
Labour	11.15*	34.46	12.82	12.61	-	12.17	46.13 (3)	11.43	-	30.50	40.52*	-
Supplies and services	1.04	3.00	0.13	-*	-	-	0.95	1.86	-	3.17	1.72	-
Transport	1.51	4.85	3.85	9.31	-	4.37	10.61	4.08	-	23.17	12.11	-
Others (1)	-	-	0.39	-	-	-	4.73	-	-	9.14	-	-
Collection total	13.70	42.31	17.19	21.92	53.46	16.54	62.42	13.29	0 (4)	65.98	54.35	4.08
Baling Cost												
Labour	-*	-	10.26	8.40	↑	8.36	- (3)	18.60	29.59	7.27	-*	-
Supplies and services	2.92	-	1.28	4.19*	48.90	1.26	1.30	2.13	2.64	0.05	1.12	-
Plant	3.57	-	1.92	-	↓	0.97	1.92	3.32	18.22	2.77	0.44	-
Others (2)	0.27	-	1.92	-	3.79#	10.39	4.72	4.66	11.59	3.72	1.33	-
Baling total	6.76	-	15.38	12.59	52.69	20.98	7.94	28.71	62.04	13.81	2.89	-
Gross expenditure	20.46	42.31	32.57	34.51	106.15	37.52	70.36	42.00	62.04	79.79	57.24	4.08
Revenue												
Sales of salvaged paper	28.26	27.69	21.67	31.05	29.66	27.18	27.60	27.20	28.26	30.80	31.32	-
Contribution to reflect disposal savings	-	13.85	10.94	-	-	-	-	1.00	-	-	-	2.82
Gross income	28.26	41.54	32.61	31.05	29.66	27.18	27.60	28.20	28.26	30.80	31.32	2.82
Loss of income from trade collection	-	9.23	-	-	-	-	3.08	-	-	-	-	17.36
Savings in refuse collection	-	10.00	-	-	-	-	20.00	-	-	-	-	24.76
Net expenditure	20.46	51.54	32.57	34.51	106.15	37.52	73.44	42.00	62.04	79.79	57.24	21.44
Net income (savings)	28.26	51.54	32.61	31.05	29.66	27.18	47.60	28.20	28.26	30.80	31.32	27.58
Profit/tonne	7.80	-	0.04	-	-	-	-	-	-	-	-	6.14
Loss/tonne	-	-	-	3.46	76.49	10.34	25.84	13.80	33.78	48.99	25.92	-

Notes :

(1) Include establishment expenses, depot charges, publicity and loan charges

(2) Include establishment expenses, depot charges, loan charges

(3) Included in collection cost

(4) Absorbed under refuse collection costs

(5) Inclusive of all recovered materials

* Inclusive

(6) Half year (1/4/80 to 30/9/80)

NA Not applicable

? Not available

Labour cost for loading of baled waste paper for deliver

Gross income=Sales of waste paper + contribution to reflect disposal savings

Net expenditure=Gross expenditure + Loss of income from trade collection

Net income=Gross income + Savings in refuse collection

56 percent, Case SD by 71 percent). While Case SC made a small profit from its high collection, Case SD was losing money. This was attributed to a peculiar factor in Case SD's baling plant, where there was always insufficient manpower to bale the recovered waste paper. The unbaled waste paper was not taken away by the mill and has to be dumped. So while much labour and money have gone in to recover the waste paper, there was insufficient of it being sold to generate revenue. In nearly all the English case studies the recovered tonnages were much smaller than the contract datum tonnage, which means that their waste paper operation could be improved to increase the supply.

Case EG was a special case by itself because of its special efforts to encourage public participation through the voluntary and charity organisations. Other than one officer from the City Council's Environmental Health Department who served as the Secretary to the recycling co-ordinating committee, and another officer in the same department who assisted with inquiries and provided information on SWAP's activities, the Council incurred no other expenses in the operation. But the intangible returns to the City Council were enormous such as, excellent public relations and goodwill and marginal savings in wear and tear in refuse collection vehicles and men. Savings to the Waste Disposal Authority in disposal costs are more tangible, if only in terms of tipping space saved.

The fact that only two of the local authorities could provide the entire set of costing information required indicated that most local authorities did not keep a separate account for their waste paper recovery operations. Most local authorities only kept figures of revenue obtained from sale of waste paper, and absorbed the operating costs into their refuse collection and disposal accounts.

5.8 True cost of the local authority waste paper recovery operations

The true cost of a waste paper recovery operation to a local authority is the relative cost of a separate waste paper collection operation. It is the difference between the costs of operating the waste paper recovery scheme and the cost of operating the normal domestic refuse collection and disposal operations. Expressed in an equation, this becomes :

$$TC = \Delta C + \Delta D + B - R$$

where TC = true cost of the recovery operation

ΔC = change in collection cost due to the separate waste paper collection scheme

ΔD = change in disposal cost as a result of less waste to dispose

B = baling cost of waste paper

R = revenue from sales of baled waste paper (income is regarded as negative cost)

Except for two case studies none of the others made any allowance for the loss of income from trade collection and the savings on refuse collection. Some local authorities claimed that the savings in refuse collection as a result of a separate waste paper salvage operation was negligible and some local authorities claimed there was no way to estimate such savings. WMAC(1976) claimed the volume of waste paper content in the refuse stream was 60 percent and argued therefore the salvage of waste paper would reduce significantly the number of households requiring a second refuse receptacle or a large refuse receptacle. But waste paper merchants and processors estimated the volume of waste paper in the refuse stream to be nearer 50 percent. Analysis of domestic refuse in Doncaster, which was very close to national average figures, set the average volume of waste paper in domestic refuse at 49 percent.

The recovery of waste paper could reduce the volume of domestic refuse by 13.0 to 25.8 percent (Table 5.3), and is therefore not negligible. However these figures refer only to energetic local authorities who collected alot of waste paper. Therefore for the average local authorities the reduction in volume of refuse as a result of separate waste paper collection may not be as high. Even at the reduction of volume at 13.0 percent, there was still a case to include an estimate of the

Table 5.3 - Examples of energetic local authority waste paper recovery scheme (in the first quarter of 1973)
Source : Holmes(1978)

Area	Population	Tonnes of refuse	Paper content at 32% by weight(tonnes)	Actual recovery (tonnes)	Percent of potential	Reduction in volume of refuse as a result of waste paper salvage	
						I	II
1	13,420	4428	1417	468	33	16.5	19.8
2	35,890	11843	3790	1560	41	20.5	24.6
3	40,860	13483	4315	1716	39	19.5	23.4
4	41,680	13754	4401	1300	30	15.0	18.0
5	64,280	21212	6788	1768	26	13.0	15.6
6	89,090	29399	9408	4056	43	21.5	25.8
7	163,380	53915	17253	7020	41	20.5	24.6
8	215,280	71042	22733	7488	33	16.5	19.8

I based on 50% volume of refuse is paper

II based on 60% volume of refuse is paper savings in refuse collection as a result of waste paper salvage.

In the short term, waste paper collection will not reduce significantly the collection cost involved in domestic refuse collection, neither will it reduce the waste disposal cost significantly or the income from trade collection charges significantly. Savings in the short term will be marginal. But in the long term a separate waste paper collection would reduce the total tonnage of domestic refuse that needed to be collected by the domestic refuse vehicles and crew. This reduction would allow the local authority to re-schedule its refuse collection rounds so that a collection vehicle could cover a greater number of premises. In the long term, the number of vehicles that would be needed could be reduced and so could the number of men involved. In the long term the average savings in domestic refuse collection cost as a result of a separate paper collection scheme could be approximated to the net cost of collection of a tonne of domestic refuse. Similiarly it would be legitimate to use the average net waste disposal cost per tonne of refuse as an approximation to the cost savings in waste disposal. This figure should be known to Scottish and Welsh District Councils. But English waste collection authorities salvaging waste paper will have to get a contribution from the waste disposal authorities to reflect this savings.

It is difficult to compute the loss of income from trade collection since it is not mandatory for the local authority to charge for collection of trade waste. Although local authorities may decide whether or not they will undertake the removal of trade refuse, they have a tradition of taking away free of charge most of the trade waste which could be salvaged, in particular waste paper, empty cartons and containers. Some local authorities do not collect trade waste and the commercial premises in these local authorities have either disposed their refuse by their own incinerators or are under contract with private contractors who have their own tipping sites. Hence, the loss of income from trade collection as a result of waste paper salvage only applied to local authorities who have been charging for the removal of trade waste. In the long run, the loss in trade collection charges as a result of collecting a tonne of waste paper from the trade premises could be approximated to the average charge for a tonne of trade collection. Among the case studies, only Case SE did not charge for trade collection from commercial premises.

In order to compute the true costs for recovering waste paper in each case study, all the relevant indirect cost and savings have to be computed and included (Table 5.4). Wherever possible, the indirect cost and savings included in each case were extra information obtained from the local authority itself or from their published accounts. Wherever such data was not available, national average estimates have been used.

After including all the relevant cost and savings, four cases (EA, EB, EE and EF) have less losses in their operations, two have higher profits (Cases SA and SC) and three (Cases SD, SE and EC) now have profits instead (Table 5.4, 5.5). Only one case (ED) has a higher loss than before. This was because in its own accounting all collection costs have been absorbed under refuse collection costs, and this gave a much lower operating cost. When the direct labour cost and transport cost due to the waste paper collection were included back into the accounts there was an extra collection cost of £26.20 per tonne. The true costs therefore gave a much higher loss than before. This clearly showed that unless the local authority compute all the related costs and savings in their waste paper recovery operation, estimates which included only some of the costs would not give an operation cost which would reflect the true situations. For example, both SE and EF based on their own accounting of heavy losses terminated their recovery operations, while the true costs showed that SE was in fact making a small profit and EF's loss was only 20 percent of what it was.

Table 5.5 also showed that subjective evaluation of the profitability of an operation without proper quantification did not reveal the true picture. Of the four cases which viewed their operations as 'marginally profitable' they were in fact

Table 5.4 - Cost of waste paper collection in the case studies expressed in £/tonne (1980/81)

Cases	SA	SB	SC	SD	SE	EA	EB	EC	ED	EE	EF	EG
Collection cost												
Labour	11.15*	34.46	12.82	12.61	*	12.17	46.13*	11.43	10.86	30.50	40.52	-
Supplies and services	1.04	3.00	0.13	-*	*	-	0.95	1.86	-	3.17	1.72	-
Transport	1.51	4.85	3.85	9.31	*	4.37	10.61	4.08	15.34	23.17	12.11	-
Others	-	-	0.39	-	*	-	4.73	-	-	-	-	-*
Collection cost	13.70	42.31	17.19	21.92	53.46*	16.54	62.42	13.29	26.20	56.84	54.35	4.08*
Baling cost												
Labour	-*	-	10.26	8.40	↑	8.36	-*	18.60	29.59	7.27	-	-
Supplies and services	2.92	-	1.28	4.19*	48.90	1.26	1.30	2.13	2.64*	0.05	1.12	-
Plant	3.57	-	1.92	-	↓	0.97	1.92	3.32	18.22	2.77	0.44	-
Others	0.27	-	1.92	-	3.79	10.39	4.72	4.66	11.59	-	1.33	-*
Baling cost	6.76	-	15.38	12.59	52.69	20.98	7.94	28.71	62.04	10.09	2.89	-*
Gross expenditure	20.46	42.31	32.57	34.51	106.15	37.52	70.36	42.00	88.24	66.93	57.24	4.08
Revenue												
Sales of waste paper	28.26	27.69	21.67	31.05	29.66	27.18	27.60	27.20	28.26	30.80	31.32	-
Contribution to reflect disposal savings	1.13	13.85	10.94	3.61	25.53	2.50	2.82	1.00	1.49	2.60	1.27	2.82
Gross income	29.39	41.54	32.61	34.66	55.19	29.68	30.42	28.20	29.75	33.40	32.59	2.82
Loss of income from trade collection	10.48(1)	9.23	10.48(1)	10.48(1)	-	6.42	3.08	6.24	12.82	24.56	4.19	17.36
Savings in refuse collection	14.66	10.00	19.93	20.89	53.46	20.85	20.00	30.34	24.94	16.69	23.82	24.76
Net expenditure	30.94	51.54	43.05	44.99	106.15	43.94	73.44	48.24	101.06	91.49	61.43	21.44
Net income	44.05	51.54	52.54	55.55	108.65	50.53	50.42	58.54	54.69	50.09	56.41	27.58
Profit/tonne	13.11	-	9.49	10.56	2.50	-	-	10.20	-	-	-	6.14
Loss/tonne	-	-	-	-	-	6.59	23.02	-	46.37	41.40	5.02	-

Notes :

* Inclusive

(1) Based on an average of £10.48 derived in Appendix VII

Gross income=Sales of waste paper + Contribution to reflect disposal savings

Net expenditure=Gross expenditure + Loss of income from trade collection

Net income=Gross income + Savings in refuse collection

Table 5.5 - Comparing the Council's computation of profitability of the operation with the true cost

£/tonne

Case	SA	SB	SC	SD	SE	EA	EB	EC	ED	EE	EF	EG
Council's computation	7.80	0	0.4	-3.46	-76.49	-10.34	-25.84	-13.80	-33.78	-48.99	-25.92	6.14
Council's view of their operation	B	D	B	D	D	(not given)	E	B	E	E	E	B
True cost of the operation	13.11	0	9.49	10.56	2.50	-6.59	-23.02	10.30	-46.37	-41.40	-5.02	6.14
Net effect of including all relevant indirect cost and savings	higher profit	no change	higher profit	profit now	profit now	less loss	less loss	profit now	more loss	less loss	less loss	no change

Note : B = marginally profitable
D = marginally unprofitable
E = very unprofitable

making good profits. Of the three who rated themselves as 'marginally unprofitable' one broke-even, and two have profits in their operations. The only assessments that seemed to be correct were those who viewed their operations as 'very unprofitable'.

6 - Major factors which affect local authority waste paper recovery

Besides the costs elements, there are other major factors which also affect the viability of a local authority's recovery operation. A number of these factors were commonly encountered during the course of the case studies. Local authorities have at one time or another quoted some or all of these factors as reasons for their unprofitable operations. Further investigations however, did not fully support all the claims of the local authorities. In this chapter some of the claims of the local authorities and their support or the lack of it are discussed.

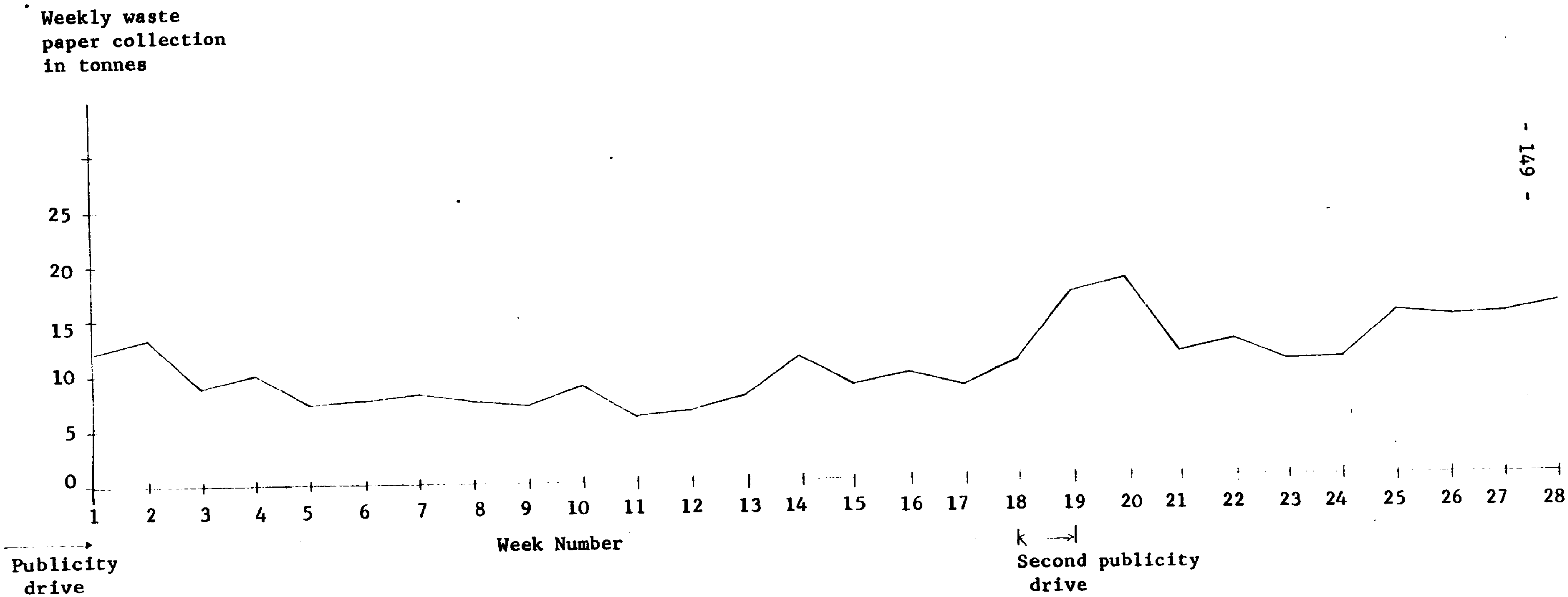
6.1 Public support

The success of a separate waste paper collection requires public support in separating the waste paper at source, without putting in contraries. This depends heavily on citizen awareness, cooperation and concern which requires a significant and vigorous public education campaign to explain the goals and the methods of the programme.

Source separation of waste paper is an easy and simple process with practically negligible cost to the householder. Although no British data is available, some American data exists which supports this view. A study of 15 families in the USA of all factors relating to the separation of glass, cans and newsprints in their homes was done for a period of 6 weeks (Hansen,1975). Incremental costs such as purchase of twine for bundling, water for washing etc. involved in participation were only 2 cents (less than one pence) per month per family. The average time spent on these activities was about 15 minutes per week per family. The separate bundling of newspapers took only 2.3 minutes per week. Another survey of American housewives' attitudes on solid waste found that 73 percent of those interviewed felt that separation of waste paper was 'easy' to 'very easy' for them to carry out (EPA,1972).

Not only is public education necessary but constant publicity is required to support a waste paper salvage scheme. Publicity has to begin well in advance of the campaign and maintained during the programme to sustain public support. It was very common for local authorities to find results at the beginning of a scheme reasonably good but subsequently the average contribution per house dropped. A pilot scheme conducted in 1974 by a Scottish District Council found that the initial yield of a separate waste paper collection was about 4.2 kg per household per week, but this figure dropped considerably later on. By March 1976 only 1.38 kg per household per week, was collected, and by October the same year this dropped to an average of 1.22 kg per household per week and have been maintained at this level. Another study on public response involving 10,000 premises was done by an English Borough Council where the results of collections for a twelve-week period in summer 1977 were recorded (Figure 6.1). After the first two weeks of high tonnage, the response started to dwindle. This was mainly due to householders putting their waste paper out at the wrong times, and the paper was not picked up by the separate collection team. A second publicity campaign was therefore mounted after week eighteen and this time not only were the residents reminded of the campaign they were also told exactly what dates were collection day and exactly where and when to place the bundled papers. Subsequently in weeks 19 and 20 there was a jump in the weekly tonnage, but by the 21st week the expected fall in response was seen, although this time the drop was smaller, and in subsequent weeks collections were equal or greater than those at the start of the scheme. Advertising materials fixed to the collection vehicles also helped to generate public awareness of the efforts made by the local authority to recover and sell waste paper. The Council claimed that re-publicity at intervals of three or four months was necessary to maintain participation rates. This was not exactly true. Figure 6.1 shows that after the second publicity drive the contribution went up to a peak but after a while

Figure 6.1 - Effect of publicity drive on waste paper collection
Source : Cooper(1978)



dropped again. What the re-publicity did was just to raise the lower collection level higher and prevent it from deteriorating.

The use of sacks to encourage householders to separate waste paper at source have also been tried. In the case studies only one local authority felt that the issue of sacks had any significant effect at increasing the amount of waste paper generated. However, the Scottish District Council in the pilot scheme mentioned earlier, studied the effect of issuing sacks to households. Their pilot scheme operated in three areas, with approximately the same socio-economic composition, A, B and C, each consisting of roughly 500 houses. In A, waste paper was collected once a week but no sack was issued, in B collection was also once a week but sacks were issued while in C collection was done every second week without any sack issued. Average tonnage obtained in these three areas in October 1976, were :

A	weekly collection (no sacks)	- 381.8 kg/week ≡	0.76 kg per household per week
B	weekly collection (with sacks)	- 941.8 kg/week ≡	1.88 kg per household per week
C	fortnightly collection (no sacks)	- 509.1 kg/week ≡	1.02 kg per household per week

(A and B consist of maisonettes while C has five-room apartment houses)

The study showed that with sacks more waste paper was collected. But the sacks were also found to contain contraries and it was not uncommon to find bottles, tins and foodstuffs mixed with the papers, which made it more difficult to separate the waste papers, not to mention the dangers involved in the process. The percentage of contraries has been found to be as high as 14 percent, although average contraries in sacks were around 7 percent. Sacks which cost 18p each (1976 price) were often used by the householders for other purposes which resulted in a high loss rate of sacks. The sorting of contraries from the sacks also involved the loss of time and labour. These two factors may outweigh the benefit of having a bigger amount of waste paper collected with sacks.

Location, social and economic background also affects the amount and grade of waste paper collected. An experiment conducted in a new industrial town in Strathclyde region showed that in an area with a high density of high income residents, as much as 8.2 kg/household/week could be collected compared to a nearby area with a high density of lower income residents, which generated only about 0.9 to 1.8 kg/household/week. Another study, Higginson(1966), showed that multi-storey flats generally generated more waste paper per household than normal properties (Table 6.1). This could be due to a tendency of burning waste paper in the latter category. Smoke control areas also gave rise to more waste papers since none could be burned within the flat or house. But data from Glasgow, sampled in February 1981 showed that multi-storey flats generated the lowest tonnage of waste paper (Table 6.2). A reason for the difference is the social and economic structure of householders staying in the different types of premises. People dwelling in houses and in bungalows have the tendency to be the middle and higher income groups which means that they have relatively more correspondence, read more types of newspapers, magazines and journals. Multi-storey flats in the cities now have refuse chutes which makes it easy to dispose of waste paper. People living in multi-storey flats and tenements have less space to keep their waste paper and so usually dispose them together with the refuse.

6.2 Waste paper prices

The profitability of the waste paper recovery operation is heavily dependent on the price received by the local authority for its paper since this is the only direct source of revenue for the operation.

There are generally two types of prices, those paid by waste paper merchants and those paid by the mills to the local authorities. Waste paper prices paid by the merchants are generally very low and it varies with merchants and from whom they buy the waste paper (Table 6.3).

Table 6.1 - Waste paper generated by different types of premises in kg per household per week
Source : Higginson(1966)

Types of premises	1961	1962	1963	1964	1965
A	2.4	3.0	3.2	3.5	2.9
B	3.3	4.5	3.6	4.2	4.9
C	3.3	4.4	4.8	3.9	4.7

A - 'Normal' properties

B - Multi-storey flats, all electric or heated without solid fuel

C - Flats and houses in smoke control areas

Table 6.2 - Waste paper generated in Glasgow in different types of premises
Source : Anderson(1981)

Types of premises	Generation per premise per week in kg
Houses & bungalows	3.60
Multi-storey flats	1.86
Tenemental	2.15

Table 6.3 - Some prices paid by waste paper merchants for certain grades of waste papers
Source : Materials Reclamation Weekly

£/tonne

Date		Cardboard & Container-board	Mixed waste	Newspaper & periodicals	Newspapers
1979					
July	7	13-17	3-15	5-15	10-18
1980					
Sept	6	10-20	2-8	7-15	10-20
Oct	4	8-16	0-8	5-12	8-16
Nov	1	5-14	0-8	5-12	8-14
1981					
Feb	7	0-8	0-2	3-10	0-10
Mar	7	0-8	0-2	4-10	5-10
May	5	5-12	0-5	5-7	5-8
Oct	3	8-13	0-5	5-7	5-8
Nov	7	8-16	0-5	5-8	6-10
Dec	5	8-16	0-5	4-8	8-10
1982					
Jan	2	8-16	0-5	5-8	6-10
Feb	6	8-16	0-5	5-8	6-12
Mar	6	8-15	0-6	5-8	6-12
Apr	3	8-18	0-8	5-8	6-12
May	1	8-18	0-8	5-8	6-12

Prices paid by mills to local authorities are more consistent and all local authorities selling to the same mill gets the same price. Some mills pay a flat rate for each tonne of each grade of waste paper. Others have a system of premiums based on tonnage, nearness of collection point to the mill and the size of the bale because a 1-tonne bale costs much less to handle at the mill than twenty 50-kg bales. Another reason is that the heavier the bale, the better the baler, the more dense the bale. A denser bale will give a better pay load making it cheaper to transport.

Mill prices to local authorities in Scotland are more consistent as over 94 percent of the Scottish District Councils have contracts with the same mill which pays a flat rate, while in England some local authorities sell their waste paper to mills (about three major buyers) and some sell their waste papers to merchants. Table 6.4 shows the waste paper prices paid by a mill to Scottish local authorities from 1968 to 1981 where the changes in prices were shown against the months in which it became effective. Prices were highest during the early 1974 waste paper boom, when mixed waste paper increased by 29.5 percent and container waste by 42 percent since 1970 in real terms. Mixed waste paper and container waste prices in December 1980 was only 2.9 times that in January 1970. But the inflation index during the same period has risen by more than 353 percent. Therefore in real terms prices of local authority waste paper have fallen since January 1970. Expressed in 1970 prices, price for mixed waste in December 1980 was only £7.90 per tonne compared to £9.75 per tonne in January 1970, a fall of 19 percent, while container waste dropped by 18 percent from £11 per tonne to £9.02 per tonne during the same period (Figure 6.2).

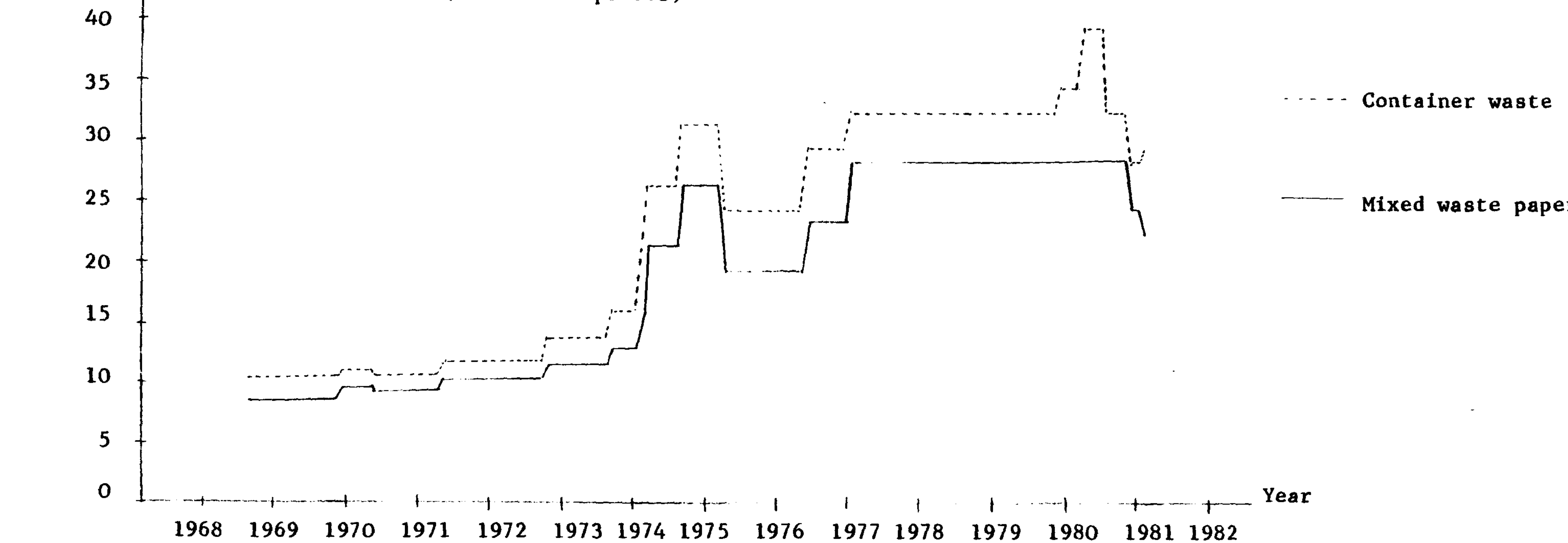
Prices paid by mills in England and Wales to local authorities follow about the same pattern as in Figure 6.2 except for an average price differential of about 75p per tonne. In Scotland the waste paper collected from local authorities are mostly sent to a mill in Aberdeen, while in England and

Table 6.4 - Waste paper prices paid by a mill to local authorities in Scotland

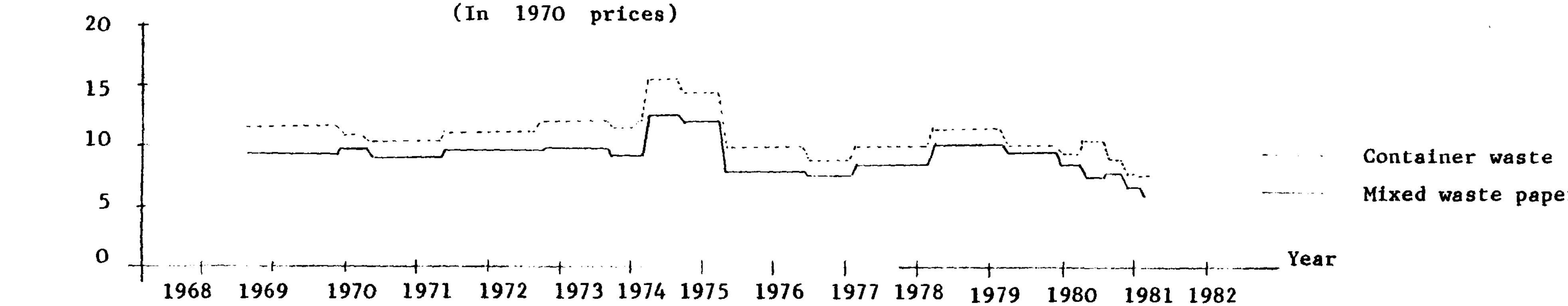
Date	£/tonne in current prices		Price * Index	£/tonne in 1970 prices	
	Mixed waste	Container waste		Mixed waste	Container waste
1968 Sep	8.75	10.50	90.4	9.68	11.62
1970 Jan	9.75	11.00	100.0	9.75	11.00
Jun	9.60	10.83	103.0	9.32	10.51
1971	10.25	11.75	106.2	9.65	11.06
1972 Nov	11.25	13.75	113.3	9.93	12.14
1973 Oct	12.50	16.00	134.8	9.27	11.87
1974 Mar	15.50	19.75	161.8	9.58	12.21
Apr	21.25	26.25	168.3	12.63	15.60
Oct	26.25	31.25	213.2	12.31	14.66
1975 May	19.25	24.25	240.4	8.01	10.09
1976 Jul	23.25	29.25	295.5	7.87	9.90
1977 Feb	28.25	32.25	318.0	8.88	10.14
1978 Mar	28.25	32.25	272.6	10.36	11.83
1979 Apr	28.25	32.25	307.7	9.18	10.48
1980 Jan	28.25	34.25	343.7	8.22	9.97
May	28.25	39.25	367.0	7.70	10.69
Sep	28.25	32.25	357.6	7.90	9.02
1981 Jan	24.25	28.25	353.8	6.85	7.98
Mar	22.00	29.00	366.5	6.00	7.91
Oct	24.20	31.90	447.1	5.41	7.14
1982 Jan	24.20	31.90	435.6	5.56	7.32

* wholesale price index of materials and fuels purchased by the paper and board industry, 1970 January = 100.0 (Monthly digest of Statistics)

<u>Figure 6.2</u> - Price received by Scottish local authorities for waste paper, 1968-1982
(in current prices)



(In 1970 prices)



Wales local authority waste papers are usually bought by mills in the vicinity. Hence transport cost for English mills to collect their waste paper is lower than that incurred by the Scottish mill. Waste paper is bulky and of low value particularly in the case of mixed waste, so that transport cost to the mill constitutes a high proportion of the price. The Scottish mill estimated that transport cost is about an additional 23 percent added on to the price paid for the waste paper. As a result, the Scottish mill pays the local authorities an average about 75p per tonne less than their English counterpart to compensate for the higher transport cost. Table 6.5, shows the annual average price index for local authority waste paper in England.

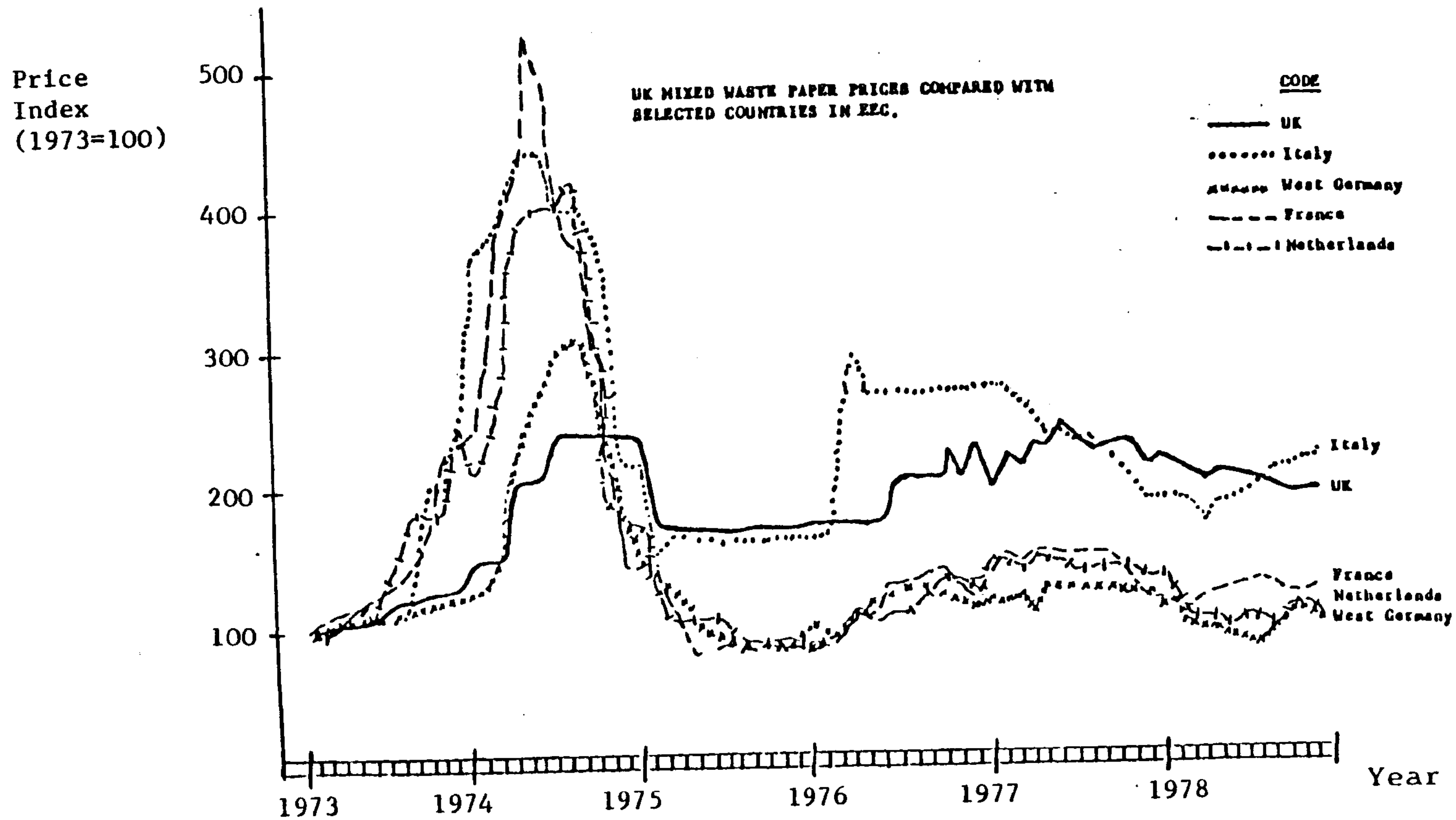
Local authorities have often quoted the low price of waste paper as a major cause for being unable to remain viable. They also said that price levels have never really followed the trend of inflation and even when price of mixed waste paper stayed constant in current value (1977 February to 1980 September), in real terms it has been declining. Mills agreed that waste paper prices have lagged way behind inflation. But the price which the mills can afford to pay for the waste paper is ultimately controlled by the price at which they can sell the finished products produced from recycled waste paper. The British paper and board industry has to compete with overseas mills using cheaper domestic fibres in large integrated low-cost mills, with significantly lower energy cost. One evaluation of efficient British mills suggested that current waste paper prices are in real terms some 30 percent higher than the economic level (Davis,1979). Although this claim is refutable, many mills generally agreed that price reductions in real terms are necessary if secondary fibre based products are to remain competitive. Figure 6.3 shows some of the price index of mixed waste paper in selected countries in the EEC which have relatively high recycling rates. British mixed waste paper prices have been relatively more stable and suffered far less violent fluctuations. Since 1975 mixed waste paper price in UK has also been much higher than most of the EEC countries except Italy and Denmark. The mills feel that £24/tonne

Table 6.5 - Waste paper price index from mills in England (1951 to 1981)
Source : Trade sources

1950 July = 100

Year	Mixed waste Price Index	Container waste Price Index
1951	136.08	268.06
1952	101.70	188.92
1953	66.71	128.92
1954	65.42	150.00
1955	75.12	162.75
1956	74.58	160.25
1957	74.58	158.00
1958	74.30	158.00
1959	74.30	158.00
1960	74.30	158.00
1961	75.13	167.75
1962	76.53	161.25
1963	76.90	158.00
1964	77.43	159.41
1965	85.35	171.00
1966	86.70	171.00
1967	78.23	168.00
1968	78.70	171.67
1969	90.45	189.75
1970	102.00	200.00
1971	102.88	202.63
1972	103.75	206.25
1973	115.92	248.17
1974	215.00	442.75
1975	212.00	440.83
1976	223.67	469.50
1977	297.92	557.04
1978	303.00	561.50
1979	303.00	561.50
1980	303.00	614.93
1981	247.36	518.42

Figure 6.3 - Price index of mixed waste paper in selected countries in the EEC
Source : Davis(1979)



(October,1981) for mixed waste paper is one of the highest prices paid anywhere in the world. For £20 per tonne they could buy from the USA, free on quay, mixed waste paper sorted and baled, although they have difficulty in controlling the quality and the level of contraries. From the USSR container waste could be bought as cheap as £10 per tonne. The only problem with buying from these countries is that orders have to be placed rather early, as long as one year ahead.

Even at current prices secondary fibre based products are under severe pressure from imported paper and boards. For example, waste paper makes up about 85 percent of the furnish for test liner which competes with imported virgin fibre based kraft liner. To allow the test liner to be competitive mills generally sell it at a price 10 to 12 percent lower than kraft liner.

There are constant pressures from merchants and local authorities to increase waste paper prices as their collecting costs rise. Increased waste paper prices would safeguard the source of supply but runs the risk of reducing the viability of some mills which will result in the reduction of long term demand. Currently mills are working at less than 80 percent capacity. Even at this low production rate local authorities are not able to supply sufficient waste paper to the mills and imports have to be made to supplement the mills' demand. If waste paper prices are lowered further there is the risk of cutting back the waste paper supply on which the future of the mills depend. Had waste paper prices kept pace with retail price index, mixed waste in November 1981 would have cost £36 per tonne instead of £24 per tonne. At £36 per tonne more mills will price themselves out of the market.

6.3 Mill quotas

In the case studies many local authorities quoted the same reason for the non-viability of their operation scheme : 'the quotas imposed by the mill limited the tonnage they could sell so that even though they could recover more paper to get

Table 6.7 - Quotas imposed on local authorities by mills since 1953

Year		Quota duration (months)	No quota duration (months)
1953 May	All quotas lifted		38
1956 July	Quota imposed on local authorities to reduce supply by 8 percent		
1957 October	Quota slightly lifted	24	
1958 July	Quota on mixed waste lifted		
1959 September	Quota on all grades lifted	14	32
1962 June	Quota imposed to reduce local authorities' delivery by 12 percent	28	
1964 October	Quota lifted		23
1966 September	Quota imposed to reduce mixed waste by 7 percent		
1967 February	Quota imposed to reduce mixed waste by 48 percent	11	
August	Quota lifted		46
1971 June	Quota imposed	16	
1972 October	Quota lifted		30
1975 May	Quota imposed	13	
1976 June	Quota lifted		50
1980 September	Quota imposed to reduce tonnage by 3 percent		
December	Quota increased to reduce tonnage by 20 percent		
1981 February	Quota increased to reduce tonnage by a further 20 percent	9	
May	Quota lifted		

higher revenue the quota limits it.' In some cases, the mill instead of imposing the quota was only willing to take the datum tonnage at the minimum guarantee price of £22/tonne which was generally less than the price offered for the quota tonnage (January 1981 price were £28.25 for container waste and £24.25 for mixed waste paper), so that in effect about the same amount of revenue was obtained.

The mill who buys the waste papers from the Scottish authorities however did not agree with the Councils' excuse. According to this mill, quotas were only imposed for only eight months from September 1980 to April 1981. The mill was willing to take away as much waste paper as the local authorities could collect. To support this, the mill produced the records of the amount of waste paper they bought from nearly all the local authorities in Scotland and a few local authorities in England for the period 1975/76 to 1980/81 (Table 6.6). While intake from the local authorities in 1979/80 was highest, intake in 1980/81 though lower than 1979/80 was no less than the earlier years. In fact for Scottish District Councils the intake was reduced by only 2.3 percent during the recession in 1980/81, while intake was reduced by 21.7 percent for English District Councils during the same period. The budgeted figures for 1980/81 were the highest tonnages so far. The total amount bought from the local authorities in 1980/81 was in fact lower than what they have budgeted for, which showed that local authorities had in fact been unable to meet the mill's demand, even with the imposed quota. The mill attributed the non-viability of the local authority waste paper recovery operation to the small tonnage collected, the inefficiency in collection and the high labour cost involved in the waste paper collection.

Table 6.7 shows the periods during which quotas were imposed by the mills, from May 1953 to May 1981. During the 28 years, quotas were imposed for only a total of 115 months, about 34 percent of the time. Intervals in between quota periods were long, with the shortest interval of 23 months. There had been duration as long as 50 months when no quota was imposed.

Table 6.6 - A Scottish mill's intake from local authorities in Scotland and England

(in '000 tonnes)

	1975/6	1976/7	1977/8	1978/9	1979/80	1980/81	Budgeted for 80/81
Scotland	39	37	36.5	36.5	42.5	41.5	43.5
England	11.5	11.5	9.0	10.0	11.5	9.0	11.0
Total	50.5	48.5	45.5	46.5	54.0	50.5	54.5

Table 6.8 - Labour cost as a percentage of total operating cost of a local authority waste paper recovery operation

Case :	SA	SB	SC	SD	EA	EB	EC	EE	EF
%	54.5	81.5	70.9	60.9	54.7	65.6	71.5	47.3	70.8

Mill quota is therefore not as serious as the local authorities have made it out to be. Even when mill quota was implemented, it only affected the mixed waste. Until 1981 there was no restriction on the amount of container waste taken by the mills. What the local authority could have done during the restriction period was to separate the container waste from the mixed waste, which could effectively reduce the total mixed waste tonnage by as much as 25 percent. In this way, the effect of the restriction on the mixed waste would have been minimized.

6.4 Labour cost and fuel costs

Labour cost is a major component in the collection and baling cost. Every vehicle taken out uses at least 1 driver and 2 collectors, each baler uses at least 1 chargehand and 1 assistant. Labour cost forms a very high percentage of the total operating cost. The case studies earlier showed that labour cost could vary from 54.5 percent to 81.45 percent of total operating cost. (Table 6.8)

Since 1970 the basic weekly wages for manual workers involved in driving collection vehicles, collecting the bags or sacks of bundled waste paper and baling them, have been rather consistent in England, Wales and Scotland. Workers involved are generally grade C for baler operator, grade E for collectors and grade F for drivers. However, in some local authorities a grade F worker may be the chargehand and a grade E worker may assist him in operating the baling plant, while in some local authorities the collection vehicle driver may be a grade F worker and the collectors are grade E workers.

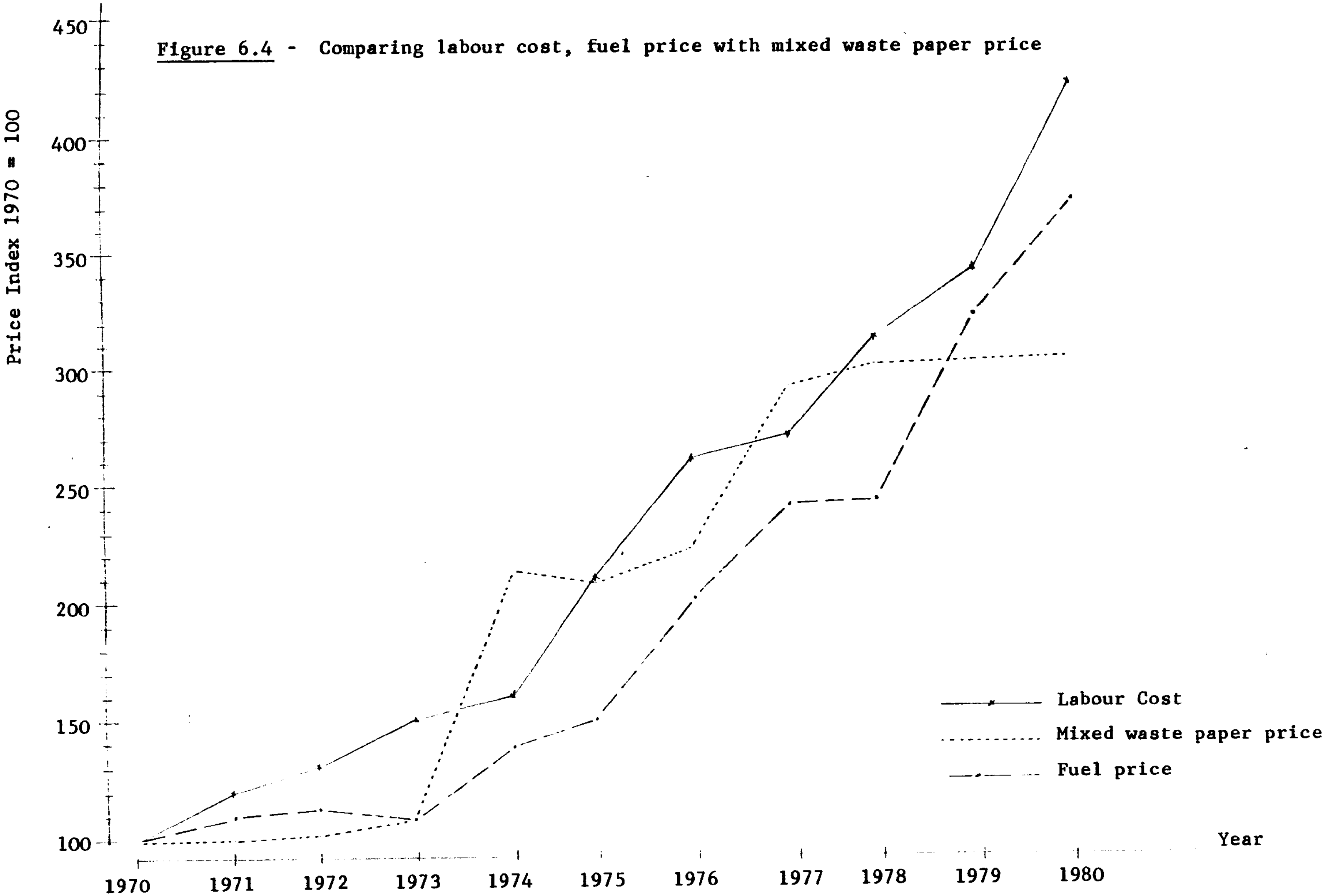
The basic weekly wage does not include added-on costs such as national insurance, super-annuation costs, bonus and overtime which have to be paid out by the local authority as well. In 1980 for example, the basic wage for grade E worker was about £3,270.28 per annum. But the total labour cost to the local authority for using just 1 grade E worker on waste paper salvage is about £6,000 which includes all the other added-on cost. A major problem of the added-on cost is the bonus. The bonus for most local authority manual workers is now easily 33.3 percent of basic wages and some authorities pay more. In some cases the bonus has been paid week after week without variation other than adjustments to keep it in line with increasing wage rates. The bonus has also been paid in full for period of absence for holidays. The bonus as such, distorts the pay structure since it is only attached to basic wage and not to overtime or productivity, and reduces to practically zero the enhancement that the bonus was introduced to attract in the first place, namely higher productivity.

Another practice common in refuse collection, which has been brought over to waste paper collection and which also caused serious distortion to the pay structure is 'task-and-finish'. This is the practice of allowing men to go home when their day's task has been completed. This condition is usually offered, and in most cases demanded, by the men at the time the bonus scheme is introduced. This practice was originally introduced as an incentive directly relating reward with effort, but it began to encourage workers to minimize efforts. Industrial sources have claimed that such practice has drastically reduced the actual working time per week and has resulted in very inflexible scheduling of work. Such situations are difficult to rectify since the workers who have experienced the short working hours over a period of time will start to regard the free hours gained as their own and re-organise their home life and activities accordingly, and it will become difficult to reverse the situation.

Transport cost is another important item. Every vehicle deployed out to collect waste paper uses fuel. Dunkelman(1981) based on a sample of 512 refuse collection vehicles from 20 local authorities estimated that fuel cost was 13.4 percent of total running cost of a vehicle (excluding driver).

Figure 6.4 compares the three different price indexes (1970=100) for basic wage, waste paper price (mixed waste) and fuel price (diesel). The basic wage increased at a much faster

Figure 6.4 - Comparing labour cost, fuel price with mixed waste paper price



rate than waste paper price, while fuel price increased at a slower rate than waste paper price. After 1977 while labour cost was increasing at more than 10 percent per year, mixed waste paper price was stagnant. Even after the fuel price increase in 1974, fuel price was not increasing as fast as waste paper price. Only from 1979 were fuel prices higher than waste paper prices. It was therefore not surprising to find many local authorities losing money in their operations particularly in the last few years.

7 - Computer models to assess the economics of a local authority waste paper recovery operation

This chapter develops a computer model to assess the viability of an on-going recovery operation and an investment appraisal model to assist in making decisions on a proposed waste paper recovery operation. The computer models will allow various inputs to be feed in to compute very quickly various results and to check the sensitivity of the operation against changes in various elements of the operation. Since local authorities have access to computer facilities the use of computerised models will not introduce any great difficulty.

7.1 The viability model

This model is used to assess the profitability of an existing operation. It will also help the local authority to identify which combination of participation ratio and contribution of waste paper will be required to get the best profit or the minimum net operating loss. With this information the local authority will be able to identify which areas in the district will be most likely to fit into this target and they can then re-organise the manpower and vehicles to concentrate collection from these areas and abandon areas which are not profitable. In this way, time, energy and manpower will not be wasted to go round the routes where participation and contribution rates are particularly low. This will allow the maximum tonnages to be collected at the utilisation of minimum operating cost. This model also allows the local authority to work out the minimum waste paper prices which they must get to break-even at various collection levels.

7.1.1 Components of the viability model

7.1.1.1 Potential yield of waste paper

The yield of waste paper from domestic premises depends on the participation rate of the householders, the average weight contributed and the total number of premises along the collection route. For trade collection, various studies (DOE,1976B; LAMSAC,1975; Bagley & Dunn,1979) have shown that the average weight of waste paper generated in trade premises could be related to the population. Let

IP = population in the district

ID = total number of domestic premises

W = average weight (in kg) of waste paper contributed per premise per week

M = participation ratio of households, where $M = 1$ represents a 100 percent participation

Z = average tonnes of trade waste generated per 1,000 population per week.

The contribution of waste paper per annum from a local authority could be expressed as follows :

Domestic premises contribution per annum, in tonnes $= \left(\frac{M*W*ID*50}{1000}\right) = 0.05*M*W*ID$

Trade premises collection per annum, in tonnes $= \left(\frac{Z*IP*50}{1000}\right) = 0.05*Z*IP$

Total contribution per annum (based on a 50-week per annum collection) $= 0.05*(M*W*ID + Z*IP)$ tonnes

7.1.1.2 Labour cost for collecting waste paper

A separate collection team will consists of 1 or more collection vehicle(s) each operated by a crew of 1 driver and NC collectors. Let the driver's basic wage be DW and each collector's basic wage be CW. These men are assumed to have the same normal working period as all local authority manual workers, 40 hours per week. Some local authorities pay 5p/hour above the normal rate as additional allowance for dirty and dangerous work which is not part of the job for which the grade rate has been fixed. But waste paper collected in separately tied bundles from domestic premises or in specifically provided bags from trade premises does not constitute work any more dirtier or dangerous than normal domestic refuse collection. Hence in this model, extra allowance of this nature is disregarded. The weekly basic wage per collection crew will then be (DW + NC*CW) and the annual basic wage per crew will be 50*(DW + NC*CW) for each vehicle operating on a 50 week year.

It is a common practice of local authorities to pay a bonus to the waste paper collection team. A common bonus is based on 33.3 percent of the basic wages. A few local authorities use a percentage share of the revenue obtained through sale of waste paper. But this method of computing bonus is not very popular with the waste paper collection team as the bonus is tied to the fluctuations of the waste paper prices.

On top of the basic wages and bonus, the local authority has also other 'added-on' cost for every man utilised. This includes National Insurance payment, holiday pay and superannuation. The total added-on cost which includes bonus, vary with local authorities. If AC represents the percentage of basic wages that is the total added-on cost, the total annual labour cost per team will be 50*(DW + NC*CW) + (1 + 0.01*AC).

The number of vehicles and therefore the number of teams to be deployed depends on basically the distance of the collection route, the number of premises participating and the contribution, along the route. According to industrial sources, one vehicle of 3-tonne capacity on the average should be able to cover up to 3,500 premises per day, provided not more than 1.05 kg of waste paper is collected from each premise, based on Q = 1, since a 3-tonne capacity vehicle (without compaction) could be filled with about 3.6 tonnes of waste paper. Since collection of waste paper is normally done once a week, in the 5 days of a week, the same vehicle and crew could cover 17,500 premises. But when the weight of waste paper collected exceeds 1.05 kg from each premise, the number of vehicles would have to be increased. Similarly, if the percentage of participation is lower the number of vehicles needed can be reduced accordingly. In general, therefore, the number of vehicles (NV) that needs to be deployed could be computed by

$$NV = \frac{0.05*(M*W*ID + Z*IP)}{1.05*17500}$$

where $NV \geq 1$ and is an integer. The total labour cost for NV teams of driver and collection crew will be

$$NV*50*(DW + NC*CW)*(1 + 0.01*AC).$$

7.1.1.3 Supplies and services for collection

Although in most places, households are requested to tie up their waste paper in bundles for collection at curb-side once a week, plastic bags or sacks are usually issued to trade premises for separating their waste paper, since their waste content are usually cleaner and of better grade, if they are properly separated. The cost of providing sacks will add an average supplies and service cost to each tonne of waste paper recovered. If CSPT represents the collection supplies and service cost per tonne of waste paper then the supplies and service cost for the trade collection would amount to CSPT*0.05*Z*IP.

7.1.1.4 Vehicle investment and loan charges

Since vehicles have to be used for collecting waste paper there should be a renewal fund contribution to reflect the utilisation of the vehicle. If the capital investment for a vehicle is £V say, and the Public Works

Loan Board rate is PWLB per annum, to reflect the depreciation of the vehicle over IYV years, a loan charge or a renewal fund contribution per annum for NV vehicles will come to $\frac{NV*V}{IYV}(1 + \frac{PWLB*IYV}{100})$.

7.1.1.5 Transport cost for the collection rounds

The transport department of a local authority normally does not keep details of the operating costs of the collection vehicles. Information such as the distance covered by each vehicle and the fuel used per collection round is not available at all. What is normally done is that the transport department charges the cleansing department a fixed sum per vehicle per day for the use of the collection vehicle. This daily cost (T) of using a vehicle will consists of a share each of vehicle licence, vehicle insurance, depreciation, fuel, replacement tyres, repair and maintenance. Assuming a 5 day collection per week for 50 weeks, the total transport cost per annum for NV vehicles = NV*5*50*T.

7.1.1.6 Administrative overheads

It is a common practice of local authorities to apportion a part of the administrative overheads from the cleansing department on waste paper collection, following common financial accounting practice. This overhead will increase the cost of waste paper recovery. But waste paper salvage must be considered to be part of the domestic refuse collection duty of the cleansing department. When waste paper salvage is terminated it does not mean that the administrative officers in the department will get a proportionally less salary then before and the amount of overheads that was once apportioned to waste paper collection is now saved. On the contrary, the administrative expense in total will remain the same. Since waste paper recovery is only a marginal administrative activity, administrative overheads is therefore omitted in this model.

7.1.1.7 On-going publicity

To maintain the enthusiasm and participation of the respondents, on-going publicity must be maintained, a publicity drive has to be conducted every three or four months to keep up the interest of the population. For an average town of about 45,000 domestic premises, leaflets and posters publication and distribution would need an average of £500 per annum (1980 prices). Therefore an annual publicity costs could come to

$$\frac{ID}{45000} * £500 = £0.01*ID.$$

7.1.1.8 Gross collection cost (GCC)

Gross collection cost per annum will add up to

$$\left[50*NV*(DW + NC*CW)*(1 + 0.01*AC)\right] + (CSPT*0.05*Z*IP)$$

$$+ \left[\frac{NV*V}{IYV}(1 + 0.01*PWLB*IYV)\right] + (250*NV*T) + (0.01*ID).$$

7.1.1.9 Baling labour cost

A chargehand to operate the baler is normally assisted by 1 or more loader(s) who will pick out the bigger and easily identified contraries and then load the waste paper into the baler. Let the basic weekly wage of the baler chargehand be BCW and the basic weekly wage of each loader be BLW, and if there are LB loaders then the total labour cost for baling the waste paper per annum, including added-on cost will come to

$$50*(BCW + LB*BLW)*(1 + 0.01*AC).$$

7.1.1.10 Capital investments for the baler

If a baling system (which includes baler and conveyor systems) is not available, the local authority has to purchase one at a cost of £B. A plant has also to be built to house the baling system, and this plant will cost another £FN. If the plant has an economic life of IYB years and the interest rate (PWLB) from the Public Works Loan Board is used, the loan charge per annum for the baling system will amount to

$$\frac{(B + FN)}{IYB} * \left(1 + \frac{PWLB*IYB}{100}\right)$$

7.1.1.11 Supplies and services for baling

Supplies and services for the baler includes baling wire, fuel, light, water and maintenance for the baling system. If the supplies and service cost for baling the waste paper is BSPT, then the total supplies and service cost for baling the recovered tonnage will come to BSPT*0.05*(M*W*ID + Z*IP).

7.1.1.12 Gross baling cost (GBC)

The gross baling cost per annum will add up to

$$\left[50*(BCW + LB*BLW)*(1 + 0.01*AC)\right] + \left[\frac{(B + FN)}{IYB}*\left(1 + \frac{PWLB*IYB}{100}\right)\right] + \left[BSPT*0.05*(M*W*ID + Z*IP)\right]$$

7.1.1.13 Revenue

Mixed waste and container waste have difference prices, S_1 and S_2 respectively. But local authorities maintaining long term contracts with the mills have a guaranteed minimum price of £22 per tonne for all waste papers. Both S_1 and S_2 are for most of the time higher than £22 per tonne. If PCW is the percentage by weight of container waste, then the total revenue per annum (SAL), received from the sale of salvaged waste paper will be,

$$SAL = S_1*(1-PCW)*0.05*(M*W*ID + Z*IP) + S_2*PCW*0.05*(M*W*ID + Z*IP).$$

With every tonne of waste paper recovered, there is a savings in refuse disposal cost. If Y is the disposal savings per tonne of waste paper recovered, then the total savings per annum (SRD) would amount to

$$Y*0.05*(M*W*ID + Z*IP).$$

The total revenue can be regarded as SAL + SRD.

7.1.1.14 Other indirect cost and savings

If C per tonne is the average charge for the collection of commercial waste, then the loss in income from commercial collection, as a result of free waste paper collection will be C*0.05*Z*IP.

The separate collection of waste paper will result in certain savings in refuse collection costs. If R is the collection cost per tonne of domestic refuse, in the long run the savings in refuse collection cost will be, as a result of separate collection of 0.05*(M*W*ID) tonnes of waste paper from domestic sources, R*0.05*M*W*ID.

7.1.1.15 The net cost of operating the waste paper recovery scheme

The net cost for collecting and baling the waste paper =

$$(SAL + SRD)-(GCC + GBC) + (R*0.05*W*M*ID)-(C*0.05*Z*IP)$$

where a positive result will indicate the net profit made by the local authority, and a negative result will show the net loss incurred in the operation.

7.2 Applying the viability model

To illustrate the application of the viability model, a hypothetical local authority (HLA) based on the most common characteristics from the Scottish local authorities is used (Appendix VI). The Scottish local authorities are used as a base case mainly because 94 percent of those who recover waste paper have contracts with the same board mill making the revenue obtained per tonne very consistent and secondly because they are also responsible for their own waste disposal and will be able to make rather accurate reflections in waste disposal savings in their waste paper accounts.

7.2.1 Characteristics of HLA

For the hypothetical local authority (HLA), the following characteristics are assumed :

Population	= 80,000
Number of domestic premises	= 28,070
Average population per premise	= 2.85 about national average
Area served by the local authority	= 150,000 hectares

HLA operates an on-going waste paper recovery operation because it is interested in providing a service to the public and also because the Council believed that waste paper recovery is a good means of conserving national resources. Waste paper is collected once a week and the whole district is divided into 5 sectors where each sector is collected on a specific day of the week.

Waste paper is collected free of charge from trade premises in specially provided sacks. But other trade wastes are collected at a charge of £10.48 per tonne (based on the 1979/80 average charge for trade waste in England/ Wales - Appendix VII). Average commercial waste generated per annum = 0.046 tonnes (Appendix VII). This gives the average commercial waste generated per 1,000 population per week to be around 0.885 tonnes. If 30 percent of this is waste paper, then there is approximately 0.266 tonnes generated per 1,000 population per week. WMAC(1976) estimated that 75 percent of this could be recovered from the trade premises, that is the expected collection from trade premises is about 0.2 tonnes per 1,000 population per week. But Bagley & Dunn(1979) based on the average of a number of surveys gave the potential contribution from trade premises per 1,000 population per week to be only 0.18 tonnes. Z is assumed to be 0.18 for the hypothetical local authority.

If the trade premises do not separate out the clean waste paper into the sacks provided and if too much contrary is found in the sacks (10 percent is the limit), the Council will regard the waste paper as trade waste and a charge be placed on its collection. There is therefore an incentive for the trade premises to provide clean waste paper. This practice is currently implemented by only two local authorities, Glasgow and Dunfermline.

To provide the sacks to the trade premises costs the local authority an average collection supplies and service cost of 19p per tonne of waste paper collected. This local authority like most others, does not provide sacks to domestic premises because of high loss rates and high contraries level found in the sacks collected back from domestic premises. Householders are therefore requested to help by tying up their waste papers in bundles for collection at the curb-side.

HLA is assumed to follow the common practice of using 1 driver and 2 collectors for each vehicle. Drivers are not allowed to leave the vehicle for safety reasons, so the two collectors are solely responsible for picking up the bundles and sacks of waste paper and placing them in the collection vehicles. Drivers are usually paid a higher grade basic weekly wage than the collectors because of their bigger responsibility. HLA is assumed to pay the driver a grade F basic wage of £66.11 per week and the collectors a grade E basic wage of £62.89 per week (DEMP,1980).

For operating the baling system it is common to have a chargehand to operate the baler, assisted by 1 loader. HLA is assumed to pay the chargehand a grade F basic wage of £66.11 per week and the loader a grade E basic wage of £62.89 per week (DEMP,1980).

Dunkelman(1981) in a survey of local authority transport cost in England was able to collect transport cost information of sufficient details from only 20 local authorities involving 512 vehicles (Appendix VIII). The average cost of £47 per vehicle per day is used for HLA's transport cost. This covers vehicle licence, vehicle insurance, depreciation, fuel consumption, replacement tyres, repairs and maintenance for the entire year averaged out per vehicle per day.

Baling supplies and services cost covers the use of fuel and light, wires used and maintenance of baling system. Table 7.1 shows a summary of some of the costs available. An average of £3.64 per tonne for baling supplies and services cost is used for HLA.

Waste disposal by landfill is still the predominant means of waste disposal (Table 7.2). 71 percent of the refuse in England and Wales are disposed by landfill. Scottish local authorities also disposed off most of their waste by landfill, which is still the cheapest method relatively. Rushbrook(1982) estimated that for a landfill site disposing between 10 to 500 tonnes per day, the annual operating cost (Y) is related to the daily disposal tonnage (X_D) by the relation $Y = 3586\ X_D^{0.51}$. This formula is used to compute the average waste disposal cost by landfill used at HLA. An average value of £1.86 per tonne is assumed (Table 7.3).

To compute the savings in refuse collection cost the average cost for a similiar population authority in Appendix VII is assumed for the HLA. Average cost for

Table 7.1 - Summary of baling supplies and services cost (in £/tonne)

	Source	Fuel & Light	Baling wire	Maintenance	Total	Tonnes of waste paper involved
1	Touche Ross(1978)	£0.90	£0.70	£1.00		
	updated to 1980	£1.35[a]	£1.05[b]	£1.53[c]	£3.93	5000
2	Dodsworth(1978)	£0.33	£1.09	£0.28		
	updated to 1980	£0.50[a]	£1.64[b]	£0.43[c]	£2.57	375
3	Bagley & Dunn(1977)	*	*	*	£2.50	
	updated to 1980				£3.75*[a]	2250
4	Case SC	*	*	*	£1.92*	780
5	Case SD	*	*	*	£2.87*	1440
6	Case EA	£0.97	£1.17	*	£2.14*	1030
7	Case ED	£1.67	£2.13	£0.85	£4.65	1300
8	Case EF	£2.77	£0.05	£1.55	£4.37	1805

(a) updated by fuel and light price index, by a factor of 1.5
(b) updated by metals goods price index, by a factor of 1.5
(c) updated by local authority manual works basic wages index, by a factor of 1.53

* inclusive

Table 7.2 - Methods and disposal of waste in England and Wales
Source : (CIPFA,1981A)

Method	1974/5	1975/6	1976/7	1977/8	1978/9	1979/80
	%	%	%	%	%	%
Landfill untreated	84	75	73	71	71	71
Landfill after shredding	4	4	4	3	3	2
Direct incineration	6	8	9	9	9	8
Separation and incineration	2	2	1	1	1	1
Contractor and other WDAS	3	10	12	15	15	17
Composting and others	1	1	1	1	1	1
Total	100	100	100	100	100	100

Table 7.3 - Average waste disposal cost at HLA

Average waste generated per premise per week (based on the 1979 National Survey)	= 11.03 kg
Number of domestic premises	= 28,070
Domestic waste generated per annum	= 16,100 tonnes
Average tonnage disposed per day (250 days per annum)	= 64.4 tonnes per day
Y	$= 3586 \times 64.40^{0.51}$
	= £30,001.44 per annum
Average waste disposal cost per tonne	= £1.86

collection of domestic refuse is estimated to be £19.00 per tonne.

The interest rates charged by the Public Works Loan Board depends on the mode of repayment and the period of loan. Appendix III gives the different interest rates charged from 1979 to March 1981 for various periods of loan. HLA is assumed to repay its loan by half-yearly instalments of equal repayment of principal and interest combined, spread over the economic life of the asset. An interest rate of 13.82 percent per annum is assumed.

An average vehicle replacement life is 7 to 9 years but variations by a year or two did not introduce any great cost disadvantages (Dunkelman,1981). With the recent cuts in public spending many local authorities are extending the working life of the collection vehicles to 10 years. In the hypothetic local authority the average life of the collection vehicle is therefore assumed to be 10 years. For the baling plant the average economic life is also about 10 years.

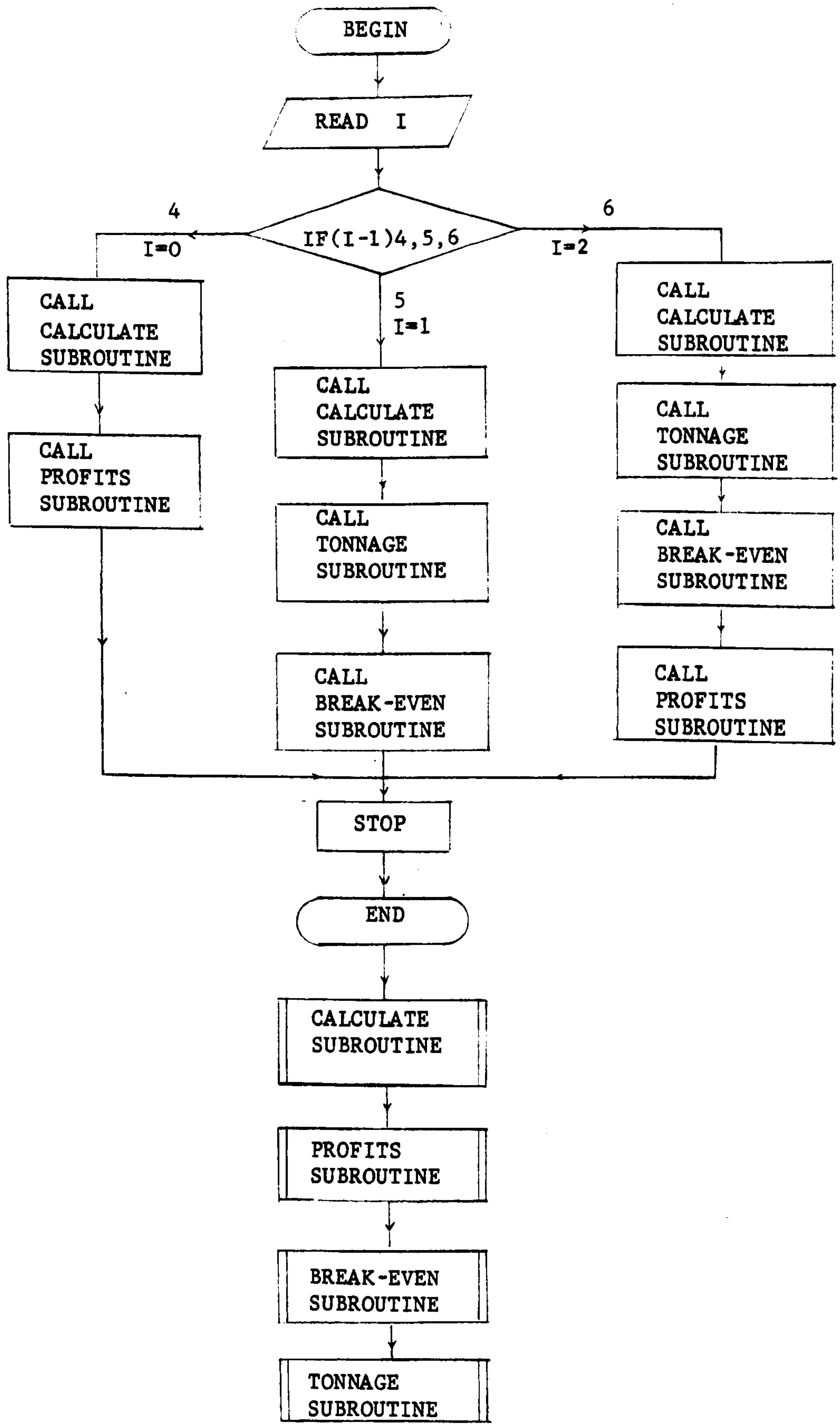
7.2.2 Computer runs

Figure 7.1 shows the program algorithm of the viability model. The algorithm of the program consists of 3 sub-routines, Calculate, Tonnage, and Profit which are called depending on the results required. The details of the program listing, in FORTRAN, is given in Appendix IX.

In the first run of the application, the minimum guaranteed price of £22 common to all contracts, both for mixed waste and container waste, was used. An average of 12.5 percent by weight was used to estimate the content of container waste on the total recovered tonnage. Tonnages were calculated from a participation rate of 20 percent onwards and for contributions from 0.5 kg per premise per week up to 2 kg in steps of 0.1 kg. Details of the algorithm, the input for the computer runs and specimen results are shown in Appendix IX.

Prices of waste disposal was also varied in steps from £1.86 per tonne to £15 per tonne, so as to study the influence of higher waste disposal costs on the model.

<u>Figure 7.1</u> - Algorithm of the viability model



7.2.3 Results of the computer runs

The program allows the local authority to get three sets of outputs depending on the control variable I. If I is 0, only the profits are printed out. If I is 1, the tonnages and the break even prices are printed out. If I is 2, then all the three tables are printed out.

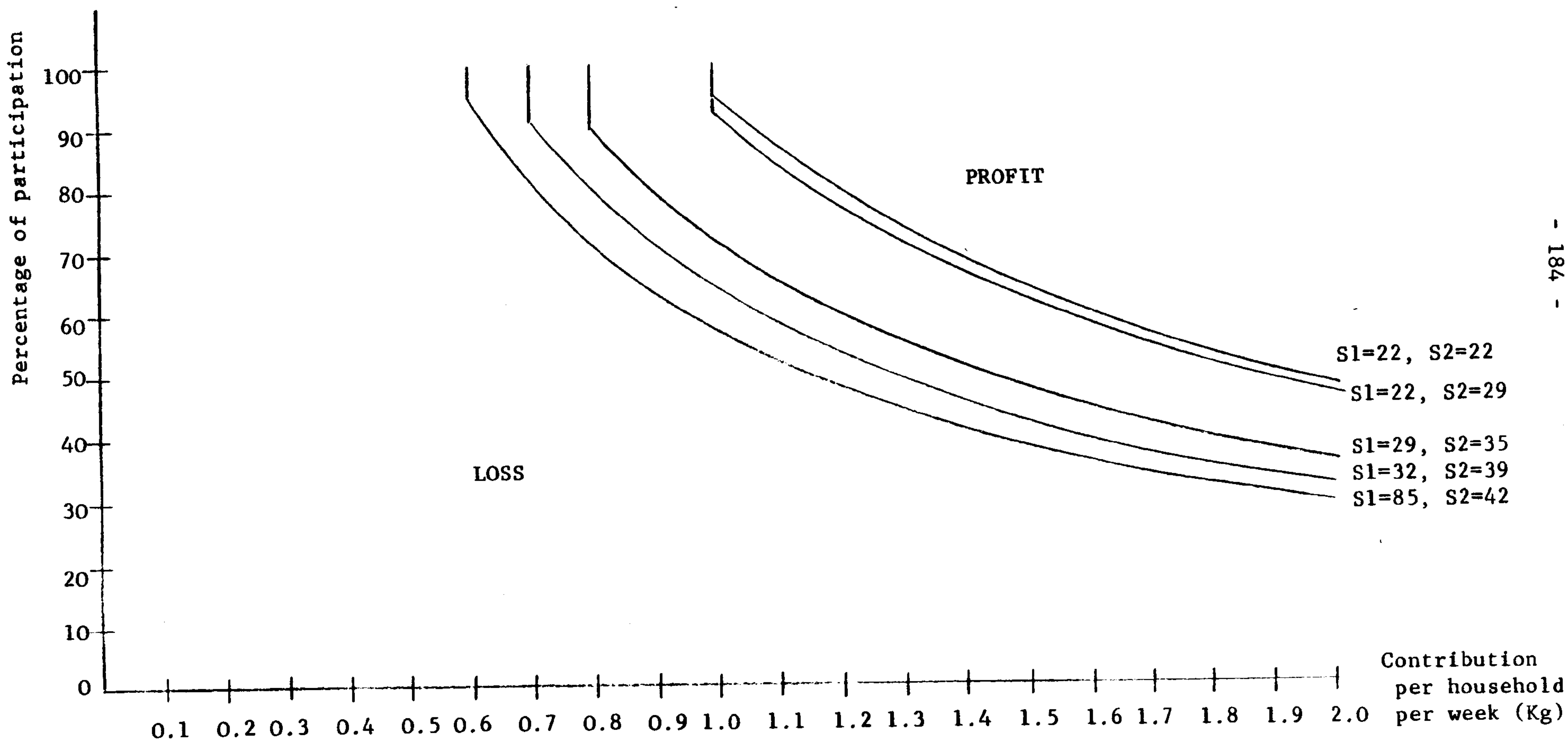
The tonnage table prints out the total tonnage that could be collected at various participation rates and contributions from the household. For each element in the tonnage table a certain average waste paper price is required before the operation breaks even. The break even price table lists the average break even price for each participation rate and contribution. The profit table lists the profit possible for each participation level and contribution level. A negative profit means a loss has been incurred. (Appendix IX, Tables AIX 1, AIX2 and AIX 3 show some sample printouts)

The profits table shows that the more waste paper collected the more likely is the scheme to be profitable. That is, economics of scale can be achieved with collection and baling of waste paper. This confirms the results of a Department of Environment departmental survey of 191 waste paper collection schemes in 1976.

By comparing the actual collection with the tables the local authority will be able to tell by how much its operation must be improved before it breaks even. In this way the local authority can monitor its viability month by month. If the local authority has several conurbation centres in the district and if some centres contribute only a small tonnage while others contribute higher tonnages, the local authority can use the tables to guide its actions. For example, will it be more profitable to concentrate only in areas where contributions are consistently high and phase off operations in areas where contributions are consistently low ?

Figure 7.2 shows some specimen break even boundaries at various percentage of participation and contribution per

Figure 7.2 - Break even boundaries



household per week, for various waste paper prices. The break even boundaries will allow the local authority to read off the participation rate and contribution level necessary to break even at each price level. At the minimum guaranteed price of £22 per tonne, to break even will require a contribution of at least 1.0 kg per household per week at 95 percent participation. Such high participation rate is very difficult to achieve and maintain. As the waste paper recovery operation settles in, the average rate of participation is about 1 in 3 households, so that the local authority should work with 35 percent participation rate. But at £22/tonne, participation rate below 48 percent will not break even, even at the contribution rate of 2.0 kg per premise per week.

When the savings from waste disposal and the loss in trade income charges (the savings in refuse collection) are omitted from the costing of the operation, the break even boundaries shift right to give a much bigger loss region (Figure 7.3). At the minimum price of £22 per tonne and even at the minimum price in 1981, there is practically no chance for the local authority to be profitable.

In the first set of runs the cost of waste disposal was assumed to be £1.86 per tonne, based on landfill. However waste disposal cost varies according to methods, and some waste disposal cost can go up to £15 per tonne, so that for local authorities with high waste disposal costs this component of indirect savings is more important. Table 7.4a shows the effect of higher waste disposal cost on the break-even prices required and the profit or loss obtained by the HLA. Therefore with higher waste disposal costs reflected in the costing system local authorities would be in a better position to justify a waste paper recovery operation.

Table 7.4a - Effect of higher waste disposal cost on break-even prices and profits for a 35 percent participation and 1.1 kg contribution per premises per week*

Waste disposal cost/tonne	Break-even prices	Profit or loss/ tonne
1.86	46.8	- 24.8
3.72	45.0	- 23.0
5.00	43.7	- 21.7
7.50	41.2	- 19.2
10.00	38.7	- 16.7
12.50	36.2	- 14.2
15.00	33.7	- 11.7

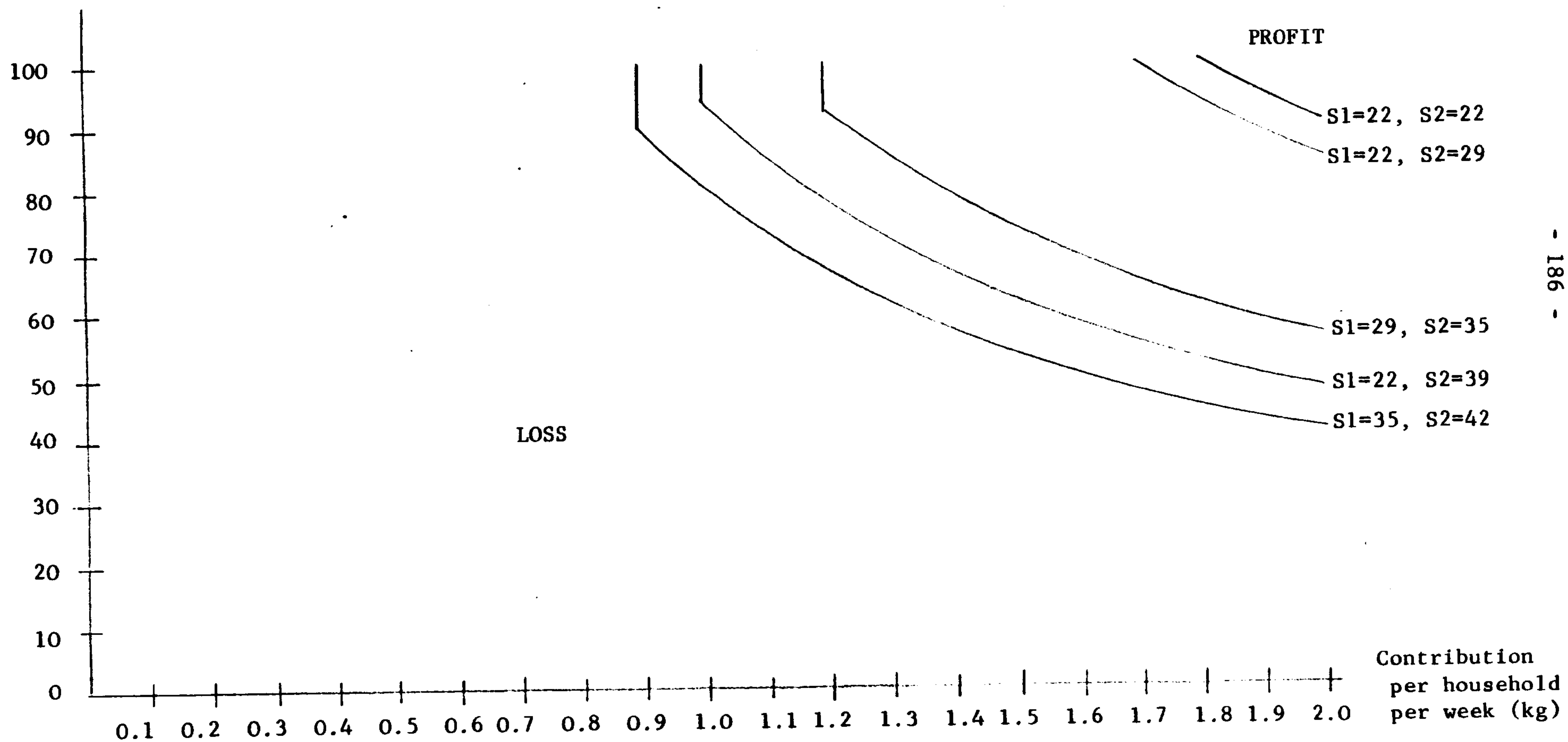
* An example of an average participation rate and contribution level

This again reflects the importance of including all relevant costs and savings in a waste paper recovery operation before a true cost can be obtained.

7.3 Investment appraisal for a proposed waste paper recovery scheme

Once a waste paper recovery scheme has been implemented and is on-going, capital investment has been committed and both loan repayments as well as operating costs have to be made. Therefore, before a local authority embarks on a waste paper recovery scheme, it will have to consider whether the anticipated revenue and savings from the scheme in future years will justify the capital expenditure on collection vehicles and baling plant that has to be incurred at the outset.

Figure 7.3 - Break even boundaries
(Savings in refuse disposal, indirect cost and savings excluded)



7.3.1 DCF method of investment appraisal

Discounted cash flow (DCF) technique of investment appraisal has been commonly accepted in both the public and the private sectors since it enables a more informed choice to be made in circumstances where cash flows of different sizes, occurring in different time periods, need to be compared.

In an investment sense, resources used now instead of in a year hence, displace a year's investment in productive use. So by consuming today society looses the goods that the investment would have produced in that year. The technique therefore involves the discounting of future cash flows, C_t for each year of the life of the project of N years, to a current or base year by using a certain discount factor r, to give what is known as the present value. The discount factor is, in fact the interest paid on the money deposited in a savings account had it not been invested. The discounted net revenue for each year is then summed up to determine the net present value (NPV) of the project. The net present value (NPV), measured in cash units (for example £'s) is then given by

$$NPV = \sum_{t=0}^{t=N} \frac{C_t}{(1 + \frac{r}{100})^t}$$

Cash flows are positive if they are in-coming and negative when out-going. A negative NPV means that a net loss is incurred in the scheme. The decision on whether to proceed with the scheme depends on whether the net present value is positive or negative. If a positive NPV is obtained the scheme should proceed, except in circumstances where the local authority has a limited capital budget and alternative schemes give a higher NPV per pound of capital invested.
If the local authority is also considering whether to recover waste paper or to dispose off the waste by other means which requires say, land for landfill or building a new incinerator, discounted cash flow technique will allow the NPV of each alternative to be determined and compared, and

the alternatives are then ranked in order of viability by their net present values. The project with the highest net present value, or lowest net present cost, will be preferred.

Capital expenditure considered are only those needed for the proposed scheme. No account need be taken of any capital expenditure of previous investment decision, however recent or expensive.

The scheme's expenditure and revenue flows based on the direct cost and revenue components and indirect costs and savings discussed earlier (para 7.1.1) have to be estimated for each year of the investment period. This period is usually the expected economic life of the largest element of capital plant that has to be purchased.

7.3.2 Inflation

The increase in the general level of prices over time has an important effect on the financial viability of the proposed waste paper recovery scheme, since it is unlikely to affect all expenditure and revenue flows in the same way. If a long term contract is maintained with a mill, stipulating only a minimum guarantee price, the guarantee price will decrease in real terms over the period of the contract as price inflation increases.

In previous years labour costs have increased at a rate far greater than that of general prices. Only in the last two years has labour cost increased at a slower rate than inflation.

It is extremely difficult to estimate the future rate of general price increases. One way to go round the effect of inflation is to evaluate the scheme in constant price terms. In this way only estimated relative price changes that affect the scheme, rather than changes in current money prices which incorporate the inflation rate, will need to be incorporated into the estimates. In general, costs associated with the scheme are assumed to rise in line with general price level so that their relative prices will remain constant. If the general cost of labour increases at a rate of 2 percent faster than general prices over the investment period, then only the labour cost components will have to be increased by 2 percent annually.

7.3.3 Treatment of depreciation and interest

In DCF techniques, capital expenditure is included in the year in which it is incurred. In many cases this will be at the beginning of the scheme or the base year, and the amount of capital expenditure can be known with a reasonable degree of certainty. With capital expenditure treated in this way it will not be correct then to include in the economic evaluation, the depreciation provisions paid to service that capital in subsequent years, since depreciation provision is just a book-keeping adjustment of treating capital expenditure to spread the capital costs over the whole life of the project. Depreciation is therefore omitted, because the DCF technique serves to bring all cash flows to a single point in time and it will not be appropriate to use a depreciation provision which effectively has the reverse effect.

The use of discount rates in DCF evaluation serves the same purpose as including interest charges in the estimated expenditures. Interest rates and discount rates both adjust future cash flows in order to bring them on to a comparable basis. Interest rates do this by compensating the lender for his 'loss' resulting from having his purchasing power put back to a later time period. The discounting process converts future cash flows into their present value equivalent. The two methods are therefore alternatives and to use both would be double-counting.

7.3.4 Sensitivity analysis

Any investment appraisal requires predictions about the future. The amount of waste paper available is based on forecasts of wastes arising in an area and the cash flows are based on future changes in relative costs and prices where there may be large areas of uncertainty about their magnitude. That a right decision is made depends to a large extent on the forecast being correct. Fluctuations in the large items such as revenue and wages will have a significant impact on the profitability of the scheme. For example, if the local authority has assumed that labour cost increases in line with general price increases, what will happen to the estimates if the labour cost increases at 3 percent higher rate than general price levels ? In order to reduce the uncertainty of the estimates used in the investment appraisal sensitivity analysis must be performed on the estimates to check the influence on the net present value to ensure that the scheme will be viable in a range of foreseeable circumstances, as once the capital investments are committed, the operation started, there will be considerable difficulties in terminating the scheme.

7.4 Applying the investment appraisal model

Many of the characteristics of the hypothetical local authority (HLA) (para 7.2.1) are used in the investment appraisal. Two additional factors have to be considered here, the length of the investment period and the discount rate to use.

7.4.1 Length of investment period

The length of the investment period is generally the working life of the highest value asset. A medium size baling system with 3 to 4 tonnes per hour capacity and the plant will together costs about £60,000 (1980 prices). The average working life of the baling system and plant is about 10 years.

Collection vehicles are normally used for about 8 years before replacement but local authorities have extended the working life of collection vehicles for waste paper to 10 years. Most of the Department of Environment's evaluation of waste management projects have also been based on a 10 year investment period. For this model, the project life is therefore assumed to be 10 years with capital investments made in year 0.

7.4.2 Choice of a discount rate

Traditionally, economists can choose between using two discount rates. One, the social time preference (STP) rate, is based on the amount of consumption necessary in the future to compensate society for the sacrifice of consumption in the present. This rate is difficult to determine, but Bird & Mitchell(1979) set this rate at about 3 percent per year.

The alternative approach is to use a social discount rate, which is the more commonly used discount rate for investment appraisal in the public sector. The role of the discount rate is to ensure the correct allocation of investment resources between the public and private sectors of the economy. Where investment funds are limited, investment in the public sector of the economy can displace investment undertaken by the private sector. Since it is rare that society will direct funds from a high return private sector project to a low return public sector project, it can be argued that the same discount rate be used in the public as in the private sector. The discount rate to be used in public sector appraisal is the 'social opportunity cost' of the investment funds. The social opportunity cost (SOC) discount rate is set to the real rate of return on marginal low risk projects undertaken by private industry on the rationale that this will be what the money can earn if it has not been invested in the public sector projects. Despite it not being a totally satisfactory measure of social opportunity cost, its definition suggests that the social opportunity cost rate is higher than that usually taken to reflect social time preference (STP).

In Britain, all public sector investments are evaluated using the Treasury test discount rate, which is set periodically as the SOC. It should be noted, however, in practice the test discount rate is used, not to decide on the amount of public expenditure, but to choose between alternative ways of doing the same thing or to determine the composition of an investment programme within a budget constraint.

Besides these two social discount rates, the local authority can use a commercial rate of return and the interest rate at which the authority may borrow.

DOE(1976B) recommended the use of 10 percent discount factor but WMAC(1979) subsequently used a 5 percent discount rate following the publication of the government's White Paper on the Nationalised Industries (Cmnd 7131). Although the House of Commons Debates, 5 April 1978 agreed with 5 percent as the opportunity cost of capital to justify in economic terms the commitment of national resources, the use of this discount rate for the assessment of expenditure on waste management is, however, still subject to agreement between the Department of Environment and local authorities.

7.4.3 Computer runs

Figure 7.4 shows the algorithm of the investment appraisal model. Details of the program listing, in FORTRAN, is shown in Appendix IX. Details of the algorithm of the program, sample inputs and specimen results are also shown in Appendix IX (Tables AIX 5, 6 and 7).

The program reads in a certain householders participation percentage and contribution input to calculate the cash flow and the NPV that can be obtained, based on a

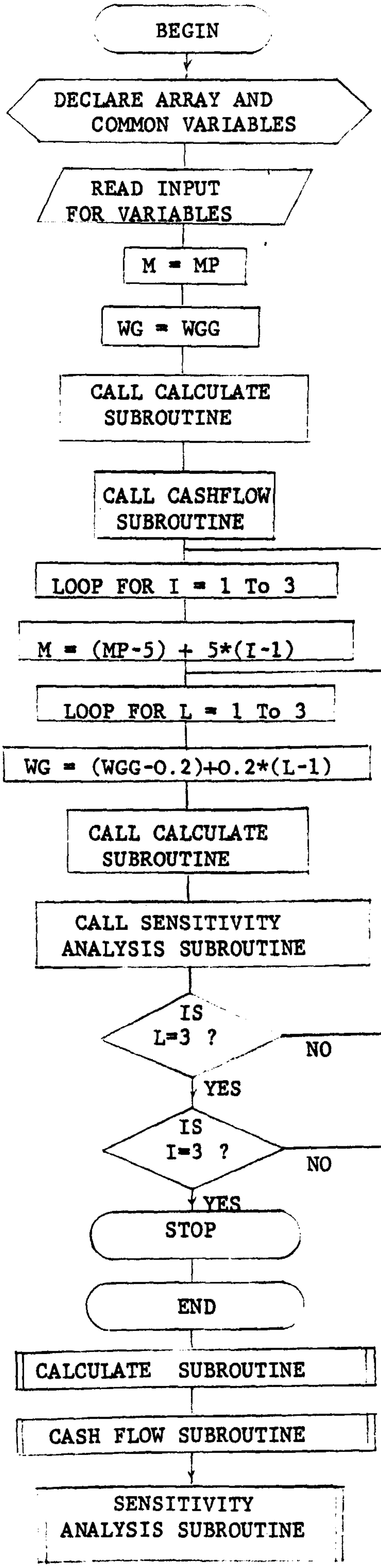


Figure 7.4 - Algorithm of the investment appraisal model

a 5 percent discount factor. A sensitivity analysis is then performed and tables are printed for various discount factors from 0.5 percent to 7.5 percent increasing in steps of 0.5 percent. Participation ratio is also changed by ±5.0 percent and the average contribution rate is changed by ±0.2 kg.

The sensitivity analysis also allows the local authority to check on the effect of labour cost when it is changing at a rate different from the general price levels.

The Public Works Loan Board interest rate is 13.82 percent. If inflation is assumed to be 11 percent per annum, in real terms the interest rate is only 2.82 percent, approximately 3 percent. Table 7.4 shows the NPVs computed for discount factors of 3 percent and 5 percent.

At the 5 percent discount factor, when the prices of waste paper is only £22 per tonne, only a 45 percent participation level and an average contribution of 1.4 kg per premise per week is required to get a positive NPV. But at the highest price paid in 1980/81, even a 35 percent participation and an average contribution of 1.2 kg per premise per week is sufficiently to get a positive NPV. When the discount factor is only 3 percent, a 40 percent participation at 1.4 kg per premise per week will be able to give a positive NPV at the price level of £22 per tonne. The table will allow the local authority, before embarking on a scheme, to assess the level of participation and contribution needed to get a minimum positive NPV at a certain discount factor.

Table 7.4 also shows that the NPV is very sensitive to changes in participation rate and contribution rate. For example at the £22 per tonne price level, at 45 percent participation rate, a different of 0.2 kg per household can change the NPV of -£8,800 to £29,500. The NPV is also sensitive to price levels. A 10 percent increase in waste paper price can make a negative NPV positive.

Table 7.4 - Summary of sensitivity analysis tables for investment appraisal model

5% Discount Factor (labour cost increasing at the same rate as general prices)

Partici-pation %	Contribution per household per week (kg)	Minimum guaranteed price S1 = £22/tonne S2 = £22/tonne		Highest prices in 1980/81 S1 = £29/tonne S2 = £35/tonne		Highest prices in 1980/81 + 10 percent increase S1 = £32/tonne S2 = £39/tonne	
		C1	C2	C1	C2	C1	C2
35	1.0	-89.5	-120.7	-17.0	-48.2	12.2	-19.0
	1.2	-59.8	-106.8	18.6	-28.4	50.2	3.2
	1.4	-30.0	-92.9	54.2	-8.6	88.2	25.3
40	1.0	-68.3	-110.8	8.4	-34.1	39.3	-3.2
	1.2	-34.3	-94.9	49.1	-11.5	82.8	22.2
	1.4	-0.3	-78.9	89.8	11.2	126.2	47.5
45	1.0	-47.0	-100.8	33.9	-20.0	66.5	12.7
	1.2	-8.8	-82.9	79.7	5.5	115.3	41.2
	1.4	29.5	-65.0	125.5	31.0	164.2	69.7
3% Discount Factor							
35	1.0	-89.4	-123.8	-9.3	-43.8	23.0	-11.5
	1.2	-56.5	-108.5	30.1	-21.9	65.0	-13.0
	1.4	-23.6	-93.1	69.4	0	106.9	37.5
40	1.0	-65.9	-112.9	18.8	-28.1	53.0	6.0
	1.2	-28.3	-95.3	63.8	-3.1	100.9	34.0
	1.4	9.2	-77.7	108.8	21.9	148.3	62.0
45	1.0	-42.4	-101.9	46.9	-12.5	83.0	23.5
	1.2	-0.2	-82.1	97.5	15.6	136.9	55.0
	1.4	42.1	-62.3	148.1	43.8	190.9	86.5

Note : C1 - Full accounting with savings in waste disposal, indirect cost & savings included
C2 - Savings in waste disposal, indirect cost & savings excluded

Table 7.4 also shows the effect on the NPV when savings in waste disposal, savings in waste collection and loss in trade income charges are omitted. Without the full costing which includes all relevant cost elements the local authority will find so many cases of a negative NPV that they will never launch a waste paper operation. When the relevant indirect costs and savings are omitted the local authority will arrive at the wrong participation rate and contribution rate and at such a low NPV that they will be discouraged from launching a waste paper recovery scheme. Again, this emphasised that all the relevant elements of the full costing must be included in the investment appraisal before the local authority could make the correct decision.

8 - Demand for waste paper

8.1 Rationale for using waste paper in the mills

Over 90 percent of the wood pulp consumed by UK mills is imported, while overseas integrated mills have the advantage of producing their paper and board from its own source of wood pulp. Using imported wood pulp in the smaller scale of production in UK, the margin between the price of imported pulp and the cost of importing finished product from overseas becomes very small. To remain competitive many mills has converted to use waste paper because of its generally lower cost compared to equivalent wood pulp. It is in fact this relative cheapness of waste paper as a raw material which has allowed a large number of British mills to remain competitive.

Compared to an integrated wood pulp mill, a recycling mill requires lower capital investment and uses less energy per tonne of output. A major reason for the lower cost is the much cheaper cost of effluent treatment plant. In addition, a recycling mill comes into production much faster thereby giving an earlier return on investment.

Profit margins in the mills are rather low and it is cheaper to convert existing machine to produce secondary fibre based products than to invest on new machines. In 1976, the cost of a single modern machine was £15 million but the cost for adapting an existing machine to use secondary fibres was only £7 to £9 million (Wray & Nation,1977). Reed's Aylesford mills spent £5.5 million in 1976 to rebuild a newsprint machine so that in the following year they could produce about 50,000 tonnes of paper per annum for the corrugated container industry using secondary fibres. This gave them pulp import savings of £7.5 million a year. The rising demand in the early 70s for packaging grade papers also encouraged Bowater to rebuild a newsprint machine in their Mersey Mills to produce disposal paper sacks and fluting medium from secondary fibres.

Mills using waste paper as raw materials are independent from market pulp supply and has the advantage of domestic supply of waste paper. Paper products made from secondary fibre also has special properties which are desirable such as greater dimensional stability, less tendency to curl, better retention of size and fillers, increased opacity, more uniform formation and better reproduction of imprint and colours.

8.2 The recycling mills in UK

LAMSAC(1975) listed 70 paper and boards which used waste paper as a raw material in some form or another (Appendix X). Among this group of mills, there are four major users of waste paper, Bowaters UK Paper Co Ltd, Davidson Radcliffe Ltd, Reed Paper and Board (UK) Ltd and Thames Board Mills Ltd. Together they recycle about 50 percent of the total waste paper consumption in UK. Between 1979 to 1981, cheaper foreign imports, low productivity, high labour and energy costs together with the recession, forced 24 mills with 63 machines to be taken permanently out of commission. Annual consumption of waste paper was estimated to be reduced by about 245 thousand tonnes per annum.

8.3 Utilisation rate of waste paper in UK

There is some confusion in the definition of the utilisation rate of waste paper. For some it is a measure of the percentage attributable to waste paper volume in total paper and board production while for others it is the amount of waste paper consumed measured as a percentage of total fibre used in paper and board production. Unfortunately in many reports, it is not always clear which basis is used. In this thesis the latter definition of utilisation rate has been adopted since waste paper is a source of secondary fibre and the measure of its consumption against total fibre consumption is more consistent. This is also in line with the definition used in FAO publications.

Waste paper consumption has been on the increase since 1952 from 835.4 thousand tonnes to 2,069.8 thousand tonnes in

1973. But between 1973 and 1980, waste paper consumption has fluctuated between 2.0 to 2.1 million tonnes, except for the disastrous slump in 1975 when consumption dropped to 1,703.8 thousand tonnes, a drop of 20 percent over the previous year's consumption (Table 8.1).

Comparing utilisation rate with recovery rate of waste paper, recovery rate has always been lower than utilisation rate (Figure 8.1). Recovery rate has been increasing rather slowly from 26.4 percent in 1967 to 31.5 percent by 1980, at an average rate of 1.3 percent per annum. Increase in the utilisation rate in 1956 to 1967 period has been slow, at an average of 0.9 percent per annum. But it picked up after that and in the 14 years from 1967 to 1980 utilisation rate has been increasing rapidly at an average rate of 3.2 percent per annum. The rapid increase in utilisation rate is due to the fact that while total fibrous materials consumption for paper and board production has been falling since 1969, the amount of waste paper consumed has been increasing.

8.4 Consumption of waste paper by groups

Consumption of the higher groups of waste paper by the mills has been fairly consistent (Table 8.2, Figure 8.2). Group 1 consumption averaged around 18.9 thousand tonnes per annum during the fifteen years 1966 to 1980. Group 2 utilisation has been on a slightly upward trend since 1966, increasing on the average 1.3 percent per annum. Consumption in group 3 has, however, been on the decline falling from an annual consumption of 29.5 thousand tonnes in 1966 to 22.5 thousand tonnes by 1980, at an average rate of 1.9 percent per annum. Group 4 has experienced very rapidly increasing trends especially in the 1978 to 1980 period. From 1966 to 1978 the average rate of increase has only been 11 percent per annum compared to 39 percent per annum from 1978 to 1980. Consumption of group 5 (over-issue news, etc) has been increasing only slightly since 1966, at an average of 3 percent per annum.

Table 8.1 - Utilisation rate of waste paper in British mills

Year	WPCS	PULP	OFMC	TFMC	UTRATE
1950	901.3	1384.9	1133.4	2518.3	35.8
1951	1014.0	1360.9	1298.1	2659.0	38.1
1952	835.4	1254.4	1082.1	2336.5	35.8
1953	927.8	1514.7	1140.2	2654.9	34.9
1954	1060.5	1694.7	1325.1	3019.8	35.1
1955	1114.1	1878.8	1344.5	3223.3	34.6
1956	1078.9	1906.6	1277.8	3184.4	33.9
1957	1113.3	1973.6	1269.0	3242.6	34.3
1958	1188.1	2025.8	1328.2	3354.0	35.4
1959	1245.8	2089.7	1409.6	3499.3	35.6
1960	1361.2	2337.4	1550.9	3888.3	35.0
1961	1376.0	2305.7	1528.0	3833.7	35.9
1962	1371.6	2257.9	1535.5	3793.4	36.2
1963	1442.7	2359.4	1592.2	3951.6	36.5
1964	1538.1	2537.6	1616.3	4153.9	37.0
1965	1624.7	2635.3	1742.9	4378.2	37.1
1966	1592.1	2541.0	1725.6	4266.6	37.3
1967	1593.1	2480.2	1779.8	4260.0	37.4
1968	1793.2	2527.3	1906.2	4433.5	40.4
1969	1855.8	2627.4	2052.9	4680.3	39.7
1970	1946.5	2539.6	2100.7	4640.3	41.9
1971	1835.2	2144.0	2044.4	4188.4	43.8
1972	1881.1	2084.6	2033.5	4118.1	45.7
1973	2069.8	2189.4	2187.5	4376.9	47.3
1974	2121.8	2139.4	2206.8	4346.2	48.8
1975	1703.8	1630.8	1834.7	3465.5	49.2
1976	2056.6	1720.0	2147.9	3867.9	53.2
1977	2114.7	1683.0	2168.1	3851.1	54.9
1978	2109.1	1707.9	2090.7	3798.6	55.5
1979	2190.6	1706.9	2266.8	3973.7	55.1
1980	2014.5	1517.2	2052.2	3569.4	56.4

WPCS,PULP,OFMC,TFMC in '000 Tonnes(Source: Annual Abstract of Statistics)
WPCS = Waste paper consumption
PULP = Wood pulp consumption
OFMC = Other fibrous materials consumption
TFMC = Total fibrous materials consumption
UTRATE = Utilisation rate = (WPCS/TFMC)*100

Figure 8.1 - Comparing utilisation and recovery rates

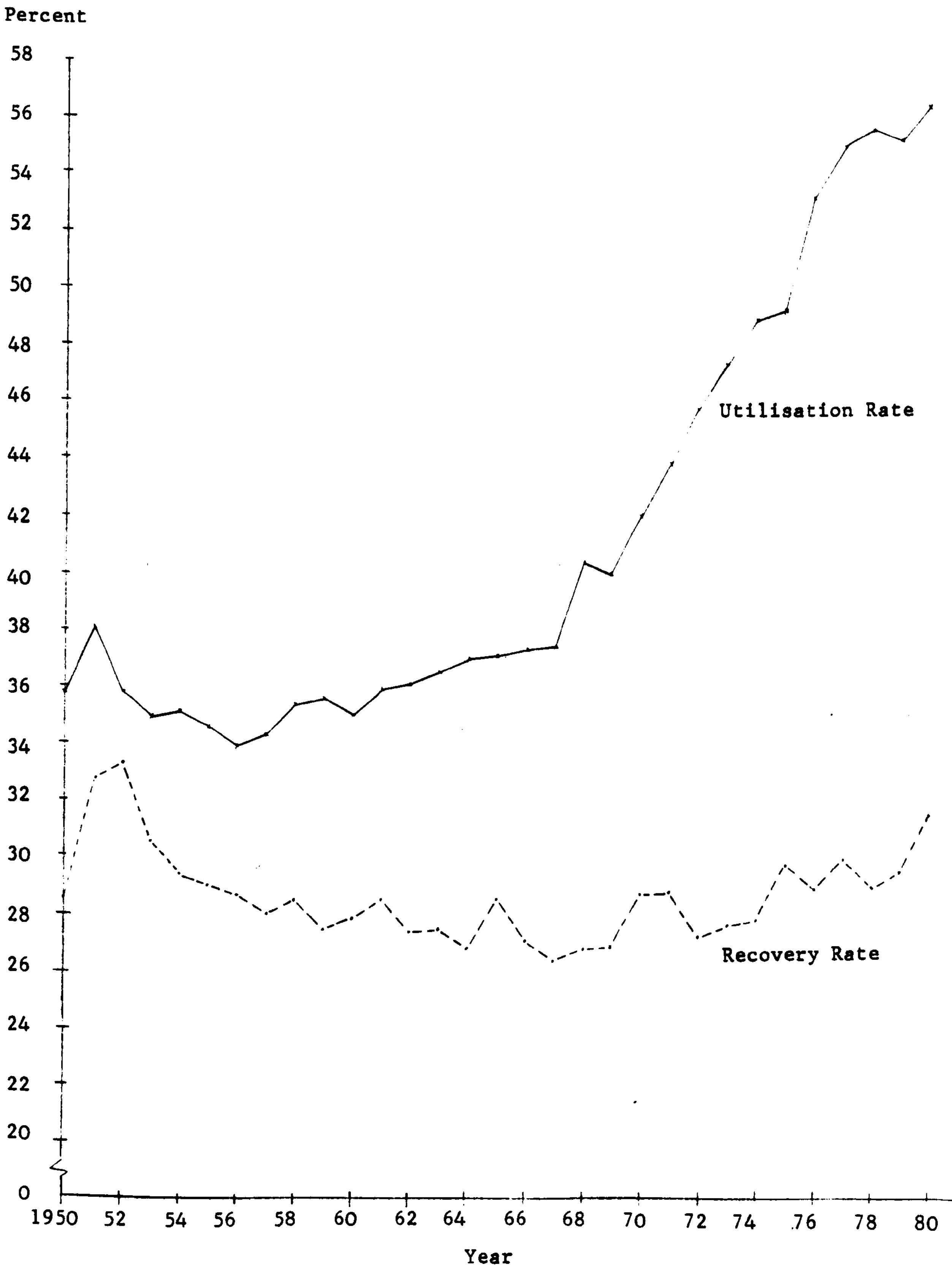


Table 8.2 - Paper mill annual consumption of waste paper by main groups
Source : Business Monitor P5, Paper & paper making materials

(Wt in '000 tonnes, air dry wt)

Group		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	Wt	18.0	18.8	19.4	16.9	17.7	20.4	17.5	20.4	23.4	17.2	18.1
	%	1.1	1.2	1.1	0.9	0.9	1.1	0.9	0.9	1.1	1.0	0.8
2	Wt	62.1	60.3	64.2	69.8	68.5	64.8	73.2	79.4	73.8	62.5	74.8
	%	3.9	3.8	3.5	3.8	3.5	3.5	3.9	3.8	3.5	3.7	3.6
3	Wt	29.5	33.6	31.4	34.1	35.6	31.7	33.7	31.6	27.9	26.2	24.2
	%	1.9	2.1	1.8	1.8	1.8	1.7	1.8	1.5	1.3	1.5	1.2
4	Wt	13.4	13.8	19.0	26.7	23.9	22.4	22.6	30.8	38.2	31.5	45.7
	%	0.8	0.9	1.1	1.4	1.2	1.2	1.2	1.5	1.8	1.8	2.2
5	Wt	139.5	144.7	163.4	175.5	205.9	196.8	183.3	196.5	224.7	157.5	173.4
	%	8.8	9.0	9.1	9.5	10.6	10.7	9.7	9.5	10.6	9.2	8.4
6	Wt	253.0	257.0	321.3	352.3	383.1	381.0	408.6	490.0	541.8	462.2	536.1
	%	15.9	16.1	17.9	19.0	19.7	20.8	21.7	23.7	25.5	27.1	26.1
7a	Wt	1046.8	1038.1	1136.8	1138.5	1169.3	296.9	287.6	333.5	364.0	249.2	363.5
	%	65.7	65.2	63.4	61.3	60.1	16.2	15.3	16.1	17.2	14.6	17.7
7b	Wt						785.8	826.9	840.5	783.4	658.0	773.9
	%						42.8	44.0	40.6	36.9	38.6	37.6
8	Wt	29.8	27.5	37.9	42.2	42.6	35.4	27.7	47.1	44.6	39.3	46.4
	%	1.9	1.7	2.1	2.3	2.2	1.9	1.5	2.3	2.1	2.3	2.3
AG	Wt	1592.1	1593.1	1793.3	1855.8	1946.5	1835.2	1881.1	2069.8	2121.8	1703.5	2071.0
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 8.2 - Continuation
Source : Business Monitor PM481, Paper & paper making materials (in '000 tonnes, air dry wt)

Group			1977	1978	1979	1980	1981
1*	1**	Wt	19.6	19.1	18.6	19.1	24.3
		%	0.9	0.9	0.8	0.9	1.3
2	2	Wt	81.7	69.8	68.4	74.6	75.8
		%	3.9	3.3	3.1	3.7	3.9
3	3	Wt	22.1	24.4	23.0	22.5	18.8
		%	1.0	1.2	1.0	1.1	0.9
4	4	Wt	54.4	49.4	59.3	95.8	123.6
		%	2.6	2.3	2.7	4.8	6.3
5	5	Wt	177.1	185.1	202.2	222.6	182.4
		%	8.4	8.8	9.2	11.1	9.4
6	6	Wt	92.1	91.3	86.9	71.0	63.8
		%	4.4	4.3	4.0	3.5	3.3
6	7	Wt	255.6	261.6	287.7	260.4	268.4
		%	12.1	12.4	13.1	12.9	13.8
7a	8	Wt	521.2	528.0	555.6	496.3	530.1
		%	24.6	25.0	25.4	24.6	27.2
7b	9	Wt	841.9	838.1	847.6	699.8	615.8
		%	39.8	39.7	38.7	34.7	31.7
8	10	Wt	49.1	42.3	41.5	52.5	42.5
		%	2.3	2.0	1.9	2.6	2.2
	AG	Wt	2114.7	2109.1	2190.6	2014.5	1945.5
		%	100.0	100.0	100.0	100.0	100.0

Note : Group coding up to 1976 consisted of 8 main groups, of which group 7 was subdivided into 7a and 7b, for container waste and mixed waste respectively.

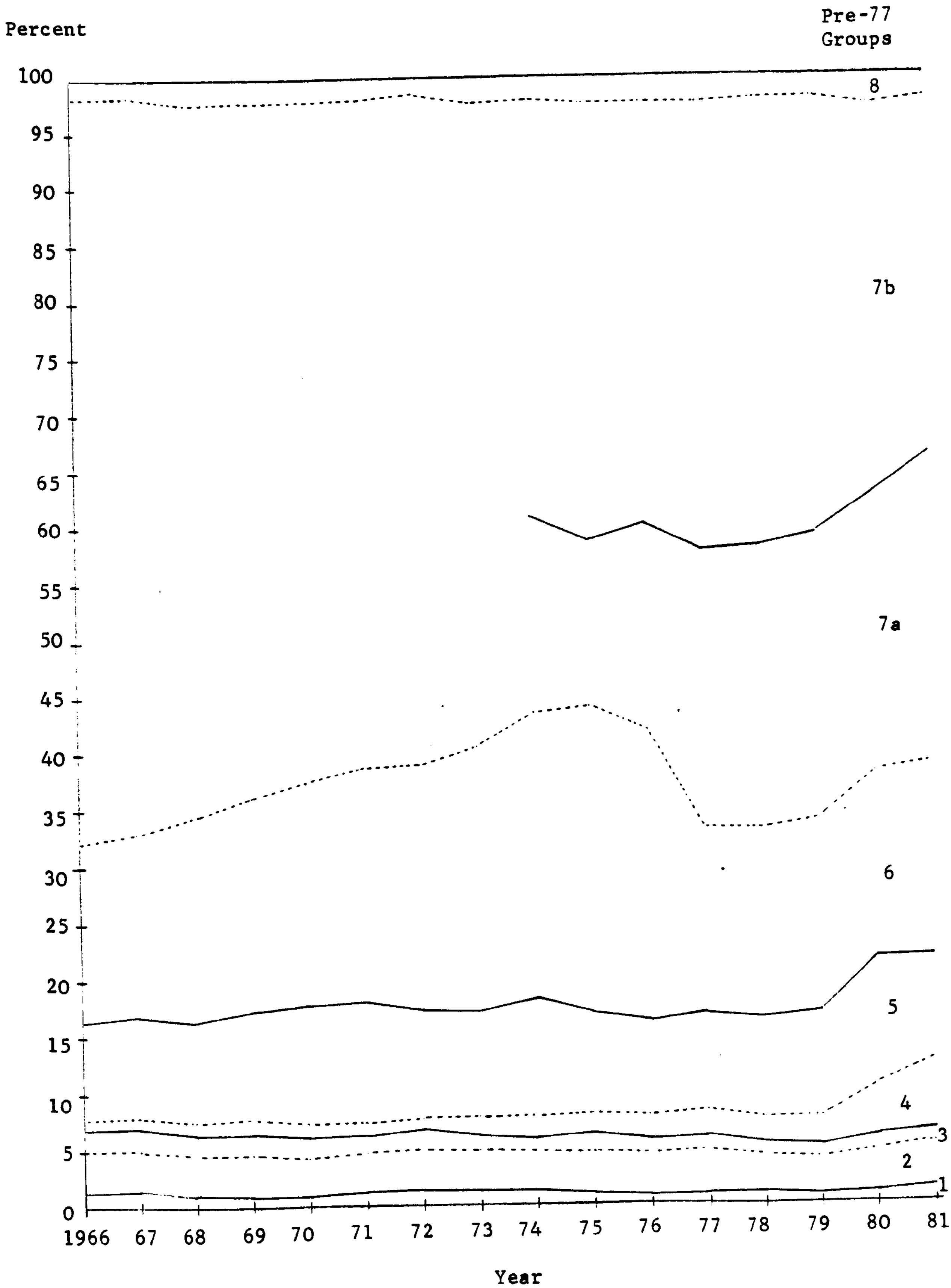
With effect from 1977 the group coding was divided into 10 main groups with the changes from old group 6 onwards :

*Old	**New
6	6, 7
7a	8
7b	9
8	10

From 1966 to 1970, both 7a and 7b were included under 7a

AG = Total consumption of all groups

Figure 8.2 - Consumption of waste paper by main groups



Among the 8 major groups (Pre-77 coding) group 7, mixed waste and container waste, is most widely used. Average consumption in 1966 to 1981 was 60 percent of total consumption of waste paper. This group of waste paper is the major raw material used in recycling board grade products and has no economic substitute. The trend of consumption before the 1975 slump was gradually upwards increasing at an average of 1.1 percent per annum. After the slump in 1975 it picked up rather rapidly from an annual consumption of 907.2 thousand tonnes in 1975 to 1,363.1 thousand tonnes in 1977 and then to 1,403.2 thousand tonnes in 1979. The slump of 1980/81 again caused the consumption of this grade to drop to 1,196.1 in 1980, a decrease of 15 percent. Mixed waste consumption has so far never exceeded 850 thousand tonnes per annum. Container waste has been used in greater and greater quantities. The general trend for the usage of container waste is upwards from 296.9 thousand tonnes to 555.6 thousand tonnes, an average increase of nearly 5 percent per annum. The drop in consumption of mixed waste in the 1979/80 was much sharper than that of container waste, 17 percent compared to 10 percent. It may well be that mixed waste paper utilisation has more or less reached its maximum recycling level, and consumption would probably not exceed the 850 thousand tonnes level unless more machines which could utilise mixed waste paper as a raw material are converted or installed.

The next group that is widely used is group 6, kraft waste. This grade is in common use because of its strength properties and is used also in recycling into boards. Consumption was increasing from 15.9 percent of total waste paper consumption to 27.1 percent in 1975 but has then dropped to settle at about 17 percent of total consumption.

8.5 Products that can be made from secondary fibres

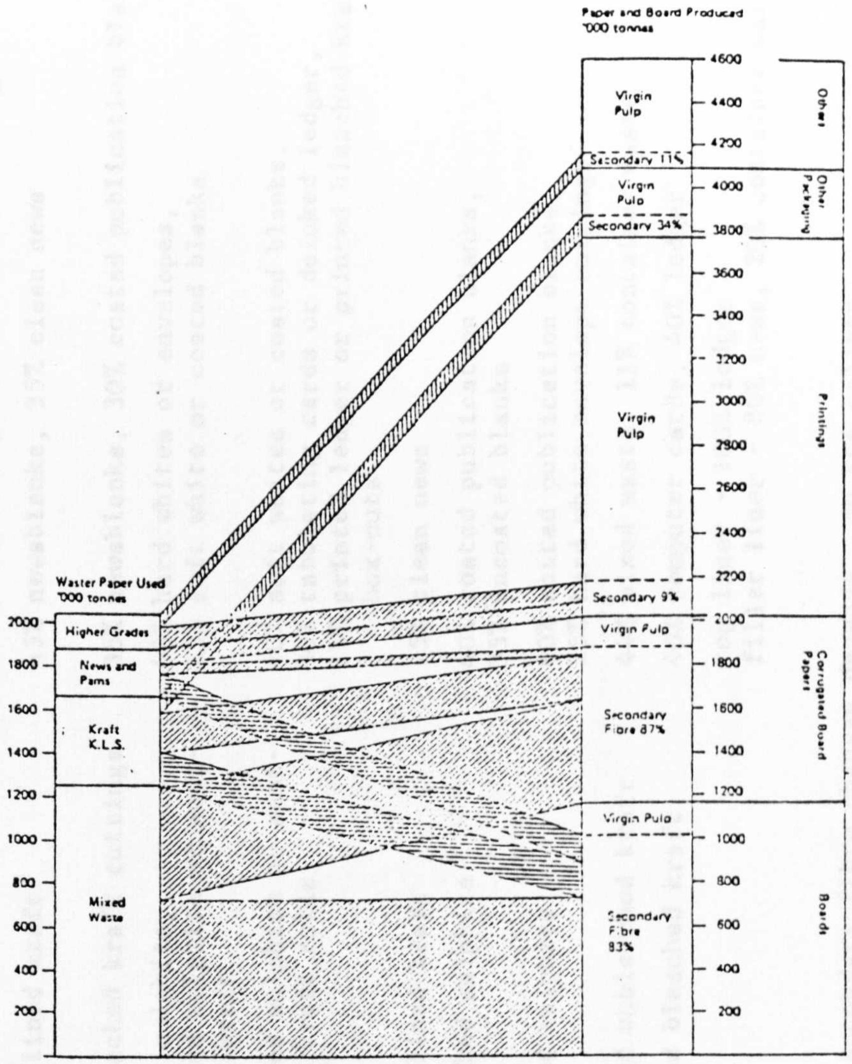
Most of the secondary fibres are used in boards, corrugated board papers and packaging materials. Rather small amounts of waste paper, mainly of the higher grades are used in printings. Figure 8.3 illustrates the main grades of waste paper collected and shows how they are utilised in the production of paper and board.

The type of paper products and the characteristics and properties of the final paper products depend on the pulp characteristics of the secondary fibre furnished to the paper or board machine. Secondary fibres obtained from the higher grades of waste papers (groups 1 to 4) have fairly accurately known characteristics but secondary fibres derived from local authority waste papers (group 7a & 7b) can have a wide range of pulp characteristics due to the heterogeneous nature of the constituent papers and boards. Commercial refuse collected from businesses, shopping centres and institutional sources tend to contain more high quality paper and board than residential refuse. Fibres recovered from commercial sources therefore generally exhibit strength properties superior to those fibres recovered from residential refuse, mainly because of the high proportion of kraft fibres and long fibres. Savage, et al(1978) noticed that the higher percentage of kraft fibres gave rise to a significant increase in the average breaking length of commercial recovered fibre, 2,765 m compared to 2,325 m of residential recovered fibres.

The large amount of newsprints that is present in the mixed waste collected from residential sources contain more brittle groundwood fibres and less chemical fibres than that from commercial sources. The short groundwood fibres give rise to the lower average freeness of pulp recovered from residential waste, and the high proportion of lignin present weakens the strength properties of the formed sheets.

Different grades of waste papers may be used to produce a particular product. Sometimes virgin fibre is used to upgrade the secondary fibres to give the caliper, formation, appearance and degree of stiffness required in the finished board. The actual secondary fibre content of individual grades of boards can vary considerably from a few percent to as much as 95 percent depending on the characteristics of the finish required by the customer (Tables 8.3, 8.4).

Figure 8.3 - Collection and utilisation of main grades of waste papers in UK, 1974
Source : Minshall(1978)



Main grades of waste papers	Collection, percentage by weight
Mixed waste papers and container waste	54.1
Kraft,sack and good quality corrugated case waste	25.2
Newspapers,periodicals and magazines	10.6
Rest of the higher grades	7.7
Others	2.4

Utilised in the production of	Percentage by weight
Boards	50.0
Paper for corrugated boards	35.0
Printing,writing & newsprint	7.0
Packaging other than corrugated and boards	5.0
Other papers including tissues	3.0

Table 8.3 - Some typical blends of fibres used for making paper and board
Source : Eckhart(1970), USEPA(1976), Iannazzi(1976), Holzhey(1981)

Product	Virgin fibre content	Secondary fibre content
Plain chipboard	25% doubled lined kraft	45% clean news, 30% box board cuttings
Newslined chipboard	20% doubled lined kraft	45% newsblanks, 35% clean news
White vat lined chipboard	35% semi-bleached kraft cuttings	35% newsblanks, 30% coated publication blanks
White lined board	25% bleached sulphite, 20% unbleached sulphite or semi-bleached kraft	40% hard whites or envelopes, 15% soft white or coated blanks
Underliner for a white lined folding carton	15% unbleached sulphite or semi-bleached kraft rolls	40% soft whites or coated blanks, 30% tabulating cards or deinked ledger, 15% printed ledger or printed bleached kraft box-cuts
Folding carton board	25% double lined kraft	75% clean news
Manilla folding carton back liner	25% unbleached sulphite	40% coated publication blanks, 35% uncoated blanks
Manilla white folding carton back liner	15% bleached sulphite	60% coated publication blanks, 25% hard white envelope cuttings
Roofing felt	45% softwood unbleached kraft	44% mixed waste, 11% container waste
Book paper	20% softwood bleached kraft	40% computer cards, 40% ledger
Folding box board	-	top liner - 100% ledger filler liner - 80% news, 20% container waste

Note : The ratio of virgin to secondary fibre changes depends on the caliper, formation or appearance and the degree of stiffness required in the finished product.

Table 8.4 - Various raw material combinations for producing a product
Source : Iannazzi, et al(1976), USEPA(1976)

Product	Made entirely from virgin fibre (100%)	Made entirely from secondary fibre (100%)	Made entirely from a blend of virgin and secondary fibres
Newsprint ($49\ g/m^2$)	75% groundwood 25% semi-bleached kraft or sulphite	No. 1 news	33% No. 1 news 67% virgin newsprint
Printing paper (uncoated)	65% groundwood 35% semi-bleached kraft or sulphite	80% No. 1 news 20% white ledger	41% groundwood 26% semi-bleached kraft 33% No.1 news
Toilet/facial tissues	50% hardwood bleached 50% softwood kraft	40% computer cards 40% white ledger 20% No. 1 news	33% deinking grades 67% softwood kraft
Kraft linerboard	80% softwood unbleached kraft 20% hardwood unbleached kraft	Container waste	20% container waste 80% softwood unbleached kraft
Semi-chemical corrugated medium	85% NSSC hardwood 15% kraft clippings	Container waste	33% container waste 10% kraft clippings 57% NSSC hardwood
Unlined chipboard	-	Mixed waste	-

8.6 Elasticity of demand for waste paper

Plaut(1978) reported detailed estimates for three US census regions, the North East, North Central and South and found that elasticity of demand for news was zero, for mixed waste varied from 0 to 0.05 while for corrugated waste varied from 0 to 0.21. Elasticity of demand is therefore even less responsive to price changes than supply. This is not surprising since the only major group of consumers for waste paper is the recycling mills. The mills control the price and price is related to the mills' demand for waste paper. When the mills have a large order to fulfil and they need waste paper they will increase the price to encourage waste paper recovery. Once their orders suffer a cut back and the mills sense a recession in the market they will try to run down their existing stock of waste paper rather than buy in new stocks. Waste paper will not be in demand and prices will drop. For certain grades like mixed waste and newspapers which has relatively limited usage, the price may drop drastically.

8.7 Forecasting the future demand for waste paper

Many local authorities and waste paper merchants have complained of the cyclical nature of the waste paper market and they have not been able to match supply with demand. A knowledge of the likely upturn of the cycle will help local authorities and various other collecting bodies to know when to step up their collecting activities to meet the increased demand. Since all these activities are controlled by many financial decisions in various parts of the industry and the local government, some views of the future demand will be of immense assistance.

Forecasting is a difficult and error-prone activity. Under the best of conditions, even short-range forecast is likely to contain significant errors and the longer the forecast period the more likely is the forecast to be wrong. All the commonly used approaches to forecasting are subject to limitation despite the development of various techniques to reduce the degree of error. This is because the only bases for forecasting is derived from past knowledge which is imperfect and incomplete. Events and conditions that are discontinuous with the past or at least not foreseen can arise to affect the forecast. Inspite of its frailty forecasting is necessary. In a rapidly changing environment forecasting will give some indication of the future. If forecasting is used iteratively, that is the forecast are periodically reviewed to bring in previously unforeseen elements, the inaccuracies can be somewhat reduced. Therefore, approached properly the grossest weakness can be minimised.

The British Paper and Board Industry Federation (BPBIF) uses the 'requirements' approach to determine what will be the most likely demand for waste paper 12 months ahead. Basically, the Federation circulates a questionnaire to its member mills asking them what their likely requirements will be for a forward period. The information required includes both the projected capacity and the actual expected usage of waste paper. The 'requirements' approach used to forecast future demand for waste paper has a number of well known deficiencies all of which lead to overstating the future demand. Each mill has a tendency to introduce some safety margin and thus overstates its demand. This is at times done because of the uncertainty of future orders and at times done with the expectation that should government planning be based on these estimates then the future policy planned may be directed towards ensuring that future supply meets the projected demand. So if the overstated projection is met there will be larger future supplies and it will result in a relatively lower price than would otherwise be. In times of a bouyance market optimistic projection of future orders also helps to overstate the predicted demand. A long term forecast by the Federation made in 1974/75 for 1980 gave a projected requirement of around 3.2 million tonnes of waste paper, a 52 percent increase over the 1974 consumption of 2.12 million tonnes, implying an average 5.7 percent increase each year compared to the average increase over the last 15 years from 1960 to 1974 of only 3 percent per annum. The projected increase was also made against the background of a paper and board production level which was 4,138.4 thousand tonnes in 1960 but increased to only 4,635.8 thousand tonnes in 1974, a production rate which increased on the average of only 0.8 percent per annum. Consumption in 1980 turned out to be just over 2 million tonnes. The regression method has been used by Deadman & Turner(1979) to forecast the demand for waste paper. In their short term forecast they arrived at a relation which projected the total demand of waste paper based on 1 variable, the Gross Domestic Product (GDP). Comparing their forecast demand with actual demand during the 1976 to 1978 period produced errors ranging from -2.5 percent to 11.4 percent. The proportion of variance explained by the GDP in their relation (R^2) was only 48 percent, which indicated that there could be other variable(s) which should be considered.

As earlier models for forecasting the future demand for waste paper were not suitable, other models which could give a better forecast have to be developed. The following sections describe two models which were developed in the course of this research to give a better forecast in the short term.

8.7.1 Short term forecast of demand for all grades of waste paper (the SFAG model)

The total consumption of waste paper includes the consumption of the higher grades (groups 1 to 4) which are pulp substitutes for mainly chemical pulp, the consumption of group 5 waste paper (the over-issue news and pams) which is a substitute for mechanical pulp. Therefore both chemical pulp consumption and mechanical pulp consumption will influence the consumption of the pulp substitute grades of waste paper and hence the total consumption of waste paper. The total consumption of waste paper is also influenced by the total output of paper and board. A short term forecast for the total consumption of waste paper should include these variables. The time horizon for a short term forecast for the

UK paper and board mills is usually 12 to 18 months. Within this time frame the mills should know what production figures in their order books have to be met, and what tonnages of chemical and mechanical pulps they have in stock and hence how much of these pulps will be used.

Since statistics published for the production of paper and board earlier than 1972 have different definitions and offered no comparison with data published after that, only data from 1972 could be used in a regression analysis. A multiple regression of the total waste paper consumption based on quarterly data from the first quarter of 1972 to the last quarter of 1979 gave the following equation, for simplicity, called the SFAG relation.(short-term forecast of all grades)

$$Y = -190 + 2.07X1 - 0.509X2 - 0.845X3 + 0.706X4$$
$$(-2.43) \quad (2.47) \quad (-3.27) \quad (-2.92) \quad (12.63)$$

$F = 137.45$

$R^2 = 95.3$ percent

Durbin-Watson statistic = 1.69

where

Y = forecast for total waste paper consumption

X1 = quarterly Gross Domestic Product Index, Expenditure data, (1975 prices) with 1975 = 100

X2 = chemical pulp consumption in each quarter ('000 tonnes)

X3 = mechanical pulp consumption in each quarter ('000 tonnes)

X4 = total paper and board production in each quarter ('000 tonnes)

t value for each coefficient is in parenthesis

The F value of 137.45 compared to the table value of 2.73 for $F_{4,27}$ at 95 percent confidence level, showed that a statistically significant relationship existed between the total waste paper consumption and the independent variables.

The high R^2 indicated that 95.3 percent of the variance was explained by the four variables in the relation.

The t ratio for each of the coefficients showed that each of them differed significantly from zero at the 95 percent confidence level, when compared to the t - table value of 2.05 at 95 percent confidence level for two tail test.

The Durbin-Watson statistic of 1.69 lied between the lower limit of 1.18 and upper limit of 1.73 at the 95 percent confidence level and therefore the test was inconclusive. But when actual values of unadjusted GDP values in £m (at 1975 prices) were used for a similiar multiple regression a Durbin-Watson statistic of 1.90 was obtained indicating no serial auto-correlation exists in the data. The SFAG relation showed that waste paper consumption increased with the gross domestic product and the total production of paper and board. More waste paper was also consumed when the amount of chemical pulp and mechanical pulp consumed was reduced. When the SFAG relation was used to compare the forecast value with the actual values from the first quarter of 1972 to the fourth quarter of 1979, percentage error varied from -4.3 to 3.8 percent and the turning points were followed very closely (Table 8.5 and Figure 8.4).

When the SFAG relation was used to forecast the 1980 and 1981 quarterly values, rather good predictions were obtained, with the highest error of only 8.6 percent (Table 8.6). Most mills keep stocks equivalent to about 5 to 7 weeks' consumption, though the bigger mills may keep stock up to 10 to 15 weeks' consumption. This means that at least 10 percent of the annual consumption is in stock. Errors up to 10 percent can therefore be adjusted through the stocks held by the mills but above all, the most important factor, however, was that the predicted values were able to follow the turning points very closely.

Deadman & Turner(1979) besides using simple regression also used the Holt-Winters method and a modified

Table 8.5 - Comparing the actual consumption with the forecast consumption derived by the SFAG relation, from 1972 Q1 to 1979 Q4 (in '000 tonnes)

Period	X1	X2	X3	X4	Forecast	Actual	% error
1972 Q1	93.6	409.5	119.2	1093.2	466.4	472.3	1.2
Q2	94.0	427.5	100.2	1113.9	488.7	477.9	-2.3
Q3	93.8	386.5	99.8	1020.3	443.4	447.9	1.0
Q4	96.3	435.2	106.8	1110.0	481.3	483.0	0.4
1973 Q1	103.3	457.6	108.7	1236.6	572.2	548.8	-4.3
Q2	101.6	455.6	110.5	1212.3	551.0	538.9	-2.2
Q3	101.5	454.2	99.9	1051.2	446.6	459.6	2.8
Q4	100.2	446.2	104.5	1171.8	529.3	522.5	-1.3
1974 Q1	98.7	460.1	112.6	1189.8	525.0	540.7	2.9
Q2	101.2	454.4	107.8	1221.3	559.4	554.5	-0.9
Q3	102.7	397.6	94.5	1055.1	485.3	497.6	2.5
Q4	99.8	426.8	85.8	1131.3	525.5	529.0	0.7
1975 Q1	99.1	371.1	68.6	921.6	418.9	411.3	-1.9
Q2	100.7	339.9	71.4	913.2	429.9	418.8	-2.6
Q3	99.2	321.7	59.3	852.9	403.7	407.5	0.9
Q4	101.0	339.2	59.7	946.2	464.0	466.0	0.4
1976 Q1	104.3	361.2	63.0	1011.3	502.8	495.2	-1.5
Q2	102.8	370.5	63.5	1056.0	526.1	516.8	-1.8
Q3	104.4	340.4	57.9	954.0	477.4	462.6	-3.2
Q4	105.6	395.3	68.1	1130.1	567.7	581.4	2.4
1977 Q1	103.9	402.8	68.9	1133.1	561.8	584.1	3.8
Q2	105.0	368.7	71.2	1070.4	535.2	545.2	1.8
Q3	105.1	317.9	55.6	910.2	461.4	464.8	0.7
Q4	107.5	338.0	60.0	999.9	515.7	520.6	0.9
1978 Q1	107.1	365.7	69.3	1045.8	525.3	535.0	1.8
Q2	109.0	391.6	60.8	1099.5	561.2	553.6	-1.4
Q3	108.6	345.1	54.6	970.5	498.2	484.7	-2.8
Q4	109.3	362.4	56.9	1049.4	544.6	535.8	-1.6
1979 Q1	106.9	376.6	62.0	1074.3	545.7	549.7	0.7
Q2	111.3	387.2	62.7	1111.8	575.2	573.9	-0.2
Q3	108.8	337.8	57.5	986.7	511.3	514.1	0.5
Q4	109.7	362.8	60.4	1049.1	542.1	552.9	2.0

Figure 8.4 - Forecast cycles and actual cycles for consumption of all grades

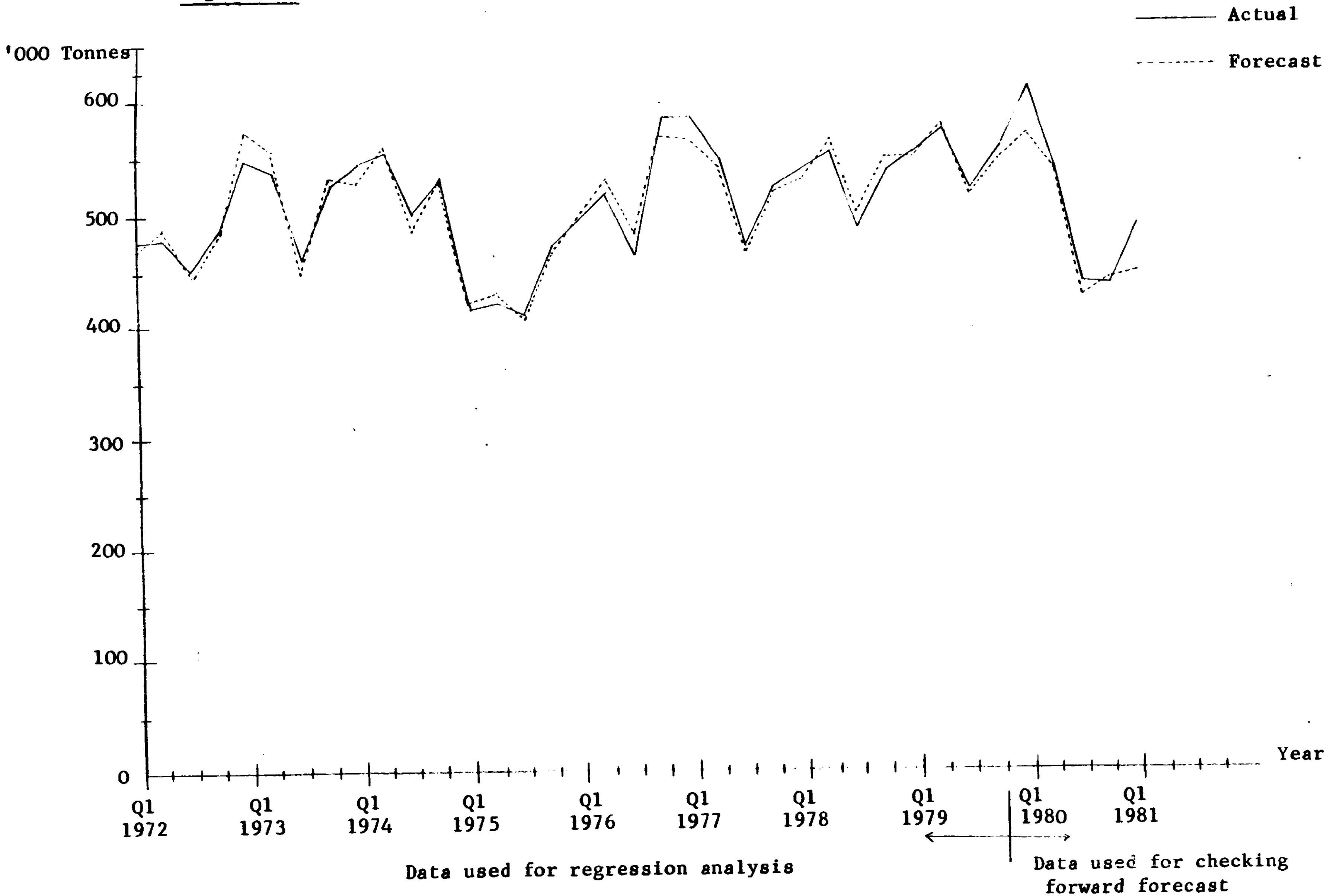


Table 8.6 - Forecast of waste paper consumption using the SFAG relation for 1980 to 1981

Period		GDP Index (1975=100)	Chemical pulp consumption	Mechanical pulp consumption	Total paper and board production	Predicted consumption for each quarter	Actual consumption for each quarter	% error
		X1	X2	X3	X4	Y_p	Y_a	
1980	Q1	108.8	374.29	57.25	1093.50	568.34	609.81	6.8
	Q2	106.5	348.62	52.48	1025.40	532.59	536.47	0.7
	Q3	106.0	292.66	50.40	828.00	422.44	434.77	2.9
	Q4	105.3	298.34	43.14	841.20	433.55	433.46	-0.2
1981	Q1	105.4	300.55	35.56	846.30	442.64	484.50	8.6
	Q2	*	319.82	34.76	881.70	-	513.67	-
	Q3	*	304.02	30.91	810.60	-	461.33	-
	Q4	105.9	304.83	26.93	844.50	447.52	485.81	7.9

Note : X2, X3, X4, Y_p and Y_a in '000 tonnes

* Data not available for this period owing to absence of overseas trade statistics. (Economic Trends, No 343, May 1982)

Holt-Winters method to forecast short term demand for waste paper. Table 8.7 compares the results of using various models to forecast 1980. The SFAG model was able to give the lowest percentage error and was therefore the best model amongst them.

8.7.2 Short term forecast of demand for groups 6 and 7 (the SF67 model)

The SFAG relation was able to forecast the total waste paper consumption only. Of all the grades consumed, groups 6 and 7 represent the highest proportions. Together they made up about 76 percent of all the waste paper consumed. Since the bulk of these two groups is so enormous, it will be important to know the future demand particularly for these grades.

Since these two groups are mainly recycled into packaging materials and are used as raw materials in their own right rather than as substitutes for wood pulp, chemical and mechanical pulp consumption would not have any significant influence on their consumption. On the other hand, production of packaging boards, printing and writing paper greater than 220 g/m^2 and other wrapping and packaging papers would now have significant influence on the consumption of these two groups. Therefore a different model from the SFAG relation would be required to forecast the demand for these two groups.

Multiple regression for group 7 alone in relation to the Gross Domestic Product and production of various boards, based on quarterly data from 1972 did not reveal any significant relationship. But when group 6 and group 7 were added together, a multiple regression of these two groups with three predictors, X1 (other wrapping and packaging papers), X2 (printing and writing paper, greater than 220 g/m^2) and X3 (packaging boards) gave a very high R^2 of 94.8 percent and very significant coefficients.

The regression equation obtained, for simplicity called SF67 (for <u>s</u>hort term <u>f</u>orecast of groups <u>6</u> and <u>7</u>)

Table 8.7 - Comparing the results of short term forecast for 1980 from various models
Source : 1 Deadman & Turner(1979)
1a for an additive trend and seasonal factors
1b for an additive trend and multiplication seasonal factors proportional to the trend

Tonnage : in '000 tonnes

Period		Actual consumption for each quarter	Forecast of total consumption for each quarter using the :							
			SFAG relation		MRP short-term relation[1]		Holt-Winters method[1a]		Modified Holt-Winters method[1b]	
		tonnage	tonnage	% error	tonnage	% error	tonnage	% error	tonnage	% error
1980	Q1	609.81	568.34	6.8	583.31	4.3	551.34	9.6	559.44	8.3
	Q2	536.47	532.59	0.7	585.84	-9.2	550.29	-2.6	555.95	-3.6
	Q3	434.77	422.44	2.9	524.87	-21.4	506.50	-16.5	492.83	-13.4
	Q4	433.46	433.55	-0.2	598.50	-38.1	556.71	-28.4	565.13	-30.4

was,

$$Y = 22.7 + 1.20X1 - 2.34X2 + 0.648X3$$
$$(1.15) \quad (14.34) \quad (-3.16) \quad (6.92)$$

$F = 169.16$

$R^2 = 94.8$ percent

Durbin-Watson statistic = 1.94

t value in parenthesis

The F statistics of 169.16 was much higher than the table value of 2.947 for $F_{3,28}$ at 95 percent confidence level. Hence a statistically significant relationship existed between the dependent and the independent variables.

t value of each of the coefficients in the relation was higher than the t - table value of 2.048 at 95 percent confidence level (2 tails) with 28 degrees of freedom.

94.8 percent of the variance in the relation was explained by the three variables.

The Durbin-Watson statistic of 1.94 was higher than the table value limit of 1.65. So auto-correlation did not exist in the data.

The equation showed that the amount of groups 6 and 7 waste paper in demand was influenced by and increased with increase in production of other wrappings and packaging papers as well as packaging boards. However, as more of the printing and writing paper greater than 220 g/m^2 were produced less of these two groups of waste paper was consumed. This was mainly because printing and writing papers greater than 220 g/m^2 were basically high quality boards who used more of the higher quality waste paper and less of the lower grades.

When the computed value from the SF67 relation was compared with the actual consumption, errors varied between -5.7 to 4.6 percent and there was a very close fit between the two sets of data (Table 8.8 and Figure 8.5). The relation was also used to forecast the demand beyond 1979, into 1980 and 1981. Errors varied from -5.2 to 3.5 percent (Table 8.9),

Table 8.8 - Comparing actual consumption with forecast consumption of groups 6 and 7, from 1972 Q1 to 1979 Q4

('000 tonnes)

Period		X1	X2	X3	Y_f	Y_a	Percentage error
1972	Q1	191.1	7.8	236.1	386.8	381.9	-1.3
	Q2	218.4	11.1	211.5	395.9	385.9	-2.6
	Q3	199.8	9.9	200.1	369.0	362.8	-1.7
	Q4	199.5	11.4	214.5	374.4	392.5	4.6
1973	Q1	247.5	12.3	241.8	447.6	443.9	-0.8
	Q2	244.2	12.6	234.6	438.3	431.5	-1.6
	Q3	213.6	12.3	201.6	380.9	366.3	-4.0
	Q4	241.2	12.9	223.8	427.0	422.3	-1.1
1974	Q1	247.8	13.8	233.7	439.2	435.0	-1.0
	Q2	258.6	14.4	234.6	451.4	439.5	-2.7
	Q3	234.6	14.1	198.9	400.1	388.2	-3.1
	Q4	235.8	16.8	222.6	410.6	426.5	3.7
1975	Q1	176.1	11.4	172.5	319.1	329.7	3.2
	Q2	194.1	9.3	149.1	330.5	334.7	1.3
	Q3	192.6	11.1	159.0	330.9	330.1	-0.2
	Q4	220.5	9.9	169.2	373.8	374.8	0.3
1976	Q1	227.7	9.9	189.6	395.6	402.7	1.7
	Q2	236.4	8.4	197.4	414.6	419.1	1.1
	Q3	231.6	8.1	179.4	397.9	376.4	-5.7
	Q4	270.9	9.0	212.1	464.2	475.5	2.4
1977	Q1	270.3	5.1	217.5	476.1	477.5	0.3
	Q2	249.6	6.9	203.4	437.9	439.6	0.4
	Q3	223.2	5.4	161.1	382.3	371.8	-2.8
	Q4	244.2	7.2	186.0	419.4	421.9	0.6
1978	Q1	259.2	6.9	193.2	442.8	435.7	-1.6
	Q2	266.4	6.0	202.5	459.6	453.4	-1.4
	Q3	240.6	6.0	166.8	405.5	392.6	-3.3
	Q4	254.4	5.7	186.6	435.6	437.3	0.4
1979	Q1	258.9	6.9	191.1	441.1	446.3	1.2
	Q2	266.4	7.2	202.5	456.8	466.9	2.2
	Q3	250.5	6.0	171.3	420.3	415.5	-1.2
	Q4	259.5	5.4	181.8	439.3	449.1	2.2

X1 : Production of other wrapping and packaging papers
X2 : Production of printing and writing papers 220 g/m^2
X3 : Production of packaging boards
Y_f : Forecast consumption using the SF67 relation
Y_a : Actual consumption

Figure 8.5 - Forecast cycles and actual cycles for consumption of groups 6 and 7

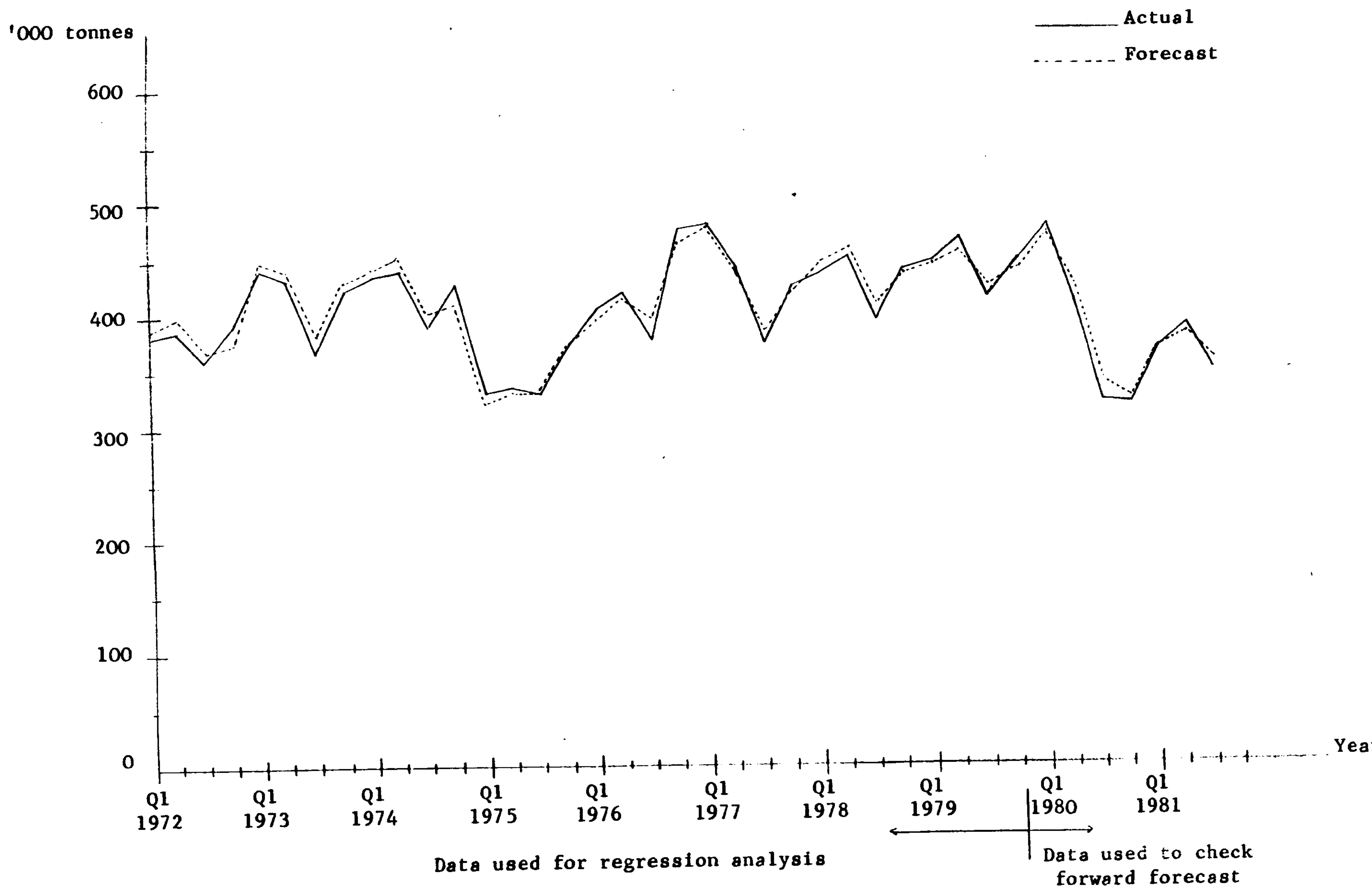


Table 8.9 - Forecast of waste paper consumption using SF67 relation for 1980 to 1981

Period	Other wrapping and packaging papers X1	Printing and writing papers >220 g/m^2 X2	Packaging boards X3	Predicted consumption Y_p	Actual consumption Y_a	Percentage Error
1980 Q1	273.00	2.10	194.70	471.55	479.72	1.7
Q2	260.40	7.20	157.20	420.20	407.94	-3.0
Q3	207.60	5.10	119.70	337.45	320.66	-5.2
Q4	201.00	6.60	114.60	332.72	319.13	-4.3
1981 Q1	228.30	6.90	138.00	369.94	369.10	-0.2
Q2	237.00	7.80	144.00	382.16	389.01	1.8
Q3	219.00	6.30	135.90	358.82	348.79	-2.8
Q4	226.80	8.40	127.80	358.02	371.12	3.5

Note : X1, X2, X3, Yp and Ya in '000 tonnes which were well within the 10 percent error that could be absorbed by stocks held by the mills. Again the turning points of the cycle were followed very closely by the SF67 relation.

The SF67 relation could only be used in the short term as the inputs are basically the orders the mill have and these inputs are not known with accuracy beyond the 12 to 18 months period.

This model is the only one at present which could give a good projection for the demand of grades 6 and 7 waste paper.

8.7.3 Short term forecast of demand for the higher grades

No statistically significant multiple regression relationship could be established for the higher grades of waste paper (Groups 1 to 4) using inputs such as Gross Domestic Product, chemical pulp consumption, mechanical pulp consumption, production output of different paper and board, or combinations of such variables. Neither did subtracting the SF67 from SFAG equation gave any good forecast for the demand for the higher grades. The high quality of the higher grades of waste paper (Groups 1 to 4) and their ability to be used in nearly all types of production and as substitutes for various wood pulp made it difficult to identify any particular pattern in their utilisation. Only their limited supply prevent them from being used more widely.

8.7.4 Long term forecast of demand for all grades of waste paper (The LFAG model)

Short term forecast has a short time horizon and is dependent on various variables such as virgin pulp consumption and production, variables which are not normally known beyond 12 to 18 months. For periods beyond this short time limit, a long term forecast has to be developed, using some economic indicator such as the Gross Domestic Product, a financial indicator which is being forecast and published regularly, for example by the National Institute of Economic and Social Research (NIESR) and by the government. The Industry Act,1975 requires the government to publish economic forecasts twice yearly and GDP is one of the indicators. Waste paper consumption is still controlled mainly by the production of paper and board, and the order books of the mills are influenced by the economic situation of the country which is indicated by the Gross Domestic Product. Once the long term trend of waste paper consumption is identified, the peaks and troughs of the waste paper consumption cycle over a longer period can be located. Prior knowledge of when the next peak or trough will occur will help suppliers to adjust their collection activities and so avoid the huge build up of unwanted stocks which so often have to be dumped into landfill sites.

Simple regression analysis of the total annual consumption of waste paper with only the Gross Domestic Product had been used by Turner & Grace(1977) and Deadman & Turner(1979), whose projection of minimum demand in 1980 had an error of 5.7 percent and by the Committee on Waste Paper Supply (DOI/DOE,1980) whose projection for minimum demand in 1981 was in excess of actual consumption by 14.3 percent. A better model for long term forecast was developed in the course of this research, and the following paragraphs describes this model.

Fluctuations in waste paper demand was related to trade cycle fluctuations. The only difference was that the two sets of peaks and troughs might not occur at the same time and a certain lag might exist between the two (Figure 8.6). Since there was a lag between consumption and GDP, the demand for waste paper could be related in some way to previous GDPs as well as the current GDP. That is, the consumption of waste paper could be influenced by the GDP one year ago, or even two years ago.

Multiple regressions of waste paper consumption with

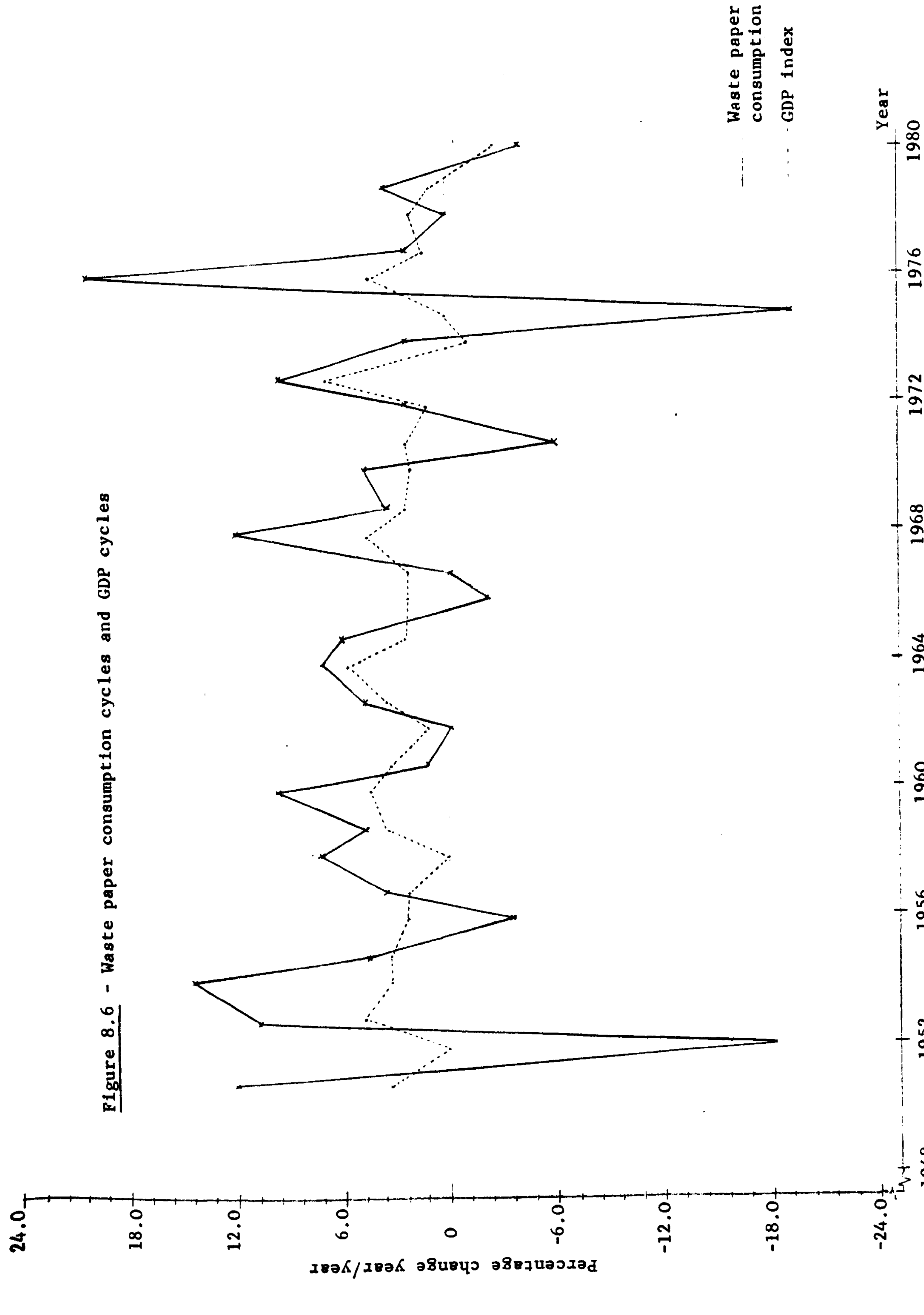


Figure 8.6 - Waste paper consumption cycles and GDP cycles

GDP and with influence of earlier GDPs were tried. GDP one year and 3 years earlier were found not to be significant in the analysis. Only the GDP two years earlier was found to have a significant influence on the multiple regression.

A regression relation which related Y_t, GDP_t and $(GDP_t - GDP_{t-2})$ was obtained, where,

Y_t = waste paper consumption in time t

GDP_t = gross domestic product index in time t

GDP_{t-2} = gross domestic product index in time (t-2)

$\Delta GDt = GDP_t - GDP_{t-2}$

The equation, called the LFAG relation (for the long term forecast for all grades of waste paper) was

$$Y_t = \underset{(-5.60)}{-308.0} + \underset{(31.66)}{21.8\ GDP_t} + \underset{(4.51)}{29.5\Delta GDP}$$

$F = 591.6$

$R^2 = 97.8$

Durbin-Watson statistics = 1.69

t value in parenthesis

Table values of $t_{\nu=27,\ \alpha=0.025} = 2.0518$

$F_{0.05(2,27)} = 3.354$

$DW : d_L = 1.28$

$d_u = 1.57$

The LFAG relation was therefore statistically significant and has no auto-correlation. 97.8 percent of the variation in the relation was explained by the two variables GDP and ΔGDP. Each of the coefficients was significant and the coefficient of GDP_t had a much higher significance than that of ΔGDP.

When this model was used to check the predicted demand with the actual demand from 1950 to 1979, only 1952 gave a big error of -11 percent (Table 8.10). The trend of

Table 8.10 - Comparing actual consumption with computed consumption using the LFAG relation, from 1950 to 1979

Year	GDP_t	$\triangle GDP$	Computed consumption	Actual consumption	Percentage error
1950	52.2	3.2	924.4	901.3	-2.6
1951	54.1	3.6	977.6	1014.0	3.6
1952	54.1	1.9	927.4	835.4	-11.0
1953	56.6	2.5	999.6	927.8	-7.7
1954	58.7	4.6	1107.4	1060.5	-4.4
1955	60.8	4.2	1141.3	1114.1	-2.5
1956	62.0	3.3	1141.0	1078.9	-5.8
1957	63.2	2.4	1140.6	1113.3	-2.5
1958	62.9	0.9	1089.8	1188.1	8.3
1959	65.0	1.8	1162.1	1245.8	6.7
1960	68.0	5.1	1324.9	1361.2	2.7
1961	70.5	5.5	1391.2	1376.0	-1.1
1962	71.1	3.1	1333.4	1371.6	2.8
1963	74.0	3.5	1408.5	1442.7	2.4
1964	78.0	6.9	1596.0	1538.1	-3.8
1965	80.1	6.1	1618.1	1624.7	0.4
1966	81.8	3.8	1587.3	1592.1	0.3
1967	83.9	3.8	1633.1	1593.1	-2.5
1968	87.6	5.8	1772.8	1793.2	1.1
1969	89.2	5.3	1792.9	1855.8	3.4
1970	90.9	3.3	1771.0	1946.5	9.0
1971	93.2	4.0	1841.8	1835.2	-0.4
1972	94.4	3.5	1853.2	1881.1	1.5
1973	101.7	8.5	2159.8	2069.8	-4.4
1974	100.6	6.2	2068.0	2121.8	2.5
1975	100.0	-1.7	1821.9	1703.8	-6.9
1976	104.3	3.7	2074.9	2056.6	-0.9
1977	105.4	5.4	2149.0	2114.7	-1.6
1978	108.5	4.2	2181.2	2109.1	-3.4
1979	109.2	3.8	2184.7	2190.6	0.3

Note : GDP_t - Gross Domestic Products Index at time t (Expenditure data in 1975 prices at 1975=100)

ΔGDP - Change in GDP over the previous two years $= GDP_t - GDP_{t-2}$

Consumption measured in '000 tonnes

the predicted demand followed that of actual demand fairly closely (Figure 8.7). For demand beyond 1980, there was an error of only 2.7 percent for 1981 (Table 8.11). From 1980 to 1986, a trough was forecast in 1981/82 and demand was forecast to pick up by 1983 to reach the next peak in 1985.

It was very difficult to confirm the accuracy of the long term forecast beyond 1981. However events in 1981 and 1982 did confirm the forecast pattern for these two years. 1981 was the year of lowest demand since 1976, when prices dropped to the minimum guaranteed £22 per tonne for mixed waste and quotas were introduced. Quotas for the local authority tonnages were however lifted by May 1981. The low prices of waste paper did not help the local authority waste paper recovery operations to be viable. In order to reduce their operation costs a number of local authorities terminated their waste paper recovery schemes. The supply of mixed waste and container waste were reduced. By autumn 1981 the existing stock of waste paper has been run down to the extent that mills began to step up their purchase of waste paper. Container wastes have to be imported from Germany while waiting for the local authorities and merchants to step up their recovery operations. The mills felt that the recession was bottoming out and was expecting the economy to pick up again. They were however rather cautious but to encourage the local authorities to step up their waste paper collection, a 10 percent increase in prices was announced in October 1981. The mills felt that local authorities around this time were preparing the next financial year's budget and since the low price of waste paper has been affecting waste paper collection costs very badly, many authorities may recommend the suspension of waste paper recovery in the coming year's budget. In an attempt to prevent this the price increase was announced. After the 10 percent price increase in October 1981 no further price increase has so far been announced. Although the upward trend of waste paper demand seems to have started, the climb has been rather slow. Trade sources currently

Figure 8.7 - Comparing long term forecast for all grades with actual consumption (1950 - 1981)

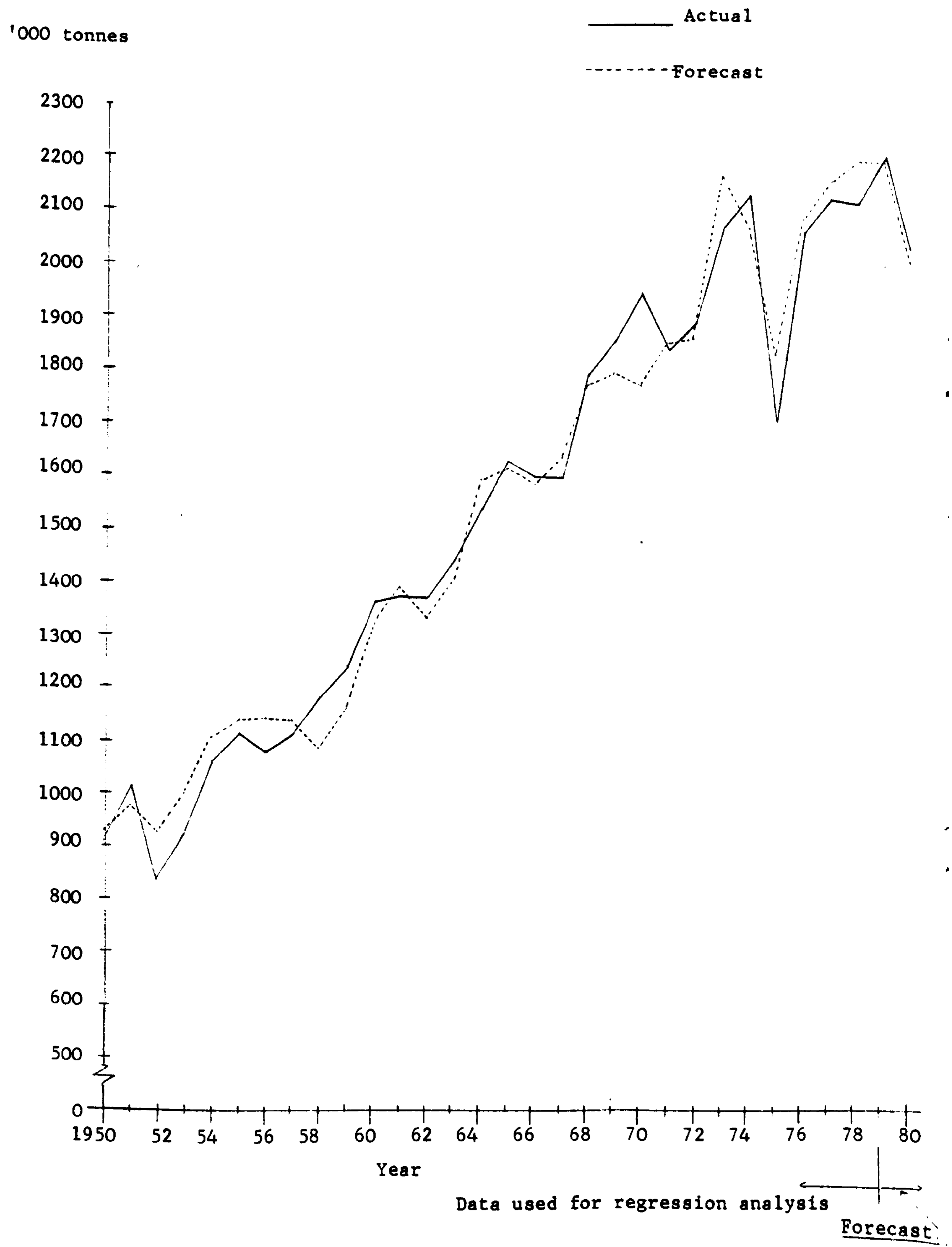


Table 8.11 - Long term forecast for waste paper demand (all grades) from 1982 to 1986

Year(t)	GDP_t	GDP_{t-2}	ΔGDP	Forecast demand	Actual demand	% error
1980	107.2	108.5	-1.3	1990.6	2014.5	1.2
1981	105.7	109.2	-5.3	1893.0	1945.4	2.7
1982(1)	104.5	107.2	-2.7	1890.5		
1983	105.9	103.9	2.0	2059.6		
1984	108.2	104.5	3.7	2159.9		
1985	109.8	105.9	3.9	2200.7		
1986	110.8	108.2	2.6	2184.1		

Note : (1) GDP index from 1982 to 1986 forecast in NIESR(1981) expect the increase in demand to pick up by 1983, which was exactly what the LFAG model had predicted.

Long term forecast of such nature is entirely influenced by the forecast of GDP in the coming years, and its accuracy is dependent on the accuracy of the forecast GDP. To take in account the possibilities of such errors, a sensitivity analysis of the forecast value was done. A ± 3 percent change in the GDP index forecast was assumed. The next peak may be expected to occur in 1985, when total demand for all grades of waste paper may vary between 2,058 and 2,343 thousand tonnes. The next downturn in the cycle may start in 1986 (Table 8.12).

The forecast has also been made on the assumption that the recycling technology will be contemporary. Even though the UK board mills have invested more than £300 million in new technology in the last five years, there has still been no major break through in recycling technology. No new technological development which will change the present recycling scene is expected.

Table 8.12 - Sensitivity analysis of LFAG with GDP varying $\pm$ 3%

Year	GDP_t	GDP_{t-2}	Forecast value	'000 tonnes (total consumption for the year)	
				Maximum	Minimum
1982	104.5 $\pm$ 3.14	107.2	1890.5 $\pm$ 56.7	1947.2	1833.8
1983	105.9 $\pm$ 3.18	105.7	2006.5 $\pm$ 164.8	2173.0	1843.4
1984	108.2 $\pm$ 3.25	104.5 $\pm$ 3.14	2159.9 $\pm$ 138.0	2297.9	2021.9
1985	109.8 $\pm$ 3.29	105.9 $\pm$ 3.18	2200.7 $\pm$ 142.4	2343.1	2058.3
1986	110.8 $\pm$ 3.32	108.2 $\pm$ 3.25	2184.1 $\pm$ 143.5	2327.6	2040.6

9 - Mill's cost to recycle waste paper

The main reason for British mills to use waste paper as a source of secondary fibres is because of its lower cost. A short study into the cost incurred in recycling waste paper was made by the British Waste Paper Association in 1972, and DOI/DOE(1980) published the 1978 financial results of six paper mills in UK. Other than these two sources, there is no published data from the paper and board industry regarding the cost involved in recycling waste paper. The aim of this chapter is therefore to look into the mill's cost to recycle waste paper and to investigate what cost savings are possible.

The higher grades of waste paper are pulp substitutes and they can be used in most products. The cost advantage can therefore be estimated by comparing the costs involved in producing the same product using either secondary fibre or virgin pulp. Mixed waste and container waste are not exactly pulp substitutes. They are used in their own rights as a raw material for the making of paper boards, and there is no economic substitute for these grades of waste paper. A case study of a board mill is used to get some idea of what costs are involved to bring the waste paper to the mill, process it and get it ready for the board making machine.

9.1 Case study of a mill using local authority waste paper

This mill, located in the North East of Scotland, is one of four big consumers of waste paper in UK. 31 out of the 33 local authorities recovering waste paper in Scotland are contracted to sell their waste paper to this mill. The mill pays a flat rate per tonne for each grade bought from the local authority, so that each local authority gets the same price for its waste paper. In 1980/81, 41,299 tonnes of mixed waste and container waste valued at £944,714.63 were bought by this mill. But the local authority supply is very small and is sufficient for only 20 percent of what this mill requires. The rest of the

80 percent have to be purchased from waste paper merchants.

To bring the waste paper from the different local authorities to the mill, the company maintains a fleet of lorries which are used to collect the waste papers direct from the baling sheds at each local authority's cleansing depot. Each lorry is a 'forty-footer' capable of carrying a load of not more than 22.5 tonnes. The lorries would carry manufactured boards from the mill to various towns in Scotland and England and on their return journey pick up the maximum waste paper tonnage from the nearest town or towns. The mill takes in an average of 3,000 tonnes of waste paper per week from all over Scotland. Transport costs as computed by the transport department of the mill varies from £5 per tonne to £10.18 per tonne depending on the distance from the local authority to the mill. However, for their own costing purpose an average carriage cost of £6.50 per tonne is used.

The mill has at one time experimented with carriage by rail, but they found it impractical due to the very strict restrictions on both the weights and the hygiene standards imposed by British Rail. Pay-load wise, a similar size train compartment carries only about 60 percent of the weight that can be loaded on a lorry. Besides, the geography of the mill location does not allow a railway terminal to be built at the mill, so that the nearest railway terminal would have to be sited about 500 metres away. This means that supplementary lorry transport would still have to be used to collect the waste paper from the various baling shed for transportation to the nearest railway station. At the end of the rail journey another fleet of lorries has to be maintained at the mill to move the waste paper from the railway terminal to the mill itself. Another problem of course, is the difficulty in scheduling transportation time to fit into railway freight time , while the company now has full control over the timing and movement of its own fleet of lorries. The mill does not maintain a sufficiently big fleet of vehicles. Its own fleet of lorries could only handle about 25 percent of all the transport needed. The rest is done by outside contract lorries. But the 25 percent of transport used by the mill gives it enough leeway to be more flexible and independent of contracted transport.

On arrival at the mill, the waste paper is cleaned, washed and de-fibered before being sent to the board machine. Local authorities waste papers are recycled without deinking into chipboards. An ink-dispersion process is used to re-pulp the waste paper which produces a greyish pulp such as those usually seen in the inside of cereal boxes or plaster-board liners and chipboards.

The contract with the local authorities does not accept more than 5 percent by weight of contraries in the baled waste paper. The cleaning and washing process takes out about 150 tonnes of contraries per week from the input of 3,000 tonnes of the local authority waste paper. The mill estimated that it costs about £3 per tonne of waste paper to remove the contraries. On top of this there is a fibre loss during the cleaning, washing and re-pulping process of about 9.5 to 11.5 percent. This means that on the average at least 10 percent of the total purchase of waste paper is lost through the processing stage. Accounting for volume loss through contraries removal and fibre shrinkage an average of 116 tonnes of waste paper is used to produce a hundred tonnes of finished product.

Once the cleaned pulp goes on the board making machine, the cost of the board making process will be rather similar irrespective of whether the pulp is secondary fibre or virgin fibres. The processing cost of waste paper is therefore the costs incurred by the mill to take the waste paper from the stage when it is purchased to the stage when the waste paper has been re-pulped and is ready for the board making machine. The cost for processing local authority waste paper can therefore be expressed by LGC where,

$$LGC = WPC + TPT + COR + SRL$$

where WPC = waste paper purchase cost

TPT = transport cost of waste paper from the local authority cleansing depot to the mill

COR = contrary removal cost (including machinery depreciation cost)

SRL = value of shrinkage lost involved in the processing.

Table 9.1 shows the 1980 cost to this mill for recycling local authority waste paper. It costs the mill between £40.58 to £47.54 to recycle a tonne of bulk grade waste paper. Comparing the cost difference of a tonne of container waste at £34.58 with a tonne of virgin kraft pulp £242 (1980 prices), the savings in raw material cost is as much as 86 percent.

Table 9.1 - Cost of recycling local authority waste papers to a mill (1980 prices) £/tonne of waste paper recycled

	Mixed waste	Container waste
WPC = waste paper cost	28.25	34.58[1]
TPT = transport cost	6.50	6.50
COR = contrary removal cost	3.00	3.00
SRL = shrinkage lost (10%)	2.83	3.46
Total cost :	40.58	47.54

[1] Container waste prices fluctuated in 1980, from £24.25 per tonne for 5 months to £39.25 per tonne for four months, and then dropped to £32.25 per tonne for three months, thus giving an average price of £34.58 per tonne for the year.

9.2 Recycling the other grades of waste paper

The higher grades of waste papers have more uniform quality and has less contraries. Besides, their qualities are more accurately assessible. Mills recycling the higher grades of waste paper buy their supply from merchants since these grades are seldom collected by local authority collections in any significant quantity.

An obvious cost benefit in recycling the pulp substitutes is the cost differential between a tonne of high grade waste paper and a tonne of pure pulp. Table 9.2 summarised some of the common grades and their substitutes, together with their purchase prices. Virgin wood pulp prices are generally quoted in the market in US$/tonne, and the prices in Table 9.2 have been converted at $2 = £1, 1979 January conversion rate. The prices are those typically paid by a British mill. Savings in raw material cost ranges from 15 to 65 percent of the virgin pulp cost.

Table 9.3 shows the operating cost for processing some of the other grades of waste papers, cleaning and re-pulping it to a state suitable for the paper making machine. These are in 1980 prices, compiled from information provided by another mill in Scotland. This mill uses a very high percentage of waste paper to produce various grades of paper bags. The management of this mill believes that its whole operation and the future of the mill depends on its ability to recycle more waste papers. The high grades such as the ledgers and tabulating cards have a low processing loss while magazines and coated papers have the highest processing loss due to the additives used in its earlier production which have now to be removed during recycling. The processing cost is therefore highest for this group of waste paper.

9.3 Some examples of recycling mill operating cost

The mill costs involved in recycling three main grades of waste paper, clean wood-free shavings (Group 1), news (Group 5) and mixed waste (Group 7b) are compared in Table 9.4. To recycle the shavings and news, deinking is used and chemical costs are incurred, while mixed waste is recycled without deinking. In each case the contraries extracted from the waste have to be disposed and mixed waste has a higher contraries level hence incurring higher waste disposal cost. Since mixed waste is re-pulped at a lower temperature than the others the steam requirement is much smaller. In all three processes, the raw material costs are the

Table 9.2 - Price differential between waste paper (pulp substitute grades) and the pulp prices (1979 July Price)

Waste paper grades	Fibre value £/tonne	Substituted for virgin pulp	Fibre value £/tonne	Savings on raw material £	as a % of virgin pulp cost
Best white shavings @ £144, with 10% processing loss	£160	bleached sulphate pulp	£205	45	22
Newsprint @ £45, with 20% processing loss	£56	mechanical pulp	£130	74	57
Computer print-out paper @ £114, with 10% processing loss	£127	bleached hard wood	£217	90	41
Computer punch cards @ £163, with 12½% processing loss	£186	unbleached sulphate pulp	£192	6	3

Table 9.3 - Operating cost for processing some other grades of waste papers (in 1980 prices)

Waste paper grades	Yield	Loss	Processing Cost/tonne
Ledger, tabulating cards, low groundwood content papers	85-90%	10-15%	£37.25-£39.90
Magazine, coated book papers	60-65%	35-40%	£46.50-£53.20
Newsprint	80%	20%	£26.60-£29.30
Plastic coated paper (polythylene, poly-vinyl or high polymer laminate)	85-87%	13-15%	≃ £39.90

Table 9.4 - Examples of operating costs of the recycling mills in 1979/80
Source : Trade and industrial sources

	Deinked clean wood free shavings		Deinked news		Mixed waste	
	£/tonne	%	£/tonne	%	£/tonne	%
Waste paper cost	144.00	71.4	45.00	47.2	28.25	47.8
Depreciation of plant and machinery	16.36	8.1	19.34	20.3	12.66	21.4
Power	7.22	3.6	11.09	11.6	7.41	12.6
Chemicals	19.25	9.5	9.25	9.7	-	-
Steam	8.05	4.0	3.68	3.8	1.80	3.0
Labour	3.26	1.6	3.31	3.5	4.70	8.0
Maintenance	2.35	1.1	2.35	2.5	2.35	4.0
Waste disposal	0.98	0.5	0.98	1.0	1.53	2.6
Administration	0.34	0.2	0.34	0.4	0.34	0.6
Total cost	201.81	100.0	95.34	100.0	59.04	100.0
Waste paper used as a substitute for	bleached pulp		sulphite & groundwood		(groundwood or neutral sulphite semi-chemical pulp)	
Price of virgin pulp	190.00		130.00		114 - 133	
Savings in raw material cost as a result of using waste paper	25.0%		65.0%		75.0 - 79.0%	

highest percentage so that cost savings here are very important. In each case there has been substantial savings by using waste paper. In the case of mixed waste, in theory it is a substitute for groundwood or neutral sulphite semi-chemical pulp, but in practice the use of imported virgin pulp would make the price of the finished product so expensive in relation to the imported finished product that the board mills would not be able to sell their products. Therefore in reality, there is no economic substitute for mixed waste papers in board making.

Newsprint is commonly produced from virgin pulp which is a mixture of predominantly groundwood with some chemical fibre, either semi-bleached kraft or sulphite pulp. Experience in the USA has showed that newsprint of the same quality can be manufactured from a 100 percent properly cleaned and deinked waste paper. Alternately, newsprint can be produced from a blend of secondary and virgin fibres, such as 33 percent No.1 news and 67 percent virgin newsprint. Table 9.5 compares the total capital, delivered costs and return on capital for three types of news manufacturing mills in the north-eastern USA. Total fixed capital for the integrated virgin and blending newsprint plants were $99 and $92 million respectively. This included paper making, deinking for the blending mill and an allocation of the capital costs for stone groundwood and semi-bleached kraft pulp production, as well as on-site power generation. But production based on a 100 percent secondary fibres required a total fixed capital of only $40 million based on a single machine without on-site power, but including deinking and cleaning equipment required to make an acceptable newsprint from No.1 news. Capital investment per daily tonne for the 100 percent secondary fibre mill was only 67 to 72 percent of that required for the integrated mills. Raw material costs with the 100 percent secondary fibre based product saved 37 to 47 percent of what was required for the other mills. The 100 percent secondary fibre based newsprint production gave the highest pre-tax return on capital.

Savings in raw material cost was the highest when mixed

Table 9.5 - Economic comparison of newsprint manufacture, basic weight 49 g/m^2 (in 1974 second quarter prices)
Source : Iannazzi(1976)

	100 percent virgin fibre base	67 percent virgin fibre and 33 percent secondary fibre base	100 percent secondary fibre
Plant size (ton/day)	550	550	330(i)
Type of plant	Integrated	Integrated	Non-integrated
Total fixed capital(ii)			
$ million	99	92	40
$'000/daily ton	180	167	121
Operating cost $/ton			
Raw materials(iii)			
Fibre	95.7	81.0	51.1
Others	2.5	4.4	8.9
Conversion	33.5	40.1	66.0
Capital-related	23.8	26.2	27.3
Sales cost (less freight)	11.4	11.4	11.4
Freight out (product)	18.2	18.2	10 9
Total delivered cost ($/ton)	185.1	181.3	175.6
Sales price ($/ton)	218.0	218.0	213.0
Profit/ton (pre-tax)	32.9	36.7	37.4
Return on fixed capital pre-tax(iv)	6.3%	7.6%	10.4%

i) Mill capacity set at 330 tpd based on the existing industry characteristics and on the judgment of the availability of fibre at competitive cost to supply the mill. No adverse effect from recycling old news that would limit the capacity of the machine, was assumed.

ii) includes pulping

iii) includes all raw material costs of delivered pulp and waste paper to paper machines plus chemicals

iv) Return on fixed capital(pre-tax) =

$$\frac{\text{Profit/tonne x operating days}}{\text{Fixed capital investment per daily ton}} \times 100$$

* Chemicals and deinking costs involved in 100 percent secondary fibre recycling is much higher than the two other process. Capital related costs in pollution control is also higher.

waste was used, and a 100 percent waste paper based newsprint production produced the best return for investment. Mixed waste will continue to be an important raw material in board manufacture and wherever possible mills will try to use more waste paper in their production.

10 - Alternative markets for waste paper

10.1 The need to diversify

The demand for waste paper can be measured by the amount of waste paper consumed per annum by the mills, while the supply of waste paper can be measured by the total amount of waste paper that is recovered in UK. When the supply and the demand are compared, supply has exceeded demand most of the time, particularly from 1951 to 1975 (Figure 10.1). Only from 1976 to 1978 was supply less than demand.

The supply of waste paper represents only the amount that has been recovered. There is still an amount of waste paper existing but not recovered. The potential supply of waste paper therefore measures the theoretical amount of waste paper that can be economically recovered from all the waste paper and board consumed each year.

Paper and board content in domestic refuse has been increasing from 16.8 percent by weight in 1961 to 36.8 percent by weight in 1970. Since then the percentage of paper and board in refuse has fallen and reached the lower level of 26.8 percent in 1974 (Table 10.1).

After 1974, paper and board content in domestic refuse has increased slowly to around 29 percent by weight in 1979 and 1980. Average weight of paper and board found in domestic premises is about 3.2 kg per premise per week. Roughly 15 percent of the paper consumed cannot be recovered for recycling because it has been used in long-lived products such as books, or dispersed during or after it has been used such as cigarette paper and toilet papers (WMAC,1976; Skitt,1979; Holzhey,1981). Allowing for a percentage for the paper and board that has been re-used for other purposes and soiled beyond recovery, Hodges(1981) estimated that 65 percent of the apparent paper and board consumption could be economically recoverable each year. If this is the potential supply of waste paper, then the potential supply is more than twice the amount that is being consumed (Figure 10.2).

Figure 10.1 - Comparing waste paper supply and demand

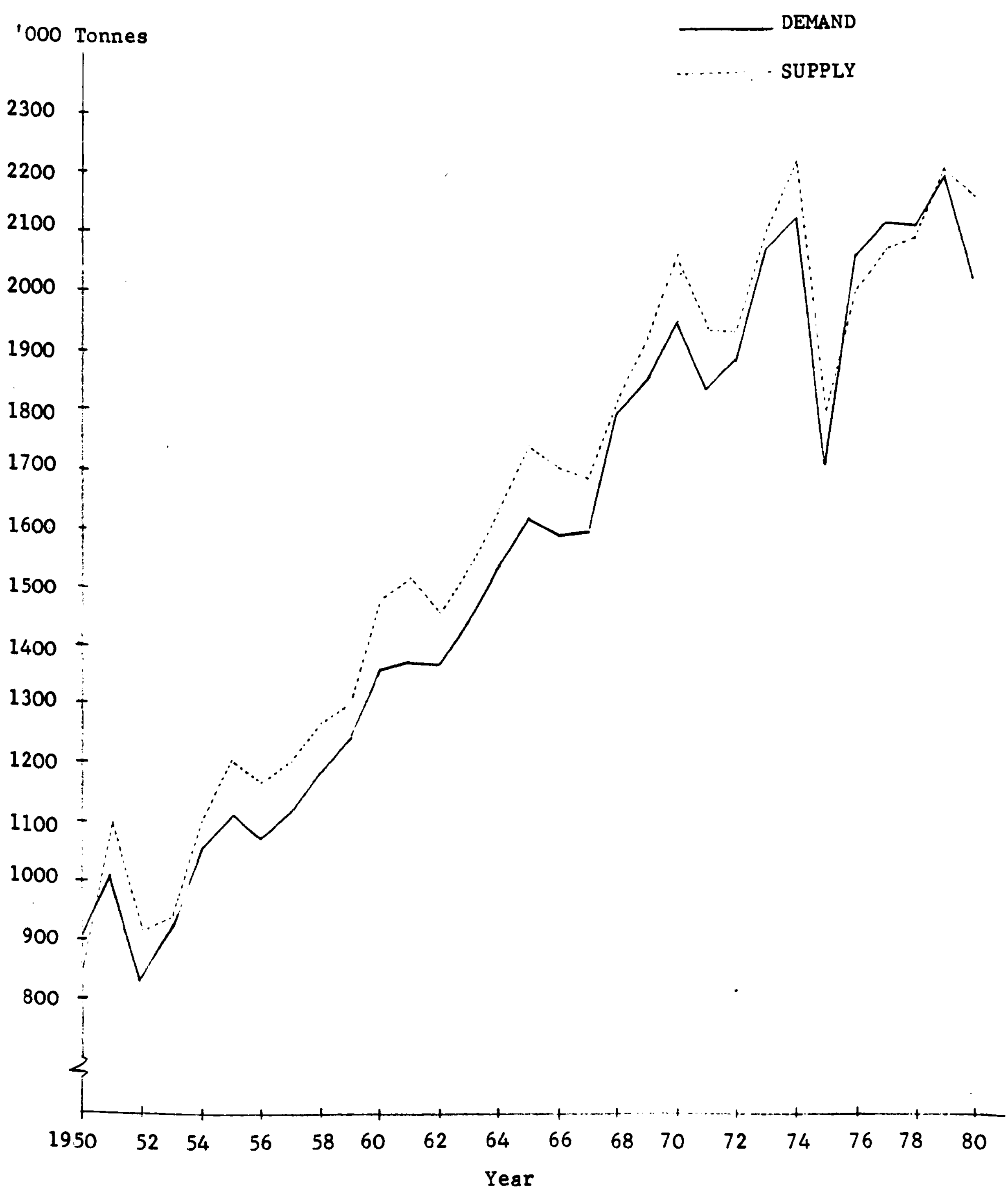


Table 10.1 - Comparing potential supply with demand for waste paper

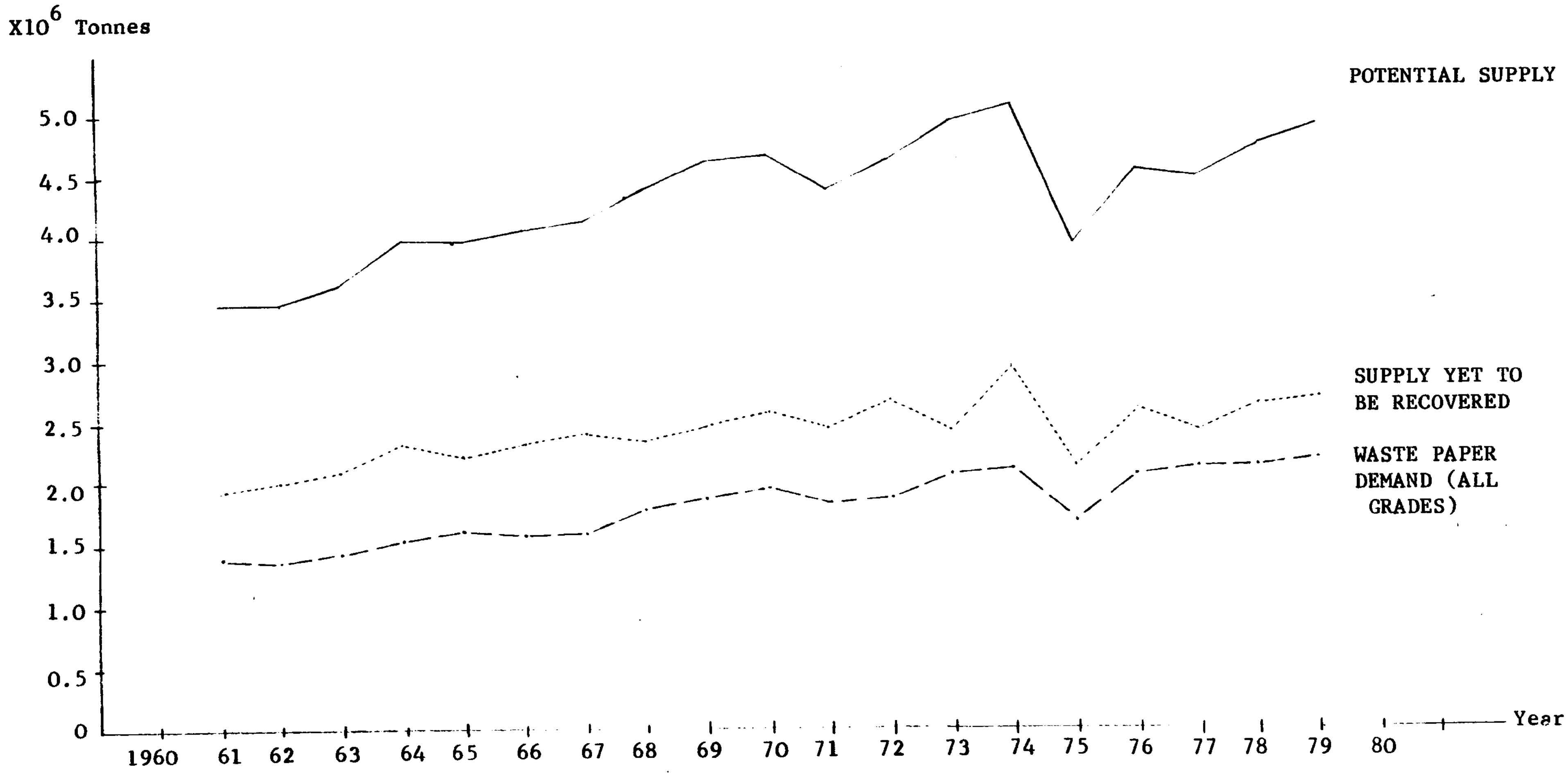
Year	Percentage of paper & board in domestic refuse	Apparent paper & board consumption in UK per annum (million tonnes)	Potential supply of waste paper (million tonnes) #	Supply = Recovered tonnage per annum (million tonnes)	Demand = Total consumption of waste paper in mills pa (million tonnes)
1961	16.80	5.32	3.46	1.52	1.38
1962	21.30	5.32	3.46	1.46	1.37
1963	23.00	5.60	3.64	1.54	1.44
1964	25.00	6.09	3.96	1.63	1.54
1965	23.00	6.11	3.97	1.74	1.62
1967	29.4	6.28	4.08	1.68	1.59
1968	36.90	6.37	4.14	1.81	1.79
1969	37.90	6.75	4.39	1.92	1.86
1970	36.80	7.12	4.63	2.06	1.95
1972	30.50	7.12	4.63	1.93	1.88
1973	32.10	6.98	4.54	2.10	2.07
1974	26.80	7.97	5.18	2.22	2.12
1975	29.30	6.04	3.93	1.79	1.70
1976	23.50	6.93	4.51	2.00	2.06
1977	26.70	6.91	4.49	2.07	2.11
1978	27.50	7.26	4.72	2.09	2.11
1979	29.00	7.50	4.87	2.21	2.19
1980	29.00	6.84	4.44	2.16	2.01

Note :

No survey was done in 1966 and 1971

Based on Hodges(1981) estimates of 65 percent of apparent paper and board consumption

Figure 10 2 - Potential supply compared with demand for waste paper



Increasing recovery rates to salvage more of the waste paper will not help to increase its demand or encourage waste paper recovery. On the contrary the amount of waste paper recovered will be so high as to drive waste paper prices down to such a low level that recovery becomes unprofitable and the recovery process will eventually be closed down. Recovery can only be increased with increased demand. The supply and demand must also match in terms of grades of waste paper. To increase the demand for waste paper, alternative markets have to be found for its use.

Various possibilities of using waste paper outside the paper and board industry can be identified, such as use as animal feed, animal bedding and cellulose insulation.

10.2 Animal feed

A common feature found among agriculture wastes which are used as animal feedstuffs, such as cereal straws, hay, groundnut hulls, etc, is their high content of fibre constituents which have been analysed recently (Van Soest,1976) as cell wall constituents : cellulose, semi-cellulose and lignin. Waste paper with its high content of cellulose could be used as a suitable substitute feed to ruminants, since ruminants can utilise large amounts of cellulosic materials in their diet. Ruminants are animals with a rumen or bacterial fermenter for cellulose break-down in their digestive tract. The principal factors to be considered when waste paper is used as an animal feed are animal acceptance and utilisation efficiences, and whether they contain compounds toxic to the animals eating them or to the humans eventually consuming the animal products.

Daniels, et al(1970) found that ground newspaper might replace at least 12 percent of the diet of growing dairy steers without reducing feed efficiency, rate of gain and carcass grade. Higher levels of newspaper would decrease productivity mainly as a result of reduced food intake. But Sherrod & Hanson(1973) in one experiment shown that this decline could occur at newspaper levels of even 6.7 percent, and the nutritive value of paper in ruminant rations was to a large extent a function of the proportion of mechanical pulp used in the manufacture of the paper and the resulting lignin content. The digestibility of various types of paper by ruminants depends upon their lignin content since lignin is not digestible. Coombe & Briggs(1974) found that waste newspapers, as distinct from other types of paper might be of only limited feed value, because of the high lignin content in newspapers.High quality papers such as bonds and computer printouts which had been produced from pulps that have been de-lignified, were therefore more digestible by ruminants than newspaper. Facial tissues are produced from chemical pulps where almost all lignin have been removed. Heffron, et al(1978) investigated the use of facial tissue as a feedstuff for lambs, using mill broke tissues which were clean and had consistent quality. The comparatively high digestibility, animal acceptance and their rate of weight gain favoured the inclusion of such tissues in lamb rations. Other experiments have found decreased voluntary feed intake as paper levels were increased, with concomitant decreases in rates of gain and feed efficiences.

Animals have also been found to sort out waste paper from the ration (Dinius & Oltjen,1972; Millett, et al,1973). However, this problem seemed to be alleviated by adding molasses (Dinius & Oltjen,1972) or by the use of pelleted feeds (Coombe & Briggs,1974).

Other studies (Merteus, et al,1971; Van Soest & Robertson,1976) have shown that waste paper generally was low in energy content, similiar to low quality forage, and the protein content was generally less than that of low quality forage. Food of high ash content has low energy values and Merteus & Van Soest(1971) have found high levels of ash in glossy papers and commented that a wide range of ash content might pose some problems to feeding waste paper to ruminants . The high levels of ash in such paper ought to be further investigated.

Some years ago the Rowett Research Institute, Aberdeen, Scotland conducted some experiments in which they included a proportion of fibre in the diets for beef cattle. The fibres were added in to provide the cellulose content and to give a roughage element in the high energy cereal diets. The waste paper was obtained from a manufacturer of high quality note paper and cheque paper and was therefore clean, of a high quality and has few contraries. Unfortunately, they found lead present in a batch of the waste paper and the experiments were terminated thereafter.

Serum, et al(1973) had measured the lead content of various papers and found 0.02 ppm (parts per million) in computer paper, 3.3 ppm in brown cardboard, 8.3 ppm in grey cardboard, 5 to 10 ppm in newspaper and 180 ppm in magazines. The usual animal feed has only 5 ppm of lead content. Various amounts of lead have been found in printed paper, 8 ppm in black and whites to 3,600 ppm in coloured papers. Lead content in waste paper is mainly due to the ink printed on it, and it can vary from 275 ppm in black ink to 29,000 ppm in yellow ink. Tolerance for chronic lead consumption by cattle is not clear but appears to be 50 to 100 ppm (Belyea, et al,1979).

Cadmium appeared to be present in rather high levels in most waste papers, varied from 4.6 ppm to 10.4 ppm compared to only 0.5 ppm present in normal farm diet. 0.4 ppm would not be harmful to ruminants while 0.5 ppm was safe for some species. 15 ppm or more of cadmium would depress intake of lambs while cows fed above 300 ppm of cadmium had decreased production. 40 ppm of cadmium would have no effect on calves but above 160 ppm would reduce their intake and growth (Belyea, et al,1979).

Daniels, et al(1970) also found aluminium, copper and iron present in significant amounts in newspapers fed to cattles. But liver tissue analysis of the animals did not reveal any toxic accumulation of these minerals.

Accumulation of various heavy metals in muscle, organs, bones and milk has been investigated by various people (Sherrod & Hanson,1973; Dinius & Oltjen,1972 and Millett, et al,1973). General agreement was that no dangerous accumulation of metals occurred in feeding trials with waste paper but monitoring should continue with longer term feeding studies.

10.2.1 Economics of waste paper animal feed

The farmer could use a variety of diets for feeding his animals. For example, for feeding a 250 kg steer the daily diet could be Diet A (Table 10.2) where around 4.1 kg of hay is used in conjunction with other food stuff. Assuming 12 percent of the weight of the total ration is replaced by newspaper, about 3.0 kg of hay could be so replaced. Savings in costs per diet per day is only £0.03. Annual savings in the cost of the diet per animal is about £10.95. Unless the farmer has a large herd, the savings is only marginal. Because there is a limit to the amount of newspaper that could be substituted in the ratio, the more hay is used the less is the savings. For example in Diet B (Table 10.2) the annual savings per steer is only £3.29.

Although higher qualities of waste paper such as pulp substitutes will be better for digestion and can be utilised in higher concentration, their prices are very much higher than hay. The farmer will be comparing hay at £52 per tonne with computer printouts at £95 per tonne (1980 prices). Although facial tissue paper mill broke has been found suitable as a source of cellulose in animal diet and is easily digestible, it is short in supply. Even if it is available, farmers will be comparing prices of around £114 per tonne with £52 for hay.

10.3 Animal bedding

Around autumn 1975 the demand for straw for feeding stock has made it expensive and as a result unavailable for bedding. Livestock farmers fearing a repetition of another straw famine started searching for any cheap alternatives to straw. Newsprint was considered as a possible alternative, mainly because it has been physically pulped with very little chemical action.

The advantage of using shredded newspaper is that it remains clean longer and requires less frequent replacement.

Table 10.2 - Cost savings in substituting newspaper for hay (1980 prices)

Diet A (Daily diet per steer)

	kg	%			kg	%
Barley	4.2	16.6		(newspaper	3.0	11.8
Hay	4.1	16.2	)----replaced by ---(			
Silage	9.5	37.5		(hay	1.1	4.4
Potatoes	7.5	29.7				
	25.3	100.0				

Cost of hay @ £52/tonne = £0.213

Cost of newspaper @ £42/tonne	£0.126
Cost of hay @ £52/tonne	£0.057
	£0.183

Savings per day = £0.03
Annual savings for 365 days = £10.95

Diet B (Daily diet per steer)

	kg	%			kg	%
				(newspaper	0.91	12.0
Hay	6.0	78.9	)----replaced by ---(			
Cereal	1.6	21.1		(hay	5.09	67.0
	7.6	100.0				

Cost of hay @ £52/tonne = £0.312

Cost of newspaper @ £42/tonne	£0.038
Cost of hay @ £52/tonne	£0.265
	£0.303

Savings per day = £0.009
Annual savings for 365 days = £3.29

Paper as animal bedding is warm, extremely absorbent, degradable in the soil and could go twice as far as straw. It is also dust-free, and more absorbent than straw. Shredded newspaper can be produced on a regular all year round, unlike straw whose supply depends on season and weather. Shredded paper bedding rots down well after use and can be collected and spread on the farm as fertiliser. Compare to wood shavings, waste paper is better because the shavings come from trees which have been treated with dieldrin, a chemical which has been identified as the cause of the death of many livestock and zoo animals.

Farmers have used various types of shredders to shred newspapers for animal beddings. But they found that post-consumer newsprints have to be carefully checked before use. Newsprints with staples and colour content higher than 25 percent have been found to be dangerous to the animals. Reports from farmers who have used their own shredded newspapers were conflicting. Some were pleased with it but others said the paper treaded quickly into a black papier-mache and became useless (Trow-Smith,1975).

Various shred width for the newspapers have been used by the farmers. It was later identified that the shred width of the newspaper was an important factor and that shred width of about 12 mm was the most suitable, because this width was wide enough not to ball up or drag and was flexible enough to weave in with itself to give good thermal quality. A machine capable of shredding the newspaper to precisely this width was marketed in 1975 by a company in Exeter. The same company also marketed shredded newspaper in 25 kg bales, packed in polythene bags under the trade name of 'Shredabed'. Subsequently the same company marketed another product called 'Diceabed'. While Shredabed are long strands, Diceabed are irregularly cut confetti. Diceabed have been found to be particularly suitable as broiler poultry bedding where a higher spreading rate and thermal efficiency are needed.

The manufacturer claims that Diceabed has no allergen dust, lower particle dust levels, allows reduction in mortality rates, cleaner birds and less incidence of breast blistering. Diceabed has also been used in cattle, pigs and horses sheds. Customers' reports for the product have been favourable. For example, one dairy farmer at Devon claimed that shredded newspaper took about half the time to spread when compared to straw since less bales were required. He spent only 20 minutes bedding down instead of the 40 minutes needed for straw. He also found that cows stayed as clean, if not cleaner then they did when he was using straw bedding. The cows did not eat the paper which was an additional advantage. A turkey breeder reported that tests carried over a 24 day period in 1975, showed that death rate among young turkeys fell from 12 percent to 5 percent when bedded on shredabed instead of straw (Materials Reclamation Weekly, Vol 127 No.43, Oct 25). A racehorse breeder has reported that his stock was no longer susceptible to respiratory problems when bedded on shredabed (Pickering,1981). A farmer near Exeter claimed that with shredabed, his herd of Friesian milkers have less cases of mastitis than before (Anon,1981).

Following suggestions that the atmosphere in broiler houses bedded with paper litter contained

a) less dust, compared with houses bedded with shavings (eg.wood);
b) less ammonia, compared with houses bedded with straw;

the Northern Ireland Agricultural Trust decided to quantify the parameters. The tests were performed in various houses when the birds in each house were at the same stage of development. While the results of the investigation confirmed the original suggestions (Table 10.3), there was no firm conclusions of the effect of these parameters on production levels in broiler breeding. The only advantage of having less dust and less ammonia in the atmosphere as a result of using paper litter was more operator comfort, which was an increasingly important factor.

Table 10.3 - Comparison of dust and ammonia level in broiler house with different types of bedding
Source : McIlmoyle(1980)

House No	Litter type	Measurement location in the house	Dust level (Mg/m^3)	Ammonia level (ppm)	
1	shavings	½	16.14	> 10	< 20
		½	13.56		
		1/3	12.35	> 10	< 20
		1/3	13.56		
		Average	13.90		
2	paper	½	9.60	> 10	< 20
		½	10.08		
		1/3	11.11	> 5	< 10
		1/3	10.36		
		Average	10.28		
3	shavings	½	13.90	> 5	< 10
		½	14.41		
		1/3	12.99		
		1/3	14.12		
		Average	13.86		
4	straw	½	7.72	> 40	< 50
		½	7.64		
		1/3	7.00	> 30	< 40
		1/3	7.17		
		Average	7.38		

Note : > indicates greater than
< indicates less than

Table 10.4 - Some examples of costs savings in using waste paper based animal bedding

	Purpose	Cost of waste paper based animal bedding	Used to replace	Savings
1976	Pig breeding[1] (24 sows)	1 bale(25 kg) of Shredabed @ 80p, per day	3.5 bales of straw @£1.20 per bale = £4.20	80% per day
1979/1980	Broiler[2] breeding (35,000 chickens)	1.25 tonnes of Shredabed @ £56/tonne = £70	24.5 tonnes of straw @£15 = £367.50	81% per crop
	Turkey brooder[3] house (4650 m^2)	3.4 tonnes of Diceabed @ £136/tonne = £464	71.5 tonnes of dry wood shavings @ £30/tonne = £2145	78% per crop
	Laying pullets[2] and broiler house (929 m^2)	0.75 tonnes of Diceabed @ £136/tonne = £102	5 tonnes of dry wood shavings @£30/tonne = £150	32% per crop
	Cow cubicles[4] (180)	7.3 tonnes of Diceabed @ £136/tonne = £992.80	61.9 tonnes of shavings @ £30/tonne = £1857	47% per annum

Source : (1) Pig International, August 1978
(2) Anon(1979D)
(3) Turkey World, May/June,1980
(4) Anon(1981B)

10.3.1 Economics of waste paper based animal bedding

Table 10.4 compares the cost savings made possible by replacing some of the conventional animal beddings by shredded newspaper. Cost shavings have been very substantial going to 81 percent per crop of breed. Straw has to be brought in bulk and farmers have to find sufficient storage for it. Shredded newspaper can currently be bought in small quantities such as two bags of 25 kg a time, so that the small scale farmers need not worry about a heavy initial outlay and finding storage space.

10.4 Cellulose insulation

Thermal insulation is composed of naturally occurring materials based principally on wood and its derivatives. Although the use of cellulose fibre insulation was known around the 1800s, the product, however, was not firmly established in the USA market until the 1950s, with particularly high growth rates in the 1970s. The growth has been attributed mainly to the cost effectiveness of using newsprints as raw material. It is both cheap to produce and to use cellulose insulation.

Despite the remarkable growth of the cellulose insulation industry in the USA there was no cellulose fibre industry in the UK until mid 1978. Diversified Insulation Ltd is the first UK company to manufacture cellulose fibre insulation under licence from a successful American company. The product marketed in UK under the name 'Shelter Shield' insulation is produced in a factory at Livingston, near Edinburgh.

10.4.1 Manufacturing process

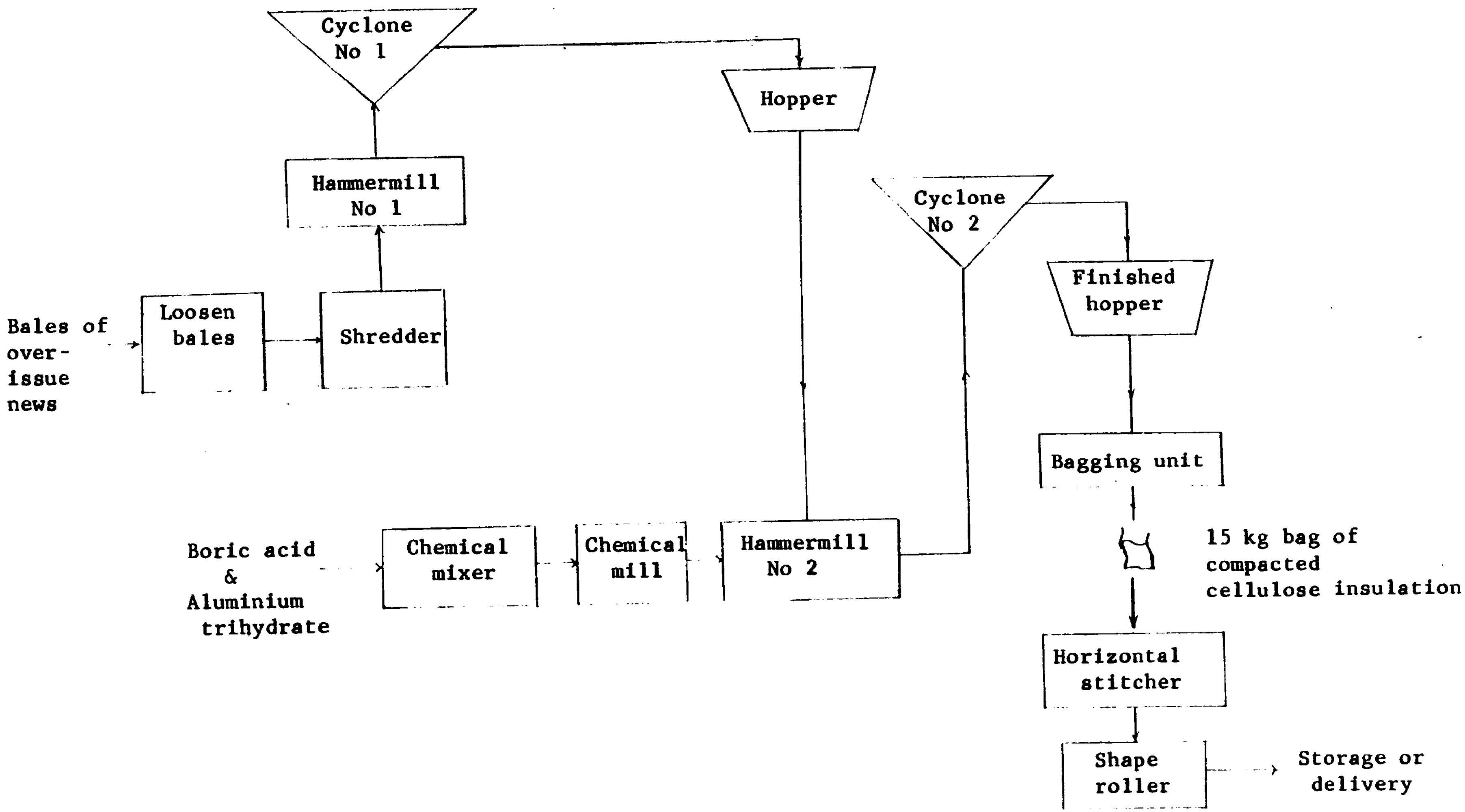
Cellulose fibre insulation may be manufactured from recycled newsprint, cardboard or virgin wood which is pulverised to fibre form and treated during processing with various fire retardant chemicals like borax, boric acid and aluminium sulphate.

Not all waste papers are suitable. Books and boxes which contain glue are avoided as the presence of starch in them will be retained in the final product and will attract rodents and insects, when installed in the loft. Currently only over-issued news is used since it is easily available and is more consistent in quality and cleaner than post-consumer news.

Figure 10.3 shows the layout of the production process in the Livingston factory.

Baled over-issued news is loosen and fed by conveyor belt into a shredder where it is broken down into strips about 70 mm square. The shredded paper is then sent to the first hammermill where it is further reduced until it is small enough to pass through a screen with mesh of about 10 mm square. The meshed paper is then conveyed pneumatically to the first cyclone where the fine dust is blown off. The paper output from this cyclone is then sent to a hopper which feeds it at a uniform rate to the second hammermill. Meanwhile, the dry chemicals, boric acid and aluminium trihydrate are proportioned and blended in a chemical mixer. About 1.4 kg of boric acid is used for 18 kg of newspaper. Besides providing fire-retardant properties, the chemicals also inhibit fungal growth and provide vermin resistance. The chemicals have to be ground to a fine talcum-like powder in a chemical mill before it is sent to the number 2 hammermill. The fine chemical powder mixture is introduced into the second hammermill simultaneously with the meshed paper so that the chemical is dispersed and blended evenly into the cellulose fibres. This is the most critical stage as quality of the finished product depends on how evenly the chemical has been dispersed and mixed. It is the blending stage here which will differentiate different qualities of cellulose insulation. The treated cellulose fibre is then conveyed pneumatically to a second cyclone to ensure that all fines are removed. The output from the second cyclone is dropped into a finished hopper from where it is fed into bags at a controlled pressure to provide 15 kg of

Figure 10.3 - Flow diagram for cellulose insulation dry production process
Source : Diversified Insulation Co Ltd, Livingston, Scotland



cellulose fibre insulation materials in each bag. The filled bags are then conveyed through a horizontal stitcher and passed through rollers to shape them to the required dimensions, ready for loading or storing.

The Livingston factory uses the dry process and so avoids the problem of water piping and effluent treatments. Two wet processes may also be used in producing cellulose insulation. One method sprays or sprinkles the chemical solution into the cellulose fibre material. The second process uses conventional paper making technique and equipment. The paper has first to be reduced to a slurry by pulping and then 50 to 60 percent of the water is squeezed out by compression. The material has to be dried and fluffed prior to bagging. Chemicals are added during the pulping process or squeezing process. Although the wet process has the advantages of better chemical dispersion with improved fire-retardant characteristics and control of corrosiveness, the problem of introducing water and then having to remove the water introduce extra capital investment and requires higher energy consumption. Since the dry process has been able to provide cellulose fibre insulation materials which has passed the various quality control tests in the USA, the relatively simpler and lower capital investments have influenced most plants to avoid the wet process. However, the second wet process which uses conventional pulping equipment should be of interest to paper mills. Since current production capacity ratio of mills in UK is only about 80 percent this offers an opportunity for paper mills recycling waste paper to diversify its production, particularly during period of low paper and board demand. No UK mill has so far taken up such diversification.

10.4.2 Properties of cellulose fibre insulation

The treated cellulose fibre is generally light grey in colour. This is mainly because of the presence of the printed ink on the newsprints. Individual fibres of the fibrous mass examined under a microscope shows a 'C' shape, which allows the fibres to interlock together.

Unlike mineral and glass fibre insulation, cellulose insulation is organic. Their cells within each fibre trap more air thus providing a greater heat resistance. Air is trapped not just within each fibre but also in between the fibres to form a barrier to heat loss, so providing very good thermal properties (Figure 10.4).

The thermal resistance of an insulating material to heat flow is measured by its R-value. Cellulose insulation produced from newsprint has a thermal resistance (R-value) of 0.65 m^2 $^oC/W$. The higher the R-value, the greater the resistance to heat. When compared to most other insulating materials, less depth of cellulose fibre insulation is required to achieve an equivalent R-value because of its greater resistance to heat (Figure 10.5).

The thermal conductivity (K-value) of an insulating material measures the rate of transfer of heat along a body by conduction. It is a specific property of the material and is defined as the quantity of heat which will flow through one metre square of surface area of material one metre thick, where there is a temperature difference of one degree celsius between its faces. Paper based cellulose insulation has a K-value between 0.035 to 0.039 w/m^2 ^oC, compared to 0.05 w/m^2 ^oC for glass fibre.

When heat is transmitted from a building, it is first transferred from the inside air to the structure, then through the structure, and finally from the structure to the outside. Both the inside and outside provide some resistance to heat flow and the thermal transmittance or U-value of the insulating material takes into account these surface resistance. The UK Agrément Board has compared the U-values of paper based cellulose insulation with glass fibre insulation. Results showed that for an average thickness of 100 mm, blown-in cellulose fibre provides about 30 percent more thermal resistance than a glass fibre quilt under the same test conditions.

Figure 10.4 - Cellulose insulation compared to mineral insulation

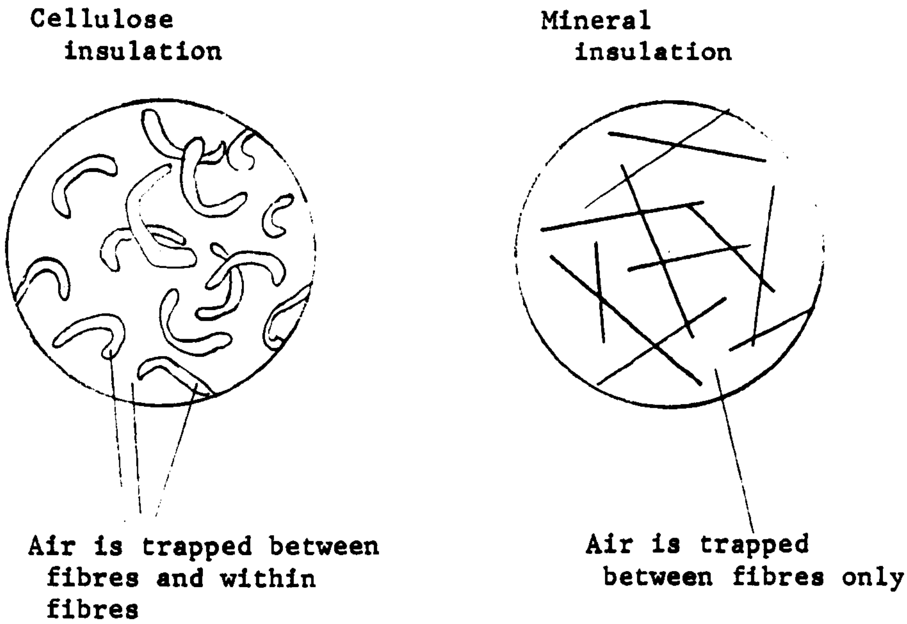
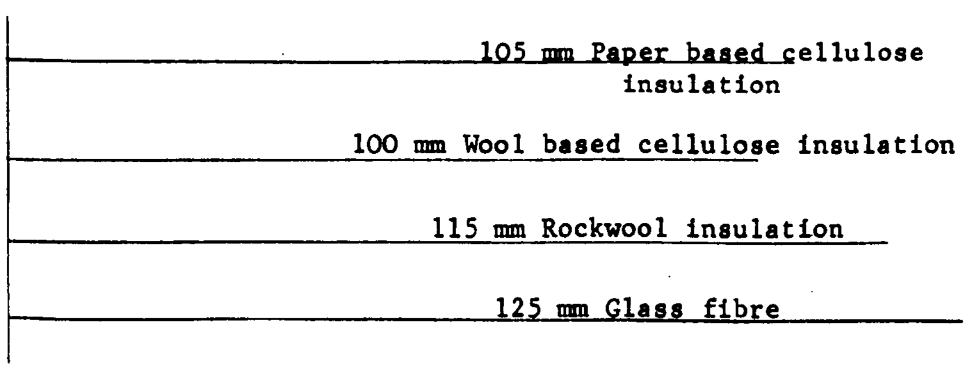


Figure 10.5 - Comparing depths of insulating materials required to achieve an equivalent R-value



The installed cellulose fibre should not sustain flames nor smoulder combustion after being exposed to an igniting source, eg. a discarded lighted match or cigarette bud or over-heated electrical wires. No accepted test in the UK has been formulated but a number of laboratory tests conducted by the Agrément Board have shown that installation of this particular cellulose fibre insulation would not result in a significant increase in the fire hazard which exists in the normal loft situation. No field test on the fire hazard of cellulose insulation has been carried out. However, the Nottingham Evening Post of 30 July 1980 reported on 'how cellulose insulation have saved a Chilwell house which caught fire'. The house has just installed cellulose insulation in the loft floor a few months earlier. The station officer at Dunkirk fire station admitted that when he first investigated the fire he thought the insulating material had perpetuated the fire. But examination of the material revealed that it has prevented the fire instead. It seems the insulation properties prevented the downward spread of the fire. The insulation material was spread over the ceiling joists and stopped them from catching fire.

Cellulose insulation can cut heat loss through the roof by as much as 78 percent and could also reduce noise nuisance from external sources.

Tests carried out on Shelter Shield insulation (HWU,1978,1979) concluded that there was no significant risk of corrosion occurring in materials with which the insulation might come into contact.

Cellulose fibre insulation contains about 70 percent by weight of readily hydrolysable carbohydrates which could be attacked by 'dry rot' and 'wet rot' fungi. Tests carried out on Shelter Shield fibres (GLAS,1978) showed that the material was resistant to fungal attack.

The installed insulation does not produce any odour and it is highly permeable. As it is still a fairly new product in UK the effect of ageing cannot be gauged, although the manufacturers claimed that dwellings in USA which have installed similar insulations have shown no change in the insulation.

10.4.3 Economics of cellulose insulation

Currently cellulose insulation in UK is marketed for loft insulating only. Each bag of 15 kg of cellulose insulation material can cover about 6 m^2 of loft area to a depth of 80 mm, at an installed density of 35 kg/m^3. To insulate the loft of a typical 3-room house requires about 6 bags of such material. Diversified Insulation quoted a price of £40 to insulate a typical 3-room house with 6 bags of 'Shelter Shield' cellulose fibre. This included workmanship. Another cellulose insulation manufacturer, U-Save (Insulation) Ltd based in Gwent, Wales quoted a cost of £3.90 per bag (15 kg weight) of cellulose insulation to a contractor. To insulate a typical 3-room house also uses 6 bags of the material at a cost of £23.40 which is about half the cost of glass fibre quilt required to achieve the same end result.

The cost of just the raw materials to cover a metre square of the loft with cellulose fibre insulation is about 65 pence, compared to the £1.10 to £1.50 required for glass fibre and £1.30 to £1.65 for mineral wool. There is therefore a savings of at least 45 pence for every metre square of loft.

Cellulose fibre insulation is fast becoming a big business in UK. In the last two years several new companies have emerged in England and Wales. In late 1980 'Maybank Insulation' was set up in South East London. Their product is marketed under the bland name of 'Warmcel Insulation'. Soon after that it acquired one of Britain's largest cavity wall insulation specialist, Modern Plan Insulation, which has contracts with seven gas and electricity boards as nominated installer of both cavity wall and loft insulation. The take-over will provide the Maybank Insulation with a national framework to penetrate the insulation market with paper based cellulose fibre insulation.

The Independent Waste Paper Processors Association in an attempt to diversify the markets for waste paper, set up in 1981 a cellulose insulation factory in Gwent, Wales, under the name of U-Save (Insulation) Ltd. They are the first within the waste paper industry itself to identify this process as an alternative use of waste paper. Current output is very small, only about 20 tonnes per week. In January 1982 two other cellulose fibre companies, Trans-Thermal Insulation London Ltd and Trans-Thermal South East Ltd joined together to market cellulose insulation under Icon Insulation Ltd. They are the sole distributors of 'Cellusave', the market name for their brown cellulose fibre insulation produced by U-Save (Insulation) Ltd in Gwent.

In the USA paper based cellulose fibre insulation holds around 40 percent of the insulation market. Diversified Insulation claims that it is taking about 70 percent of all new housing loft insulation in Scotland. Cellulose insulation manufacturers in UK forecast the market penetration to approach 40 percent over the next few years. They attributed this market growth to

1) the thermal efficiency;
2) the lower cost both for raw material and for application;
3) freedom from health hazards compared to abestos insulation; and
4) abundant supply of domestic raw material which is available at a low price.

10.5 Indirect recycling of waste paper as a heat source

In recent years high price of fossil fuel has led to the search for alternative sources of energy and it is inadvertible that some industries start considering the burning of waste paper as a source of energy. Waste paper is now a major source of secondary fibres for the paper and board industry and its use as a fuel will eventually create serious raw material for the recycling mills. But fossil fuel prices have increased substantially to the point where waste paper has to be re-assess on its worth as a source of secondary fibres and as a source of energy.

The value of waste paper as a source of secondary fibre depends upon its grade and its application. Its worth to the recycling mills may range from £29 per tonne for mixed waste to about £163 per tonne for tabulating cards (1980 prices). But waste paper used as a source of energy will not have any difference in grades except for those highly filled and heavily coated papers. All grades of waste paper will therefore be valued by its calorific value which is about the same, about 14.0 GJ/tonne for paper with 20 to 30 percent moisture content and about 18.6 GJ/tonne for dry paper (Bridgwater & Mumford, 1979; WMAC,1979). Waste paper will be suitable for burning as a supplementary fuel to coal. If the average calorific value of coal is taken to be 25.50 GJ/tonne and each tonne of coal costs £35.20 (1980 prices) then the calorific value of the waste paper will give it a value of £19.26 per tonne for paper with 20 to 30 percent moisture and about £25.58 per tonne for bone dry paper (Table 10.5). Considering only the bulk grades which are the cheapest waste papers, at normal market price in 1980, its lowest value as a fibre source is higher than its average value as a fuel source by about 26 percent. Even at its lowest price in 1981, its lowest value as a fibre source is still higher than its average value as a fuel source by 6 percent.* Waste paper recycled will not only save energy, it can be recycled repeatedly but when waste paper is burned it can be an energy source just once.

Waste paper will only have value as a fibre source when it is bought by the mills. During slack demands there is alot of waste paper not taken by the mills and it has to be dumped into tips. These waste papers will therefore have no value as a fibre source. They will then have a higher value as a fuel source and should be employed as a fuel rather than destroyed by dumping. There is also a substantial amount of waste paper in the

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* But when price of coal becomes higher, such as £53.20 per tonne (October 1982 price), then the value of waste paper as an energy source becomes higher than its value as a fibre source.

Table 10.5 - Comparing waste paper as a fibre source and as an energy source

Value as a fibre source

Grade	Price £/tonne Normal price in 1980	Price £/tonne Lowest price in 1981	Recycled into	Yield tonnes produce per tonne waste paper	Fibre value £/tonne Normal price in 1980	Fibre value £/tonne Lowest price in 1981
Newsprint	29	22	newsprint	0.94	30.85	23.40
Container waste	32	29	liner board	0.92	34.78	31.52
Mixed waste	29	22	paper board	0.90	32.22	24.44

Value as an energy source

Fuel	Calorific value GJ/tonne		Price £/tonne	Price £/tonne, when coal price is higher than £35.20/tonne	
Coal	25.59		35.20	£53.20 #	£58.52 @
Waste paper 20-30% moisture	14.0	$\frac{14.0}{25.39} \times 35.20^{*} =$	19.26	£29.33	£32.27
Bone dry	18.0	$\frac{18.0}{25.59} \times 35.20 =$	25.58	£37.42	£41.16
Average	16.0	$\frac{16.0}{25.59} \times 35.20 =$	22.00	£33.26	£36.59

Average
* Price of coal assumed to be £35.20/tonne (1980/81 prices)

October 1982
@ 10% increase over October 1982 price

municipal refuse itself which is currently not recovered for direct recycling because of its low quality. This type of waste paper should be recycled indirectly as an energy source.

Paper and board content in domestic refuse contributes around 43.4 percent of the entire heat capacity when refuse is burnt. The average calorific value contributed by paper and board to the entire heat output when domestic refuse is burnt is about 4.21 GJ/tonne (Table 10.6). The plastic content contributes another 26.8 percent of the total heat output. The use of the paper and board together with the plastic content of the domestic refuse to produce a fuel pellet is currently under intense study in UK and many other countries. The real advantage of pelletising such combustibles is the creation of a storable fuel which enables the energy to be easily transported and the energy release to be better tuned to the demand. Refuse derived fuel (RDF) as it is called, does not resemble household waste and is likely to be more acceptable in an industrial site. Properly produced it can be stored, under cover, without detriment to the environment and neither will it deteriorate in quality after storage, up to a year (Hook,1981).

In UK itself there are at least three plants, Byker, Doncaster and Eastbourne, involved in RDF pellet production. Refuse treatment plants and RDF pellet production in UK have not been in operation long enough on a continuous basis to allow meaningful process cost evaluation to be made and it is difficult to assess at present how successful the operations of these plants will be. However, if the USA experience is any model to go by for comparison, information received to date does not give a very bright future for the waste treatment plants. Most of their schemes have been dismal failures and there are ominous signs that there are no genuine markets for much of what is recovered from separation and processing plants (Holmes,1979). Current production problems in British RDF plants include blockage to the pelletiser, inconsistent heat output, sensitivity of pelletisation quality and quantity to changes in the feed materials.

Table 10.6 - Heat content of household refuse

Components in domestic refuse	Percent by weight (i)	Heat energy content GJ/tonne (ii)	Contribution to total refuse heat value GJ/tonne	
Dust and cinders	14.0	7.0	0.98	10.1
Vegetable & putrescible	25.0	5.8	1.45	14.9
Paper and board	29.0	14.5	4.21	43.4
Metals	8.0	-	-	-
Textiles & man-made fibres	3.0	15.8	0.47	4.8
Glass	10.0	-	-	-
Plastics	7.0	37.2	2.60	26.8
Unclassified	4.0	-	-	-
		Total	9.71	100 %

Note :

(i) Based on 1980 national analysis of domestic refuse in UK (Burtenshaw,1982)

(ii) Bridgwater & Mumford(1979)

At present there is still no clear indication of the size of market for RDF produced in UK, although most of the small output that is currently being produced by the three RDF plants in UK are being taken away by customers under contract. The possible outlet that has been widely suggested is the electricity generating industry but there is currently no evidence that pulverised fuel burning power stations could accept RDF and it would not be economic to burn RDF in the older stoker-fired station (Porteous,1977). With the higher prices of conventional fossil fuel industry may eventually find RDF pellets a cheaper supplementary fuel. R & D work must be continued to overcome the production problems and to produce a dense pellet with consistent calorific value.

10.6 Effect of alternative products on the consumption of waste paper

Use of over-issued newspaper and other higher grades of waste paper as a part of the diet for ruminants do not offer much costs savings. With the problem of possible toxic contamination of the animals there is still much speculation on the feasibility of using waste paper on a large scale to substitute hay for animal feed. Two other products at present are able to offer additional markets to waste paper, namely animal bedding and cellulose insulation. But the use of waste paper for animal bedding is currently limited to only used newspaper and the annual consumption is about 28,800 tonnes per annum. At present cellulose insulation uses only over-issued newsprint and the total consumption by the 3 producers in UK is currently only about 15,600 tonnes per annum. With the closure of the 2 deinking mills in the last two years, which recycled over-issued newspaper into newsprints, the cellulose insulation market is just absorbing the tonnage of over-issued newsprints which had originally been consumed by the deinking mills. Therefore the amount of over-issued news available at present is still sufficient for the cellulose insulation product. The re-structuring of newspaper vendor system in recent years had reduced the amount of over-issued news that could be available and this amount is expected to be reduced year by year as a result of the newspaper publishers' effort to reduce production cost. Should the two deinking plants re-start there will be high demands for over-issued newsprint and the present low cost of raw materials for cellulose insulation may not be maintained. When that happens cellulose insulation production will have to convert to using post-consumer newspaper as a raw material, like their counterparts in the USA.

RDF production is currently rather limited, output from the three major plants, Byker, Doncaster and Eastbourne, is still rather small. Alot of work is still being done by these three plants to interest industrial users in burning RDF. Annual production from the three plants are estimated at 43,200 tonnes. Assuming a 73 percent contents of waste paper in the RDF pellets, a total of 31,536 thousand tonnes of waste paper would be used.

The net effect on the amount of recycled waste paper is still very small, being only a 3.6 percent increase over the 1980 recycled tonnage (Table 10.7). In terms of increasing the utilisation of mixed waste the present alternative products have very little effect, since mixed waste is suitable as a raw material for RDF production only. Therefore other alternatives capable of recycling waste paper, particularly the lower grades such as mixed waste, have still to be developed.

10.7 Other possibilities

Chapter 4 earlier, have shown that except for three years, 1976 to 1978, more waste paper have been exported than imported. Exports were highest from the mid 50s to the mid 60s (Table 4.6) when exports of up to 8 percent of the total recovered tonnage had been made against imports of less than 1 percent of total recovered tonnage. But by 1980 exports were only 3 percent of total recovered tonnage. Export and imports were done on an ad-hoc basis by merchants depending on prices and demand in UK and overseas. Exports of waste paper should be used to increase the demand for waste paper but must be a planned approach, particularly by the British Waste Paper Association, with a

Table 10.7 - Effect of other products on the amount of waste paper recycled

	'000 tonnes		Percentage of potential supply	Alternative use of waste paper as a percentage of 1980 recycled tonnage
Potential supply of waste paper (1)		4440.0	100.0	
Amount recovered for recycling in the paper mills (1)	2155.3		48.5	100.0
Amount recycled into animal bedding (2)	28.8		0.6	1.2)
Amount recycled into cellulose fibre insulation (3)	15.6		0.4	0.8) Net effect = 3.6
Amount recycled into RDF (4)	31.5		0.8	1.6)
Maximum recycled tonnage in all		2231.2	50.3	
Remainder yet to be recovered for recycling		2208.8	49.7	

Note :
(1) 1980 figures, from Table 10.1
(2) Based on 9 production units in 1981/82, each using about 3200 tonnes of waste paper per year
(3) Based on 3 manufacturers (1981/82) each consuming about 5200 tonnes of waste paper per year
(4) Assuming all outputs from the Byker plant, the Doncaster plant and the Eastbourne plant are eventually sold.

Plant	Output pa
Byker	18200 tonnes
Doncaster	7500 tonnes
Eastbourne	17500 tonnes
Total :	43200 tonnes

73% content of waste paper = 31536 tonnes of waste paper proper strategy to handle the exports at a strategic level rather than at a tactical level. The forecasting models developed in Chapter 8 will be able to help them to do this. A 10 percent export of the 1980 recovered tonnage of 2,155.3 thousand tonnes would improve the demand for waste paper by another 215 thousand tonnes.

Other products which are currently being investigated and which may have potential for increasing the demand for waste paper are :

a) animal feed, at the University of Wisconsin in conjunction with the Department of Agriculture, USA;
b) use of newspaper as a casing medium, at the University of Aston in Birmingham; and
c) an inexpensive hardboard using shredded newspapers and an equal weight of urea-formaldehyde flash (a plastic industry waste material), at Westinghouse Research Laboratories, USA.

Household tissues and other tissues production in UK have been growing steadily from an average 28.6 thousand tonnes per month in the first quarter of 1972 to 37.7 thousand tonnes per month in the third quarter of 1981. The paper and board industry regard this sector of market to be growing. Recycling of waste paper into tissues and toilet papers in UK use mostly the higher grades of waste paper. Toilet paper quality in UK is much better than many of those used in the continent and in the Scandinavian countries where alot more of the deinked newsprints are used in their production. This is mainly because consumers in UK demand a higher standard of toilet papers than those in the continent. If consumers in Britain could lower their standard for toilet papers more newsprints could be used for producing the lower quality toilet paper.

These products will be able to improve the demand for newspapers and other better grades, but not for mixed waste. Mixed waste, because of the uncertainty in composition and fibre characteristics, currently has very little alternative markets.

New products which could possibly extend the use of mixed waste are :

a) protein production, currently being explored at the US Bureau of Waste Management; and
b) production of industrial alcohol, being explored at the University of Glasgow and also at the New York University.

Mills with low utilisation of their production capacities should explore the use of mixed waste in conventional pulping equipment to produce cellulose insulation by the wet process. The use of mixed waste in producing RDF pellets could also be considered.

11 - Future technological development required to improve recovery and recycling of waste paper

The potential supply of waste paper is in the lower grades, particularly mixed waste which currently has very restricted use because of its short fibre length and its heterogeneous fibre composition. But technical development has expanded to some extent the use of mixed waste. Several years ago, for example, fluting media made from mixed waste paper would not be as good as that made from semi-chemical pulp, but today improved technology has altered this situation. Technological development is therefore required to expand the use of waste paper before recovery and recycling of waste paper can be increased. Some future areas of technological development in this direction are, research into the fibre characteristics and the effect of multiple recycling, contraries removal, deinking processes, the commercial development of a solvent for cellulose and the integrated recovery of waste paper with waste disposal.

11.1 Fibre characteristics and multiple recycling

More work still needs to be done to try and identify the character of fibre degradation caused by recycling, to understand the mechanism and processes by which fibre degration may be reduced or repaired so that the properties of the finished product made from secondary fibres can be substantially improved.

The essential and industrially relevant differences between secondary fibres and virgin fibres need to be defined in physical and chemical terms, which will then help to indicate the type of practical measures to prevent or remedy the adverse effects of recycling.

11.2 Contraries removal

Chapter 3 have shown that contraries removal is the major problem in recycling and there are still a number of pernicious contraries that are difficult to remove, particularly the new synthetic or rubbery adhesives and thermo-plastic materials such as hot-melt, pressure sensitive and latex emulsion adhesives which are becoming more common in many consumer stationery. Much lower capital cost and application cost than other adhesive systems supported the use of hot-melt adhesive coatings systems and promoted its use. Application energy costs for hot-melts are so low that energy savings of as much as 84 percent of other systems are possible (Anon,1979C). The advantages of using hot-melt coatings in the future will increase with the rising cost of energy. Therefore hot-melt contraries can be expected to be on the increase. Various types of equipment for removing such contraries have been developed but all have disadvantages of high purchase cost, operating cost and they introduce deterioration to the mechanical properties of the recycled fibres. Improved techniques for the removal or dispersion of thermo-softening contraries must be found.

New forms of additives that are cheaper to use and yet will not interfere with recycling of the fibre will also have to be developed. Kungnees(1974) have shown that it was the removal process, not the contraries, which was responsible for changes in the fibre properties. He also shown that fibre bonding and strength can be restored to essentially their initial values by chemical treatments used in the aqueous polyethylene removal and deinking processes. It is therefore important that more of the characteristics of the various additives now used in paper and board production be known before they are being employed, particularly the ways of removing them from waste paper without damaging and degrading the fibres during the removal process.

New methods have to be developed for quantifying, characterising and analysing sticky contraries. Surface and colloid chemistry properties of sticky contraries need investigation as their knowledge can be applied to the use of flotation cells for stickies removals. Engineering fundamentals involved in the solids/fibres separation processes ranging from pulping, screening, centrifugal cleaners and other processes used for contraries removal also need further research and better understanding.

11.3 Deinking processes

Both deinking methods, washing and flotation have many limitations and drawbacks which require further research. Two processes are currently in development but still require a good deal of perfecting. One tries to improve the flotation method while another tries to use a mixed process combining both methods of deinking by flotation and washing. Experiments with new processes which have reached a semi-pilot stage include one form of deinking using solvents and another form of deinking by means of coagulating the ink before filtering it by centrifugal means. Deinking by using ultrasonic means has also been developed to the pilot stage. This method will offer great potential once it is fully developed as there is no effluent problem involved, being a rather dry process.

High speed printing has led to the development of binders and ink drying methods that have the effect of bonding the ink more tightly to the fibres, making removal difficult. The longer the ink stays on the paper the harder they are to be separated from the fibres. Development of pulping at high consistency of 10 to 15 percent has helped to overcome this problem to some extent. But the removal of ink particles is accompanied by a loss of around 5 to 10 percent secondary fibres. Research to perfect new ink formulae for easier and cleaner removal as well as undertaking research on new and better techniques of ink removal will be required. Further research in the surface physics and chemistry of fibres, inks and their interference with and the effect on each other, will be required. The results of these research will allow greater use of deinked pulp in the manufacture of newsprint, extend use of deinked pulp to other paper products such as tissue papers, toilet papers, printing and writing papers.

Associated with deinking is the effluent problem. Dry deinking process such as by ultrasonic means will eliminate this problem but until the process is commercially viable, ink manufacturers will have to help in manufacturing inks which will give lower effluent loadings and also use chemicals which are not toxic to solubilize the ink. Deinking also gives rise to alot of sludge which needs disposal. EEC(1977) estimated that every 800 kg of deinked pulp produced will give rise to 660 kg of sludge. Research into the properties of the sludge, its possible dehydration for easier and cheaper removal to landfill, possibilities of recycling through selective recovery of fibrous and mineral substances, will need to be done.

11.4 Solvent for cellulose

A new solvent for cellulose, a combination of dimethyl sulfoxide and paraformaldehyde had been developed in mid 1975 at the Institute of Paper Chemistry in Appleton, Wisconsin, USA (Anon,1975B). Previous solvents were not economical enough to be of much use in most of the existing processes for making paper and paper chemicals but dimethyl sulfoxide was a by-product of paper making. The new solvent dissolved a variety of cellulosic materials including filter papers, cotton linters and even long fibre cottons having molecular chains containing up to 8,000 glucose units. An important aspect was that this solvent did not degrade the cellulose chains in solution. Exploratory experiments showed that this solvent selectively dissolved carbohydrates in the cellulose of a high-yield pulping wood leaving the lignin behind. Although the detailed mechanism involved in the solution of cellulose in the new solvent has yet to be elucidated, it was believed that the solution caused the formation of a methylolcellulose complex when the cellulose contacted the paraformaldehyde. The complex appeared to be solvated and stabilised by the dimethyl sulfoxide.

In principle the solvent could be applied to recover cellulose from waste paper simply by dissolving the waste paper in the solvent and then recovering the cellulose for pulping by simple filtration, since only the cellulose is dissolved. Contraries left behind can be filtered off and would not affect the fibre properties as conventional methods are doing. The laboratory experiment is still undergoing further research before it could be scaled up and finally made available commercially.

11.5 Integrated recovery of waste paper with waste disposal

Current local authority practice of recovering waste paper is not adequate to meet the needs of the recycling mills, particularly at times of high demand. The limited long term public response to source separation and recovery at the collection point plus the high cost of separate collection have caused a number of authorities to consider sorting and separating the waste paper at the disposal point. About 8 to 13 percent of local authority supply of waste paper have been salvaged in this way.

Another alternative is to collect all the domestic refuse together in the usual refuse vehicle and then sort out the waste paper at a central municipal site by entirely mechanical approach. With the appropriate technology this method will give amongst other things, the advantages of simplicity of collection, minimum cost of transport, fits in with the mechanical recovery of other materials such as metals, glass, plastics and a fine combustible fraction for waste derived fuel.

Various mechanical sorting processes have been designed in recent years in different countries. Most are at various stages of development and none has proven itself in either technical or economic terms. The most promising system at present seems to be the Dutch Flakt RRR resource recovery system, which is capable of recovering 16,600 tonnes of waste paper from a refuse input of 125,000 tonnes each year. Two relatively uniform grades of paper are recovered :

a) a light grade which consists primarily of newsprint, mechanical pulp and thermo-mechanical pulp with a mixture of tissues; and

b) a heavy grade consisting mainly of kraft pulp, corrugated board, bag paper and cardboard.

The two paper fractions have been tested in various paper mills in Holland and it has been found possible to sell the light paper fraction for recycling into the middle layer in cardboard and the heavy fraction as an ingredient in wood fibre board. No actual operation cost has so far been published and it is difficult to assess the viability of this system.

In UK itself, there is only one such plant currently in pilot operation at Doncaster. Coming on line in November 1980, the plant has since introduced many modifications to its system and it is still not possible to recover waste paper with a contrary level low enough to be acceptable to contemporary cleaning equipment in the mills. So far samples of waste paper recovered from the solid waste is only mixed waste paper grade and they are heavily contaminated and soiled. Experience so far has pinpointed three major problems with waste paper extracted from municipal solid waste, irregular and heterogeneous composition, rather low quality of fibres, presence of contraries and non-fibrous contaminants. Further developments to the Doncaster system is still needed before a paper-rich fraction which is acceptable to the mills for recycling could be recovered.

Research will also be needed to study the range of composition of waste papers that can be recovered from municipal waste, taking into account the different population features of different regions so as to identify regions where sufficiently good fibres can be recovered in quantity.

Recycling of waste paper from municipal waste carries with it bacteria and possible traces of toxic heavy metals. Methods to measure their content present in the waste paper and the evaluation of health hazards that could arise from using products manufactured from such secondary fibres will need to be clearly examined. It should include studies of sterilization processes and development of technology for bacteriological purification of waste paper pulps. Evaluation of the health hazards in finished paper products which may come into contact with food stuffs for human consumption will be of major importance.

12 - The role of the government

In a number of countries where waste paper recovery rates have been high, the government has been seen to be actively involved. For example, excess stock schemes as short term measures to counteract temporary recessions in the waste paper market have been tried out by governments in Japan, Holland and Norway. The Swedish and the Swiss governments have made source separation of waste paper mandatory by law. But in UK the central government had only published a Green Paper War on Waste - A Policy for Reclamation (Cmnd 5727) in 1974, to show its support for and to encourage reclamation of secondary materials. This chapter therefore looks at why government support for waste paper recycling in UK is needed, what has been done so far, and what further government actions are needed to improve the rate of recycling.

12.1 Rationale for government support of waste paper recycling

Secondary fibres provide a saving in the use of 'scarce' resources. Although trees for wood pulp are renewable, its growing period may go up to as long as 60 years for certain species. Britain has very little timber suitable for paper making because its forest area is small and its average wood output per hectare is also small (Cumming,1980). Home produced pulp in UK is minimal, producing about half a million tonnes per year, capable of meeting only 8 percent of the raw material input requirements. Even by the end of this century it is unlikely local timber could provide more than 12 percent of the raw material requirement of British mills (DOI/DOE,1980). Much of the wood pulp required would have to be imported. Waste paper is therefore an important domestic resource and the greater the recycling rate, the less wood pulp need to be imported.

The burden on the balance of payments from imports of wood pulp is considerable. In 1974, the import bill was £270 million, went up to £986 million in 1977 and to £1,272 million in 1979. Mixed waste paper has no economic substitute for paper and board production, so that if it is not recovered from domestic sources, it would have to be imported. A reliable local supply of waste paper would give greater independence from foreign supplies and remove a possible obstacle to economic growth. Although it was immensely difficult to be accurate, Taylor(1977) estimated that if an additional one percent of the consumption of paper and board was met from recycled paper, import savings on wood pulp would approach £10 million. The Committee on Waste Paper Supply estimated that in 1978 the import savings as a result of reduction of imports achieved through the use of 2.1 million tonnes of home produced waste paper was £373 million. With the trend of increasing wood pulp prices, this savings can be expected to be bigger in the future.

Use of secondary fibres also leads to less energy consumption. With the price of energy on an upward trend, recycling waste paper will also help to conserve precious fossil fuels.

When waste paper is recovered from the solid waste stream, the volume of refuse can be reduced up to 20 percent and the weight by about 11 percent (Table 5.3). Not only will more compact and therefore better tip be obtained, tipping space will also be conserved through the exclusion of the volumetric paper element. In real terms, tip life is money. At the present recovery rate, tip life could be increased by at least 13 percent per year (para.5.8).

The calorific value of paper is considerably higher than other refuse constituents. Separation of waste paper from solid waste lowers the risk of costly damage to the refractory linings of refuse incinerators. When refuse is pulverised, the breakdown of the solid waste is speeded up by paper separation and excessive wear on the hammer is subsequently alleviated.

Effluent treatment in the mills will be reduced when secondary fibres are used. This is especially true in the case when deinking is not used. Recycling of waste paper will reduce the amount of virgin wood pulp that needs to be produced which results in reduction of air and water pollution.

Every tonne of waste paper recovered would give rise to savings in waste disposal costs. Waste disposal savings based on an average £1.86 per tonne, for a tip disposing anything from 10 to 500 tonnes per day (Rushbrook,1982), would give an annual waste disposal savings of around £4 million when 2.1 million tonnes of waste paper are recovered for recycling.

12.2 Government involvement to date

Government participation in waste paper salvage was most intense during the two World Wars, when there was extreme shortage of imported wood pulp due to restricted trade movements. In World War I the Royal Commission on Paper established rules in the form of a Waste Paper Order, under which the saving, collection and recycling of waste paper was organised by the Board of Trade. In World War II similar regulations for controlling waste paper supplies were introduced under the Ministry of Supply's Paper Controller. Not only were both the public and the local authorities encouraged to salvage waste paper, maximum prices for waste paper were also fixed which allowed local authorities to compute with rather good accuracy the potential returns from their salvage activities. Recovery rate of waste paper during 1941 to 1945 was 47.8 percent (Liversay & Barcena,1975) compared to an average of 28.7 percent in the 1970s. The resumption of free trade following the end of the war finally removed the strict war time controls, in 1949.

Apart from the duration of the two world wars the government did not attempt to stimulate waste paper recycling until 1965 when the marked increase in the waste paper requirements of the paper and board mills led the government to set up a working party in the Economic Development Committee (EDC) for the Paper and Board Industry, to consider future demand for waste paper and to consider all possible means of meeting that demand. The aim was to reduce imports of wood pulp by substituting them with recycled waste paper, so as to reduce the UK's then adverse balance of payments. The working party published in February 1966 a report which projected an increase in demand for waste paper over the next few years, which could only be met by increased local authority collection, since other sources of waste paper were already fully exploited. It recommended the use of contracts of reasonable duration, up to 5 years or more by the mills to guarantee purchase from the local authorities besides other financial terms to cover the costs, as means to encourage local authorities to increase their waste paper recovery effort and also to encourage local authorities to start collection. A recommendation to help keep down transportation cost was for mills to collect from districts within a 'reasonable' distance of the mills, say 100 miles (161 km). The report warned that if all local authorities were to salvage waste paper there would be a surplus.

The energy crisis of 1973/74 and the adverse balance of payments following that led to another government initiative calling for the growing reliance on the country's own resources. In early 1974 waste paper was again in short supply. In September 1974 the government published a Green Paper - War on Waste - A Policy for Reclamation (Cmnd 5727).

12.2.1 'War on Waste - A Policy for Reclamation'(Cmnd 5727)

The paper explained the government's intention to launch a national drive to cut down waste and promote recovery and re-utilisation of materials, and invited the entire community to cooperate. The vital role of the local authorities was to organise the separation and reclamation of recoverable materials, to win cooperation from the public and voluntary bodies, the industry and their work force and trade unions, and in operating recovery schemes. The public was urged to learn or re-learn the habit of regarding waste material as potentially valuable resources. Industry was to reduce unnecessary packaging and encourage the re-processing of waste. An integrated approach to the whole recycling chain was the aim. Market forces were to be examined to see how adequate they were in encouraging reclamation and whether new financial incentives or disincentives were necessary.

The Green Paper identified waste paper as an area that offered considerable potential for greater reclamation efforts, particularly by local authorities in their function of refuse collection and disposal. The paper pointed out that a policy of encouraging local authorities to make separate collections was not enough. Co-ordinated planning to ensure that the paper industry could absorb the increased arisings on a continuous and long term basis was essential. That would involve, amongst other things, consideration of changes in product mix from types of paper-based or virgin wood fibre to alternative waste-based products.

At that time the government was seen to be genuinely committed to a positive leadership role in the war on waste. Various factors supported this view. The Control of Pollution Act,1974 was just introduced, though not fully implemented. Under this Act, when the relevant sections are implemented, waste disposal authorities would have the new duty of surveying most of the wastes arising in their areas and making a comprehensive plan for their disposal. The Act specifically required the disposal authorities to consider ways of reclaiming wastes when preparing their plans, and also conferred wide ranging powers on them to engage in reclamation activities. A special Advisory Group on Waste Paper Recycling have been set up just before the Green Paper was presented to Parliament. The Green Paper also announced a new high level Waste Management Advisory Council being set up to examine ways of promoting the reclamation of waste. Further support to this new scheme was given by the Government's declaration of its role in assisting the development of the reclamation industry in four major ways :-

a) support and publicity campaign to encourage reclamation work throughout the community;
b) research and development into waste processing and reclamation technology;
c) stabilization and orderly development of the markets for recycled materials; and

d) possibility of new regulatory or financial measures to promote the right level of reclamation activity.

12.2.2 Special Advisory Group on Waste Paper Recycling

This group was formed within the Department of Industry in summer 1974 with representatives drawn from the paper and board manufacturing industry, local authorities, trade unions and both the Department of Industry (DOI) and the Department of Environment (DOE). Its terms of reference were to advise the government on measures to increase recycling of waste paper in UK and in particular to consider and advise on, -

a) the future waste paper requirements, nationally or industrially, of the paper and board industry;
b) the extent of which these future requirements could be met from current sources of supply;
c) the degree to which additional collection through local authorities and/or other organisations should be encouraged and what actions ought be taken to achieve that aim;
d) ways by which cyclical variations in demand of substance might be reconciled with the need for continuity of recovery;
e) the national financial, economic and environmental effects which might occur from increased recycling;
f) the potential for increased exports in the medium and long term;
g) the need for further R & D, particularly in the field of handling, sorting and processing plants; and
h) the benefits of internal collaboration in the field.

One of the first jobs of this Group was to try to find out more about the activities of waste paper recovery operations in the local authorities. A working party was set up to conduct a survey of English and Welsh local authority waste paper salvage schemes in 1974/75 (para 5.1.2). Subsequently the Report on Waste Paper Collection was published. No precise recommendation was made except that a standard accounting procedure for waste paper recovery by local authorities should be devised (para 5.2).

Within 12 months of the formation of the Advisory Group, their work was put to the test. Waste paper recovery is associated with cyclical and fluctuating demands where peaks and troughs of demand throw collection and processing schedules off-key with great regularity. In August 1974 waste paper was in very short supply and there have been calls in Parliament to stop exports of waste paper to even the EEC. But by January 1975 there was over supply of certain grades of waste paper and by February 1975 many people suddenly discovered that the waste paper they have laboriously collected was not wanted. Collection was estimated to have exceed usage by between seven to fifteen thousand tonnes per week. Representatives of the mills and merchants shared the government's anxiety to maintain faith with all collectors but explained that they have been taken by surprise by the unprecedented speed of the turn around of events from under to over-supply and the severity of the cut-back in the paper mills' orders due to general drop in economic activity. Whilst in November 1974 the paper industry had broken its all-time record for waste paper consumption, yet by February 1975 mill output had to be reduced by an average 40 percent and stocks of waste paper at the mills and merchants were totalling between 280 to 300 thousand tonnes. Many mills and merchants had no more room for further stock and all were affected by cash flow problems. The mills have also not expected the general public to take the Green Paper so seriously with such rapid response in salvaging waste paper.

The unstable and chaotic waste paper market with large fluctuations in supply and demand is not unfamiliar to the local authorities, the waste paper merchants and the mills. Waste paper consumption cycles are related and are due entirely to trade cycles. There is nothing unusual about it since cyclical variations are also found in many industries. As such, waste paper market fluctuation cannot be treated independently of overall macroeconomic policy, although proposals of stock support schemes have been put forward by various parties at different times to try and reduce the impact of such variations. The purpose of the scheme was to finance the holding of stocks over and above the normal level during a down turn in the trade cycle, with the aim of supporting and stabilizing the demand for waste paper. The stock accumulated would then be readily available to the mills in the following upswing of the trade cycle. A possible way of financing the scheme could be through a combination of merchants, recycling mills, local government and central government. In the short term this scheme would help to keep the mills supplied with sufficient tonnages during the high consumption periods. In the long run the smoothed market would induce sufficient confidence in waste paper collectors and suppliers to make investment to increase their supply.

Simulation exercises for stock support schemes have been done by various economists (Dyer, et al,1975; Pearce & Grace,1978; Pearce,1979) and all concluded that the suppliers could easily make less revenue over the trade cycle in a market with a stock support schemes than they would have if they were operating in a free market. If the stock support scheme, although capable of reducing price fluctuations, incurr a net loss to the suppliers, the suppliers would obviously oppose the establishment of such a scheme. The reason commonly used by local authorities for not entering the waste paper market was because of the fluctuating prices. If an excess support scheme reduced the fluctuations of the waste paper market, but the net revenue obtained now may well be less than what they could get in a free market, they would also be just as easily deterred from entering the market.

In a fluctuating market some local authorities were already loosing money in their operations. In a controlled market more local authorities would loose money, so that a stock support scheme may not help to encourage more local authorities to recover waste paper. But the reduced income may be acceptable to some local authorities if, the risk of having a greater loss than budgeted was less.

Stock support schemes had been implemented in various countries, in Japan in 1974, in the Netherlands in 1976 and in Norway in 1975. The Japanese found that there was insufficient financial backing and the 1 percent of total consumption stock piled had negligible effect on price stabilization. In both the Netherlands and Norway there were insufficient storage space and financial backing to continue the schemes and the schemes had since been terminated. Belgium after some consideration of such a scheme rejected it.

In the summer of 1975, the paper and board industry was lobbying for government stock support schemes and the local authorities were pleading for price stabilization. The Advisory Group on Waste Paper Recycling in 1975, proposed that after mill stocks have reached the normal stock holding of 5 weeks' normal consumption, government aid should be available to allow a further 5 weeks' consumption to be stored as excess stock. The central government was to be involved initially for 7 years with a review after 5 years. Two points were put forward to support their recommendation. First, waste paper took time to be diverted to meet increasing demand and it also took time to stop waste paper recovery operations during slack demand. This could not be done without incurring heavy loss in capital investment and loss of confidence on the part of the suppliers. Secondly, a successful stock support scheme would encourage a steady increase in waste paper recovery in line with demand and would help to stabilize prices. While the paper and board industry supported the scheme, waste paper merchants feared that a stock support scheme would reduce their ability to make profits from their flexibility to meet market fluctuations. Their view was that government should not assist in stocking waste paper which should be done by the paper and board industry. The government should instead provide assistance to help the paper and board industry to use more waste paper. The government did not specifically imply that stock support scheme was not useful during periods of reduced demand. They claimed that it was rather complicated and difficult to administer particularly when the recession got deeper and longer than expected. There was also no assurance that an excess stock scheme would be sufficient in itself as a solution to smooth out waste paper market fluctuations. Instead, the government provided a £23 million aid scheme for the paper board industry under Section 8 of the Industry Act, 1972. The government estimated that this aid would result in the investment of £100 million over a 4-year period and could increase waste paper consumption from the 2 million tonnes a year to 3 million tonnes a year by 1980 (Financial Times, 16 June 1976). This aid scheme was really an attempt by the government to increase the total demand rather than to try to smooth out the market fluctuations.

12.2.3 Waste Management Advisory Council (WMAC)

This Council was formed just after the Green Paper (Cmnd 5727) was published. The terms of reference of the Council were somewhat general,

a) to keep under review the development of waste management policies in the United Kingdom having regard to the need to secure the best use of resources, and the safe and efficient disposal of wastes;

b) to give particular consideration to ways of reclaiming materials from waste, recycling techniques, the inter-relationship of waste utilisation and waste disposal, and the reduction or transformation of waste arising;

c) to consider the technical, economic, administrative and legal problems involved;
d) to consider the programme of research and development; and
e) to make recommendations.

The Committee's purpose was too wide ranging and could not have been very effective right from the start. It also started off on a wrong footing, being suspended in between the Departments of the Environment and Industry. The Committee was therefore subject to conflicting interests of the Departments. The split into the two camps of industry and environment was accentuated by the non-too harmonious co-chairmanship by two junior ministers, one from each department (Cooper,1980).

From the 29 Council members, a general policy Standing Committee of 12 was set up. A number of study groups were also formed -

a) an economic studies working group, which soon lost two members by resignation;
b) a ferrous and non-ferrous metals working group, which soon became moribund;
c) a packaging and containers working group, which persisted without much contribution until the whole Council was dissolved; and
d) an information, publicity and education standing committee, with little information to disseminate, no policy to follow or publicise and therefore no plans to promote public education on waste reclamation.

A National Anti-Waste Programme was also set up under the WMAC in June 1977. The basic objective of the Programme was to create a national awareness of the waste problems and to harness the energies of people willing to do something about it. The national campaign was launched with publications and guides such as <u>Save and Recycle : a guide to voluntary waste collection</u> , which gave voluntary organisations information on how to organise collection, the prospects and the problems involved. By November 1977 some 16,000 copies of Save and Recycle had been distributed with various campaign posters and there were signs that voluntary bodies were increasingly assisting with the campaign. Two other publications, Directory of Waste Collection and a list of Waste Merchants were compiled by the Secretariat and were freely available. One of the proposals of the programme was the appointment of waste wardens within industry at managerial level, who would be responsible for ensuring that their firms use materials with the minimum of waste and that any waste arising was recycled by themselves or by some other industry. A working group was set up to draw up codes of packaging practice for the industry. Another party was working on refillable or non-refillable containers. Such proposals looked good on paper but without legal backing from the government to enforce the practice, they were really of little practical use.

12.2.4 Report of the Committee on Waste Paper Supply

The Committee on Waste Paper Supply was set up in November 1978 jointly by the Departments of Industry and the Environment, with the following terms of reference :-

a) to study in depth, the availability of waste paper in relation to the future needs of the paper and board industry; and
b) to identify any problem requiring special measures, other than those already available to the industry, collectors or the government, and to make recommendations.

The Committee was set up at the time when the paper and board industry was expected to increase its use of waste paper substantially over the next few years, partly as a result of the investments on new recycling plant and technology which the industry was making following the Department of Industry's £23 million financial aid scheme made available under the

Industry Act,1972. The Committee was also to study existing and new methods of collection and supply, especially those methods which might increase the volume and stability of supply through the operation of market forces, taking into account alternative and new uses for waste paper and the interest of users of paper and board.

The Department of Industry at that time also commissioned an independent study by a private consultant, Touche Ross, on the cost structure of mills using waste paper, waste paper merchants and the waste paper collection schemes run by local authorities. The Touche Ross Report in fact became the basis for many of the Committee's consideration and recommendations made in their Report published in October 1980.

The Committee's report went over much of the old grounds which have been covered by earlier WMAC publications, such as problems and requirements of the paper mills, the merchants, the local authorities and voluntary organisations. Econometric models similar to those of Deadman & Turner(1979) which related waste paper consumption to the gross domestic product (GDP) were adapted to forecast future waste paper demand. Four alternative uses for waste paper were discussed by the Committee's Report. They were waste derived fuel, moulded pulp product, loft insulation and animal beddings. Lessons from other countries within the EEC and the OECD were cited and there was consideration of whether separate charging for waste disposal as in the Continent should be introduced in UK, but no final conclusion or recommendation was reached.

The Report also included costing done by Touche Ross, for a typical local authority new waste paper salvage scheme based on its own assumption which showed that it was a profitable venture. But the calculation was based on a high waste paper price and a high tonnage recovered by trailers which were no longer used by local authorities. On the cost structure of the mills, Touche Ross worked with a very high pre-tax return of 10 percent while in reality the paper industry could only achieve a much lower return of 1 to 2 percent before tax. Some recommendations were not practical, such as asking mills to increase their utilisation from 75 to 95 percent. Mills would like to have even 100 percent utilisation, but the high utilisation factor could only be achieved if they have sufficient orders for the products. Touche Ross compared the UK waste paper prices with those in Holland and claimed that waste paper price in UK was about 38 percent of production cost compared to 25 percent in Holland. But Dutch collection of waste paper operated on a different basis from UK and the Dutch government subsidised collection. Prices in UK seem high because they were maintained even during periods of low demand to allow collectors to sustain collection activities. But in the Continent mills bought at market prices and it was not uncommon to see Continent markets collapsing totally during recessions in the waste paper market while British markets were still operating.

The conclusions in this Report were rather similar to those of earlier reports on waste paper recycling, and the recommendations were too wide-reaching and generally of little use to the industry. The Committee however, pointed out that if Britain was to capitalise on the huge potential of unrecovered waste paper, the initiative should come from the paper and board industry.

12.3 How constructive were the government actions ?

Out of the four ways in which the government promised in the Green Paper to assist the development of reclamation activities, only some half-hearted attempts were made to follow them. In term of support and publicity, other than those issued with the National Anti-Waste Programme whose activities soon died down, no further active support was seen. Research and development work was concentrated at Warren Spring Laboratory more on the activities of integrated waste recovery plants. Markets for recycled materials experienced the same market fluctuations, in fact a slump in the waste paper market occurs within 12 months of the publication of the Green Paper and no government action was given to stabilise it.

Markets were still allowed to develop on its own in accordance with the rising and falling demands of secondary materials. Of the £23 million financial assistance made available under the Industry Act, 1972 only £18.04 million was paid out by the time application for the fund was closed in June 1978 (<u>British Business</u>, Vol 5(1), July 1981). No government report on how this fund was given out and utilised was ever made or published. A sad note to this assistance scheme was that 8 mills and 14 machines which were subsidised by the scheme closed down during the 1980/81 recession (Bone,1981). The government's forecast of the effect resulting from the £23 million grant has been over-optimistic. They have estimated that the grant would help to increase recycling by an estimated 750 thousand tonnes per annum by 1980. Added to the 1978 consumption of 2,109 thousand tonnes, the expected consumption from 1980 onwards was 2,859 thousand tonnes. But actual consumption in 1980 was just 2.0 million tonnes, far from the government estimates.

The Association of District Councils (ADC) argued that a successful war on waste needed not only more governmental exhortations to local authorities but also more meaningful direct incentives to put a recycling policy into practice. There must be more tangible incentives such as subsidies, charges to industry and specific grants for reclamation projects made available. The ADC suggested one of the ways which the government could show its serious intent and set an example was to insist on using recycled paper in government paper and cardboard contracts. Although waste paper is the most promising area for extending recycling by local authorities, without adequate safeguards to rate payers the ADC felt that it could not urge its members to begin collection schemes because of possible losses resulting from fluctuating market forces (Anon,1975A). But no financial incentives nor disincentives to ensure the maximum possible use of waste paper was ever introduced by the government. In fact, this has been made clear to the public in a statement by the Parliamentary Under-Secretary, Department of the Environment on 28 November 1974 when he opened a two day conference on reclamation and recycling organised by the <u>Local Government Review</u>.

He said :

> " .... At present the government could give no undertaking of financial aid ! .... "

There was no sign of the government promoting the reclamation effort at national level. The 1975 slump forced 13 local authorities to close their waste paper salvage operations and persuaded 40 potential local authorities in making a decision to suspend the launching of their waste paper salvage operations (Taylor,1977). These events were concrete evidence of the government's lip service to an ideal which they have elevated through the Green Paper to national importance. The Green Paper like most government documents stated the obvious. While everyone took the Green Paper in all seriousness, the government itself had only brought it to the drawing board stage and abandoned it there. Taylor(1977) regarded the Green Paper as it stands today, the biggest non-event of all time and considered that,

> " ... were its implications not so traumatic perhaps the most pathetic practical joke ever played on society."

The WMAC's first Council was made up of many people who had little first-hand knowledge of managing waste, and it was soon wound up. A new Council was announced on November 1978 with a membership of 17 people plus Dr R Berry, director of the National Anti-Waste Programme. Out of these 17 only 7 were from the first Council. There was however, no positive Ministerial lead and the Council did not meet very often. In 1979 the Council held only 5 meetings, and their work had not been as beneficial as it was hoped to have been (BWPA,1980). The existence of the WMAC seems to have been more for the convenience of Ministers answering questions in Parliament, as support for their statement that something was being done. Before the formation of the Council, Parliamentary answers have not been of much help, it was rather vague and did not provide much information. During the Council's existence Parliamentary answers shown a rather dis-spirited consistency. Since the WMAC was the direct outcome of the Green Paper War on Waste , the General Policy Standing

Committee was logically expected to be deeply involved in compiling a White Paper to follow it. But no White Paper was ever proposed and it soon became clear that no policy would follow.

Cooper(1980) described the WMAC as a reflex action that grew out of muddled thinking and summed up the influence or significance of the Council as,

> " ... it hasn't met since the present government took office, although it has so far survived the onslaught against the quangos. Its profile is so low it has probably been overlooked."

The government cut-backs did finally catch up with it and the WMAC was dissolved in January 1981. In announcing the Council's abolition the government claimed that after reviewing the activities and achievements of the Council and the work which remained to be done, believed that, even though the Council had made a valuable contributions in identifying the main problems and priorities, further progress could best be achieved by more direct and informal cooperation between central and local government and other interested concerned. Following the abolition of the WMAC the National Anti-Waste Programme was disbanded. The government claimed that it still remain committed to waste management, reclamation and recycling and that units with responsibility for these aspects of the government policy would be retained in the Departments of Industry and the Environment to continue the close collaboration on this subject. But these units such as the Recycling Coordination Unit in the Department of Industry is manned only by a skeleton staff of the seconded civil servants who were returned to their Departments and are currently involve mainly in a reactive rather than an initiative role.

12.4 Further government actions needed

There are various things which the government could do to assist in increasing waste paper recycling. For a start, both local government and central government will require new thinking, approaches and systems. Central government could begin with a positive campaign to alter the attitudes, the range of costs incurred in waste collection and disposal and show the true total costs of waste management.

Local authorities have the statutory function of waste collection and/or waste disposal. These functions at present have no definition, national standards or positive encouragement to treat the materials in any alternatives other than the 'status quo', and yet it has the monopoly in the critical area of waste cycle (Hook,1981). With such a monopoly there is no assessment of performance, efficiency levels, cost involvement or critical appraisal of the actions carried out with their statutory function. These have made comparison between local authorities difficult. The inability to compare has made it impossible to assess efficiency or monitor local authority waste management on a financial basis. There is therefore a need for a national policy for waste treatment which spells out standards, common basis for costing these actions and ensure that the total waste treatment cost is economically efficient.

Research and development now in progress at government sponsored institutions will undoubtedly help both to produce improved methods of material recovery and recycling and improve recently developed techniques to allow more waste treatment than waste disposal. Such work must be allowed to continue.

Taxes or subsidies may also be used individually or simultaneously by the government to encourage recycling. Some kind of direct payment or subsidy can be made to the waste paper collector, processor or user of waste paper. Subsidies can be arranged for freight rates and government sponsored research and development programmes on how to incorporate more low grade waste paper in existing manufacturing operations and in diversifying the use of waste paper in other products, such as waste derived fuel, housing insulation materials, animal feed and animal beddings, to name a few of them. Incentives can also include various forms and types of tax credit. A tax credit can be designed so that waste paper processors or waste paper users can receive a credit for waste paper recycling. Another method is a tax deduction for the use of waste paper as raw materials. An indirect method is the use of special tax credits for investment in equipment designed to process or utilise low grade waste papers.

Disincentives measures that can be introduced include the imposition of taxes on undesirable activities, such as on virgin pulp use. Taxes may in principle, be imposed in the form of product charges on items made from virgin wood pulp such as newspaper not made from recycled paper.

Regulations can be introduced to set various standards of behaviour. For example, it may specify the amount of secondary fibre that has to be contained in paper products. These regulations may need to be enforced by law or relate more narrowly to the products purchased by government. The HMSO stationery office is the control agency for supplying stationery and other requisition to government departments. In terms of paper consumption the various printing, publishing, book binding and stationery supplying activities made it a very large consumer. It is difficult to assess the total aggregate expenditure on paper and board by HMSO but expenditure estimates for 1969 to 1970 on paper for major end-uses amounted to £13.75 million (Bone,1981). The huge buying power allows the government to influence reduction in over-specifications. For example, high quality paper for printing and stationery can be replaced by paper with a higher specified percentage of secondary fibre content in their stationery tenders. Local authorities can also in the same way stipulate a certain percentage of secondary fibre content in their stationery tenders. This would, not only increase the consumption of waste paper, but also enhance the efficiency with which essential resources are employed.

Now that the Waste Management Advisory Council (WMAC) has been abolished, there is no guiding hand to the government in waste reclamation. As far as the British reclamation industries is concerned the abolition of the WMAC is of no great concern. Both the WMAC and the National Anti-Waste Programme were regarded

only as communication channels to the government. The British reclamation industries is now concerned over which department they should deal with, the Department of Industry or the Department of the Environment, or a mixture of both ?
A successor body to the WMAC is much needed to advise the government and to coordinate waste reclamation in the country. But a successor body should only be appointed after the government has decided that something positive must be done and is either seeking advice on what it should do, or is determined to see its decision carried out. A new council would have to be given more specific terms of reference with a capable membership and leadership, armed with sufficient authority and backed by the proper legislation to carry out its duties. The council should also have a fixed time horizon to achieve its objectives.

With these actions, the government could make positive contributions to assist the nation's waste paper recovery and recycling industry.

13 - Conclusions and recommendations

13.1 The study in perspective

Although much have been written on various aspects of waste paper recovery and recycling, the bulk of the work has been very general. A few economists have developed some econometric models while engineers have always concentrated on very specialised aspects of particular problems encountered in their own mills. No accurate and meaningful cost data has been publicised by the local authorities, the waste paper industry or the board industry in recent years. This study has placed emphasis on the information collected for the first time from a wide range of sources and inter-disciplinary, systems approach adapted in this work is one of its main innovations. Much of the information of waste paper prices, recovery and demand have been brought up to date. Statistics on waste paper collection regarding tonnage and value of Scottish local authority collection have been collected and presented for the first time. It is hoped that this contribution will serve as a useful data base for policy makers such as the Scottish Development Department, the Department of the Environment and local authorities, to make sound management decisions regarding waste paper reclamation in the future.

A costing system has been designed for the local authority waste paper recovery operation. This costing system is an improvement on earlier accounting systems recommended by LAMSAC and the Department of the Environment and will allow costings which will reflect the economic reality, to be produced. A computerised costing system was also developed to assess the viability of an on-going local authority waste paper recovery operation. An investment appraisal model was developed separately to evaluate the net present value of proposed operations. Using a comprehensive set of inputs based on a hypothetical local authority, the models were used to identify the influence exerted by certain components in the costing system and to perform sensivity analysis on the operation. The computer costing models will be of use to the local authority involved in waste paper recovery and to the potential local authority embarking on a waste paper recovery scheme.

A prior knowledge of what is going to happen to the waste paper demand is always important if future fluctuations in market and prices are to be reduced. Forecasting models developed earlier have not been very successful in predicting future demand for waste paper. Using multiple regression analysis forecasting models which could give better predictions in both the short term and the long term were developed. Use of the models will, within limits, give fairly good indications of future trends in the waste paper market.

13.2 Conclusions and recommendations

Most local authorities involved in recovering waste paper do not have a proper separate accounting system for their waste paper operations. Although the Report on Uniform Accounting was recommended to the local authorities in 1976 many local authorities have rejected this accounting system because of the difficulties in implementation. Case studies have shown that most local authorities costing their waste paper recovery operations did not include all the relevant cost items so that many of their costs were high thus resulting in 'heavy losses'. With a re-designed accounting system which included all the direct and indirect costs and savings, such as the system used in evaluating the true cost in the case studies, local authorities have been found to have much smaller losses in their operations and some could in fact profit from their waste paper recovery operations. Therefore some decision makers could have made the wrong decision in suspending their waste paper operations based on information derived from an inappropriate costing system. Although local authority supply of waste paper is rather small being only about 10 to 12 percent of the total tonnage recovered in the country, it is nevertheless an important source of waste paper, particularly for mixed waste and container waste. Domestic sources still offer the potential for increasing the supply of waste paper and local authorities must therefore not be discouraged from recovering waste paper as a result of wrong decisions based upon information derived from a costing system which did not reflect the true economics of the operation.

A computerised costing model developed for checking the viability of an on-going recovery operation has shown, with the help of hypothetical inputs, the importance of knowing the variables which control the viability of an operation. The viability model would allow the local authority to identify the tonnage that must be collected to remain viable at each price level. It would also allow different variables in the model to be changed very quickly for a fast check on their influence on the viability of the whole operation. Local authorities should therefore use the viability model to derive break-even boundaries to help them to identify the most suitable areas of collection in their district. The investment appraisal model would allow any local authority thinking of recovering waste paper to study the net benefit of introducing a proposed waste paper recovery operation. Sensitivity analysis based on hypothetical inputs to the investment appraisal model have shown that the net present value was very sensitive to participation and contribution levels. For example, a difference of 0.2 kg in contribution per premise per week could make a positive net present value negative. Similarly a 10 percent increase in waste paper price in certain circumstances, could change a negative net present value to a positive one. Local authorities using the investment appraisal model should therefore base the evaluation not only on the current market price and the expected collection tonnage but also check the net present values obtained for the scheme should the price drop to the minimum guaranteed price and only the datum tonnage is bought by the mills.

A major problem associated with the recovery and recycling of waste paper has always been the need to achieve a rate of recovery corresponding to demand, and accurate forecasts for the future demand of waste paper will help tremendously. The short term forecasting model for all grades of waste paper gave better predictions than earlier models, while the short term forecasting model for groups 6 and 7 waste paper was a new model which allowed future demand for these two important groups of waste paper to be projected for the first time. An improved long term forecasting model for all grades of waste paper has also been developed based on lagged GDP effect. The models were able to follow the past trends very closely, particularly the turning points in the consumption cycles. There is therefore now available a tool for the mills to forecast ahead the appropriate demand. Use of the forecasting models would allow the mills to warn the suppliers the forthcoming upturn or downturn in demand and allow the collectors to plan their activities accordingly so as to avoid the excess collection of waste paper or the lack of collection activities which would result in shortage of supply.

Taking into account the recovery rate in UK is only 30 percent, it is evident that the recoverable but not collected tonnage is still enormous, about another 2.2 million tonnes. Waste paper demand in the mills has stabilized around the 2 million tonnes level and there is no sign of increasing consumption. Alternative markets must be found to expand the use of waste paper. A number of alternative markets for waste paper already exists, such as use in animal bedding and as cellulose insulation for the loft. A number of feeding trials with beef, cattle and sheep have shown suitable animal preference when newspaper was used at levels up to 12 percent of the ration. Higher grade waste papers were found suitable to be used up to 50 percent of the ration. But certain toxic elements in the ink compounds have prevented the widespread use of waste paper as an alternative animal feed.

Cost savings in substituting newspaper for hay in animal bedding are high and this area of the market may have potential in expansion. The use of paper-based cellulose insulation for lofts is much cheaper and better than other insulating materials. But these market diversifications have been based on over-issued news and post-consumer newspapers. There is still very little alternative uses for mixed waste, except perhaps for the production of refuse derived fuel.

However, there are still various production problems which need solutions before refuse derived fuel could be marketed on a commercial basis.

The Independent Waste Paper Processors Association realised the importance of finding other markets for waste paper and has taken the initiative in diversifying into cellulose insulation production and marketing. Other waste paper merchants should also follow suit. Through a centralised trade organisation, in conjunction with the BWPA, they could invest in research and development for alternative products which could expand the demand for waste paper particularly in the bulk grades such as mixed waste.

Improvements in recycling technology will be required to make it possible to use the lower grades of waste paper in areas where they are little used at present, such as printing and writing papers, papers for domestic and sanitary purposes. Research into the characteristics of secondary fibres, improved techniques in the removal of contraries and deinking will allow better utilisation of waste paper. Old newspapers and leaflets now used in the production of paper and board would, with efficient deinking, be usable for producing printing papers and toilet papers. Consumers, on the other hand, must lower their standards and accept a lower quality of paper products before the producers could incorporate more waste paper in their production.

The central government has published many brave words in support of waste paper recycling but little solid follow up action has been seen. Financial support for recycling has been minimal and its impact has yet to be felt. Cuts in public spending have prevented local authorities from expanding their waste paper recovery activities and in certain cases have helped expedite the termination of a number of waste paper recovery schemes in the last few years. Both central and local governments do not have any long term waste paper policy. A long term strategic plan should be drawn up with the objective of improving supply and consumption. For example, a total waste paper recycling system should support an energetic paper recovery programme based on separate collection at source and the use of the balance of waste paper in the refuse for the production of refuse derived fuel.

There must be better coordination between waste collection authorities (districts) and waste disposal authorities (counties) in England to pass back any savings in waste disposal caused by separate waste paper collection, to the collection authorities from the disposal authorities. The GLC is already giving a rebate or other forms of assistance to borough and district authorities for materials removed from the waste stream by any recycling scheme. Other waste disposal authorities should follow suit. Section 14 of the Control of Pollution Act,1974 only allows the collection authority in England to retain its waste paper. This section would need modification to enforce the savings on waste disposal to be returned to the waste collection authority. It may also be time for the government to re-think its waste management policy and re-examine the separation of the collection and the disposal activities into district and county responsibilities respectively. In Scotland and Wales, the same authority performing both functions has worked successfully, why not in England ?

Trade marks and emphasis in advertising to sell the fact that a product or publication contains so many percent of secondary fibres, are now becoming fashionable. This trend should continue and the use expanded. Consumers and environmental pressure groups could help by promoting the demand for products with a higher content of secondary fibres. If public pressure persists and stays long enough to influence legislation, changes in the basic economic relationship between secondary fibres and virgin fibres will take place. This will in turn induce significant new investments by industry to recover and recycle more waste paper.

13.3 Suggestions for future research

Chapter 11 has described mainly the future technological research needed to improve waste paper recovery and recycling.

There are still a number of issues of wider interest which could affect waste paper recovery and recycling in the future and further research in these areas could be productive.

Earlier in Chapter 12, the possibility of using stock support schemes to reduce waste paper market instability has been discussed. Although for the moment, stock support schemes do not seem to provide an unequivocal solution to reducing waste paper market fluctuations, nevertheless it offers an interesting area for future research into its possible use, with modifications perhaps, to help stabilise waste paper markets.

In the last two or three years there has been increasing interest in the revival of contract refuse collection, particularly in its use in urban areas. Various reasons to support the growing interest exist. On the government side, the present Tory government's political idealogy that private is good encourages it. Local authorities disenchanted with the inefficiency and high costs of their own refuse collection teams look towards contract cleansing for possible savings in capital and revenue expenditure. On the entrepreneurs' side rich pickings are expected. With such trends developing, what will be the possible implications of contract cleansing on waste paper recovery schemes ? Would the contractor take over the separate collection of waste paper or would they abandon such schemes because of uncertainty in profits. Would the introduction of contract cleansing eventually reduce an important source of waste paper in the country ? The role of contract cleansing on waste paper recovery would be an important area to study in the future.

Printing paper and other publication costs are rising while the costs of electronic storage and access are dropping. Microprocessor technology and very large scale integrated electronics have made possible not only the storage of large quantities of information compactly and retrieving it electronically over any distance but also brought it within reach of most business organisations. With the widespread use of tele-text systems, will newspapers in the late 1980s and the

1990s face stiff competition and result in the widespread closure of newspapers and reduce significantly the supply of waste paper particularly the newsprints ? These questions are still too early to answer.

The use of futures markets in currency trading and ferrous scrap trading in the USA is familiar. A futures market is an organised trading place for formal transactions in futures contracts for a commodity. A futures contract for waste paper is basically an agreement that calls for delivery of a given quantity and grade of waste paper at a set future date. But what is actually bought and sold is only the contract. Price of the contract is basically set by the market information available. The use of futures market in waste paper trading to help reduce the uncertainty of the market and hence help to reduce market fluctuations have been proposed by Dower & Anderson(1980). In theory the use of futures market looks reasonable (Appendix XII). But there are still many debatable issues. For example, will futures market stabilise suppliers' incomes is still being argued. Whether the activities of speculators will help the futures market to function smoothly or will they de-stabilise the market, is a complex issue still not resolved.

13.4 Epilogue

Much of the findings and developments from this study can be of immediate use to the local authority and the paper and board industry.

The computerised costing model makes only two basic assumptions which may not be universal to all local authority costing systems. First, the models assume that waste paper collection is done by a separate team of collection vehicles, and the vehicles have a maximum capacity of 3.6 tonnes, which is the average capacity of existing local authority collection vehicles. If a local authority uses a different vehicle size, then all that needs to be done is to change the denominator in the relation for calculating the number of vehicles (NV). The second assumption is that an average local authority with about 45,000 domestic premises needs an average on-going publicity cost of £500 per annum. Local authorities with an on-going publicity cost of a different amount will need to adjust this component in the costing model. After these two components have been modified, all the local authority needs to do is to plug in all the other inputs to the model and the printouts will provide sufficient information for the local authority to make appropriate management decisions. As the value of waste disposal cost has an important bearing on the costing of the operation, local authorities should use a range of waste disposal costs to study the effect of increasing waste disposal costs on the recovery scheme.

The short term forecasting models is of immediate application to the paper and board industry to check the demand for waste paper in the next 12 to 18 months period. The long term forecast can be used by both the paper and board industry as well as the waste paper industry to estimate the long term trend in demand. Results of the forecasting models properly co-ordinated will allow the mis-match between supply and demand to be reduced. This in turn will help to dampen the fluctuations in the waste paper cycle.

It is hoped that this study would offer some practical contributions to the local authorities, the waste paper merchants and the recycling mills besides the policy making government bodies. When the data and information, the computerised costing systems and the forecasting models are used and the recommendations accepted and eventually implemented, the real contribution of this study might then be established.

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Glossary of terms

Absorbency	Capacity of paper or paper board to absorb liquids, e.g. printing inks, varnish
Additives	Substances added to the stock during preparation, include alum, loadings, colouring agents and size
Air-dry	It refers to air-dry fibres in the form of finished paper. When referred to fibres in pulp form, it refers to the consistency. In connection with pulp, refers to 10 percent moisture in the wood pulp
Alum	A general term for a member of a group of double sulphates, all of which crystallise in the same form. In paper making it is aluminium sulphate - $Al_2(SO_4)_3.14H_2O$. It is used in the beater to precipitate rosin (used as a size) on to the pulp and makes the paper resistant
Beating	Process of macerating natural wood or waste paper to pulp
Bogus	Used to describe paper and board made principally from recycled waste paper stock, in imitation of grades using a higher quality raw material, e.g. bogus fluting medium
BPBIF	British Paper and Board Industry Federation
Breaking length	Measures the tensile strength in relation to paper or board substance. Expressed in metres of a strip of paper 25 cm wide, that would break by its own weight when hung from one end
Brightness	Measures the hue and intensity of light reflected from the paper surface
Broiler	A young chicken specially reared for broiling or roasting
Broke	Mill waste i.e. paper thrown out in sorting, reeling and other finishing processes in the mill. Usually returned for re-pulping at the stock preparation stage. There are two kinds, 'wet broke' which is accumulated at the wet end of the paper making machine and 'dry broke' which is accumulated at any stage at the dry end of the machine
Bulk	The ratio of the thickness of a piece of paper or board to its substance. It is the reciprocal of apparent density

Burst factor	Also known as burst ratio. It is the quotient of the bursting strength of paper or board and its substance
Bursting strength	A measure of the pressure per unit area required to rupture a sample of paper under standard conditions
BWPA	British Waste Paper Association
Caliper	The thickness of a sheet of paper measured under standard testing conditions, measured in microns
Cellulose	An inert surface constituting the chief part of the cell walls of plants and trees
Chemical pulp	Wood chips cooked in chemicals
China clay	A fine clay used as a filler for certain papers
Classifier	A rotary, pressurised screen
Compressibility	The property of a sheet of paper which allows it to withstand pressure, such as during printing
Coniferous	Trees of the gymnosperm group, so called because they are cone-bearing, generally softwood
Consistency	The percentage by weight of the fibre in the total weight of water and pulp. A consistency of 1 percent means a weight of 1 part of fibre in 99 parts of water by weight. That is, the mixture contains 1 part of AD fibre and 99 parts of water
Contraries	Substances in the waste paper which is unwanted and is harmful for paper making
De-fibering	Or breaking, is the separation of pulp fibres from each other, which takes place as the initial stage in the paper making process in breakers, hydrapulpers and kollergangs
Deflaker	A device filled with two stationary and one rotating disc, perforated in a variety of sizes to meet individual fibre requirements. Used to break out the flakes of fibres at the re-pulping and cleaning stages of waste paper processing
FAO	Food and Agriculture Organisation of the United Nations
Fibre	A general term for a narrow, elongated cell with tapering ends

Fibrillation	The degree of shredding, beating and refining in water. As treatment proceeds, the cellulose structure of the fibre walls becomes increasingly retentive towards water and splits up to produce very fine fibrillae in the form of external fibrillation
Fibrils	Thread-like filaments of the wall of the cellulose fibre. They are exposed, by beating, to give the potential bonding properties of fibres in the sheet
Filler	A method of filling in the pores in a sheet of paper to improve its printing qualities. Also refer to as 'loading'
Flote purge	System added to a continuous hydrapulper to remove contraries in the pulping stage
Fluting medium	Corrugated filler between layers of corrugated boards. Can be made from semi-chemical pulp or waste paper
Freeness	A property used to describe the readiness with which the pulp will lose water by drainage
Furnish	A mixture of fibres and water which is fed into the paper machine. The particular ingredients that comprise the components for forming a specific paper
Gloss	The surface reflectance of light on a piece of paper
Hydration	The process created by beating, that alters cellulose fibres so as to increase their capacity to absorb water. May be referred to as 'wetness' the opposite of 'freeness'
Hydrolysis	A chemical process in which the organic compounds in the refuse (mainly the cellulose) are converted into fermentable sugar, by boiling with acid and water at high temperature
Hydrapulper	Bowl-shaped instrument used to pulp wood chips or waste paper
Integrated mill	A paper or board mill that produces nearly all its own pulp and uses them in its own paper or board manufacture
KLS	Kraft liner strawboard, which is actually pure kraft pulp board and contains no strawboard at all. Trade name commonly used in waste paper industry for container waste

Kraft paper and board	Kraft originated from German, meaning strength. These are products of high mechanical strength made entirely from unbleached sulphate softwood pulp
Latex	A colloidal solution of high polymers from sources related to natural rubber or of synthetic high polymers which resemble natural rubber
Lignin	The main non-cellulosic constituent of wood and plants which are removed during chemical pulping
Liner	The external layer or ply of a multi-layer board, generally better in appearance or quality than the body of the board
Liquid cyclone	A free vortex centrifugal cleaner used to remove medium and high density rejects
Macerate	To bruise and separate individual fibres of wood or waste paper through beating
Market pulp	Pulp sold on the open market to the non-integrated mills, supposed to be 'excess' pulp produced by the integrated mills
Mechanical pulp	Pulp produced by grinding down chips of wood, usually used for newsprint and cheap printing paper. Most of the lignin is therefore not removed
Newsprint	Generally refers to uncoated paper, containing at least 60 percent mechanical wood pulp, weighing between 45 to 60 grammes per square metre. Used for printing newspaper and cheap magazine
NSSC pulp	Neutral Sulphite Semi-Chemical pulp, used in making corrugating base paper, fluting medium and liner, which require high burst strength and stiffness
Pams	A grade of waste paper consisting of old pamphlets
Paper board	Paper product with a weight $\geq 220\ g/m^2$ (in UK)
Permeability	The rate at which a fluid, usually air, passes through a sheet of paper under prescribed conditions
pH value	A scale of 0 to 14 where 0 to 7 is for acidic and from 7 to 14 is alkaline

PIRA	The research association for the paper and board, printing and packaging industries
Pullets	Young domestic hen from the time of beginning to lay until the first moult
Pulp substitute	Grades of waste paper that can be used to make paper products which would otherwise use chemical or semi-chemical grades of pulp. Generally the higher grades of waste paper
Pulverisation	Mechanical treatment of solid waste to break down and reduce the average particle size of the larger materials
Pyrolysis	Recycling process which relies on the physical and chemical decomposition of organic matter under the influence of heat in an atmosphere which is deficient in oxygen
Ragger	A motorised capstan used in a continuous hydra-pulper for the continuous removal of strings, rags and wire from waste paper
Recovery rate	The ratio of waste paper collected to the apparent consumption of paper and paper board
Recycling rate	The amount of waste paper consumed measured as a percentage of total fibre used in paper and board production.
Resin	A group of oxidised hydrocarbons, usually of plant origin
Secondary fibres	Fibres derived from reclaimed waste paper
Size	Solution of glue or gelatine or rosin added to paper to prevent the writing ink from spreading on the paper
Slurry	Stock to which the proper amount of water is added to form a suspension which is ready to be sent to the paper machine
Stock	Pulp ready to be formed in sheets. A term loosely applied to paper making fibrous material in all stages before formation on the wire of a paper machine
Sulphate pulp	The alkaline or kraft pulp prepared by an alkaline process
Sulphite pulp	Chemical pulp prepared by acid processes
Woodfree	Paper made from chemical wood pulps only

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Appendices

Appendix I

Schedule of United Kingdom descriptions of standardised grades, free from contraries which are not suitable for re-pulping processes
Source : BPBIF

Grade	Name	Description
1	Best white shavings	Best white, writing shavings, envelope cuttings free from coated paper and free from mechanical.
2	Fine shavings	White writing and ledger shavings, may contain feint, ruled papers, free from coated paper and free from mechanical.
3	White and cream shavings	White and cream book shavings and free from coated paper and free from mechanical.
4	White coated shavings	White art shavings, free from mechanical wood pulp; must not contain photographic papers.
5	White unprinted	Unprinted newsprint and similar paper containing mechanical wood pulp;may contain shavings.
6	White duplex and other mechanical wood pulp cuttings	White duplex, mechanical wood pulp cuttings, unprinted and free of wax. (This grade may contain coated boards).
7	Slightly printed white card cuttings	As above, but may contain up to 10% coloured strips in light colours only.
8	Best one-cuts	One-cut shavings, free from mechanical wood pulp; each bale may contain up to 10% coloured strips. No printing.
9	Printed woody one-cuts	One-cut shavings, may contain mechanical wood pulp; bales may contain up to 10% coloured strips. With printing.
10	White and light toned shavings	White and light toned shavings free from coating.
11	White and coloured shavings	White and light toned shavings, but containing mechanical wood pulp and darker colours. May contain coating.

Grade	Name	Description
12	Buff envelope cuttings	Unprinted buff envelope cuttings, containing mechanical wood pulp with a strong or unbleached sulphite/sulphate base.
13	Buff tabulating cards	As described.
14	Coloured tabulating cards	As described.
15	Light browns or buffs	Buff papers containing mechanical wood pulp with a strong or unbleached sulphite/sulphate base; printed or written upon, may include postage stamps. Free of sealing wax.
16	Ledgers	Stripped ledgers without covers or indices, marble end-paper; must be free from mechanical wood pulp and consist of tough ledger paper.
17	White heavy letter	White writing papers printed or written upon; may contain pins and small paper fasteners. Free from covers, string and elastic bands.
18	Coloured heavy letter	White and coloured writing papers, printed or written upon; may contain pins and small paper fasteners. Not to contain more than 20% mechanical wood pulp. Free from covers, string and elastic bands. May contain small percentage of carbonless copy paper.
19	White continuous stationery waste	As described; free from mechanical wood pulp.
20	Coloured continuous stationery waste	As described; free from mechanical wood pulp.
21	White carbonless copy paper waste	New white carbonless copy paper or shavings, free from print.
22	Coloured carbonless copy paper waste	Same as above but containing coloured paper or shavings.

Grade	Name	Description
23	Quire	Printed quire waste, unbound and unstitched, free from mechanical wood pulp and coated papers, may contain a limited percentage of coloured illustrations.
24	Best white pams	Books and pamphlets, without hard covers, but may contain stitched cotton and pins; free from mechanical wood pulp; may contain up to 10% coloured printings.
25	Over-issue news	Unsold newspapers free from pins; may contain up to 3% of tinted.
26	Once-read news	Flat or shredded or processed newspapers may contain up to 3% tinted, free from pins.
27	Over-issue white woody pams	As described.
28	Over-issue coloured woody pams	As described.
29	Once-read woody pams	Periodicals without hard covers; containing mechanical wood pulp. May contain pins.
30	News and pams	A combination of Grade 26 - Once read news - and Grade 29 - Once read woody pams, with the quantity of Grade 29 not exceeding 30% of total.
31	Telephone directories with soft covers	As described.
32	Coloured manilla	Strong coloured papers printed or unprinted with a manilla or strong sulphate/sulphite base.
33	Used brown kraft	Used brown kraft paper with a sulphate pulp base, printed or unprinted. Free of bitumen-union, wet strength and waxed paper and plastic laminates.

Grade	Name	Description
34	New brown kraft	New brown kraft (sulphate base) printed or unprinted. Free from bitumen-union wet strength and waxed paper and plastic laminates.
35	Coloured kraft	New or old coloured kraft paper in various colours as described in 33 and 34 above.
36	New wet strength kraft	New cuttings and sleeves from manufacturers may include print, kraft wrappers from pulp with a sulphate pulp base. Free from stitching.
37	Used multiple ply feed flour and starch sacks	Feed, flour and starch sacks free from sacks unsuitable for papermaking, i.e. cement - may contain up to 5% wet strength.
38	New kraft lined corrugated waste (No.1)	Trimmings and other waste arising in the manufacture of corrugated boxes. All liners to be kraft and the fluting medium may be of any re-pulpable material. Not to include non-soluble adhesives, treated materials or butt rolls.
39	New kraft lined corrugated waste (No.2)	Trimmings and other waste arising in the manufacture of corrugated boxes, and not specified in 38 above. Not to include non-soluble adhesives, treated materials or butt rolls.
40	Container waste	Also known as 'Old KLS Container' or 'Fibre board Container'. Used corrugated and solid fibre board cases free of board or paper of any other description. Proportion of solid board not to exceed 10%.
41	Coloured card	Printed or unprinted card waste other than strawboard and including lined waste paper based boards.
42	Mixed paper	Mixed waste paper and board, sorted for the removal of contraries.

Appendix II

The 1974/75 Survey on Waste Paper Salvage conducted by the Scottish Development Department

The Scottish Development Department (SDD) on 18 December 1974 wrote to the then Scottish counties, cities and large burghs to seek their assistance in completing a questionnaire (REF WS/5/7/7/1). Small burghs were not included in this survey. Completed returns were received from 31 local authorities operating waste paper salvage schemes, while another 27 local authorities submitted nil returns. The returns from the survey were not analysed. None of the Scottish statistics was included in the Report on Waste Paper Collection by Local Authorities, published by the Waste Management Advisory Council in 1976. With the Scottish Development Department's permission, a full analysis of the returns from these 58 local authorities was done in the autumn of 1981, with the objective of studying the viability of their operations.

II.1 Local authorities with nil returns

Of the 27 local authorities who submitted nil returns only 14 of them gave some reasons for not operating a waste paper salvage. Some of these local authorities had salvaged waste paper at one time or another, in fact one had been salvaging waste paper since pre-1939 till 1973, but they have since terminated their waste paper recovery operations. Some of the more common reasons given for terminating their waste paper operations or for not operating a waste paper operation have been summarised below :-

a) frequent occurrence of fires created problems of storing waste paper and have led to difficulties in getting insurance for the storage building;
b) shortage of staff and vehicle to operate a recovery scheme;
c) costs of staff and equipment were considered too big to render the scheme economical;

d) high transport cost was involved in collecting only small tonnages of waste paper, especially in rural areas where the small population was widely dispersed.

II.2 Local authorities operating waste paper recovery schemes

Of the 58 local authorities involved in the survey, 31 were involved in permanent waste paper recovery and 1 was doing a pilot study in some other district in the burgh as well. All the local authorities have their own equipment for sorting and baling. Not all the local authorities completed the questionnaire in full and it was common to find missing data in many parts (these local authorities have been so indicated in the tables below).

II.2.1 Collection sources

The table below shows the number of local authorities collecting from each of the two sources, domestic premises and commercial premises.

	Domestic premises	Commercial premises
No. of local authorities NOT collecting from the area	8	2
No. of local authorities collecting from part of the area	11	6
No. of local authorities collecting from WHOLE of the area	12	23
Total	31	31

The high number of local authorities collecting from commercial premises in the whole area was because of the better grade of waste paper (more container waste) which could be recovered and sold for a higher price than mixed waste paper. Commercial premises were usually concentrated in an area and collection was therefore easier.

II.2.2 Total number of premises and type covered

	Domestic premises	Commercial premises
No. of premises covered	395451	45302
No. of local authorities who covered these above premises	26	28
No. of local authorities with missing data	5	3

II.2.3 Collection vehicles

	Domestic premises	Commercial premises
Local authorities which used trailers	0	0
Local authorities which used separate vehicles	19	27
No. of local authorities with missing data	4	2
Total	23	29

Of the local authorities who did not response to this part of the questionnaire some could have used racks attached to their collection vehicles and since there was no specific box for this answer they have not filled in the response. Since 14 of the local authorities also recovered waste paper at the tip site, a few of them could have collected the waste paper tied bundles or packed into separate bags, with the same collection vehicle and then separated the waste paper at the tip site. This would cut down the extra cost involved in using separate vehicles although sorting at the tip site could be labour intensive.

II.2.4 Analysis of collection by grades

Total tonnage collected by the 31 local authorities was 41,151 with the following composition.

Grade of waste paper	Tonnes	Percent by weight
Newspapers	755	2
Fibre board containers	6475	16
Mixed waste papers	33480	81
Others	441	1
Total	41151	100

Mixed waste paper was the predominant grade collected by the local authorities. Next was fibre board containers.

The following break-down shows that most of the paper have been collected by the cities.

Type of collecting authority	No.	Tonnage collected	Percentage
Cities	3	22120	53.7
Counties	9	5301	12.9
Large burghs	19	13730	33.4
Total	31	41151	100.0

II.2.5 Contribution (in kg) per premise per week

The table below shows the trend of contribution per premise per week in kg.

	No. of LA collecting this weight
Contribution up to 1 kg	11
1 kg - 2 kg	4
2 kg - 3 kg	1
3 kg - 4 kg	1
4 kg - 5 kg	1
>5 kg	8
Total	26
No. of local authorities with missing data :	5

Contribution per premise per week varied from 0.26 kg to 26.92 kg. The 8 local authorities with contribution above 5 kg per premise per week were rather special cases. Of those eight local authorities, 2 were big cities, one collecting from 7,000 domestic premises and 2,000 commercial premises, the other from 11,500 domestic premises and 17,000 commercial premises. Two were big towns, one collecting from 3,000 commercial premises and the other from 1,800 domestic premises and 1,216 commercial premises. Although the remaining four collected from only a small number of premises, one from only 500 to 600 commercial premises, these local authorities have within the area big whisky plants and book publishers who generate a high tonnage of waste papers.

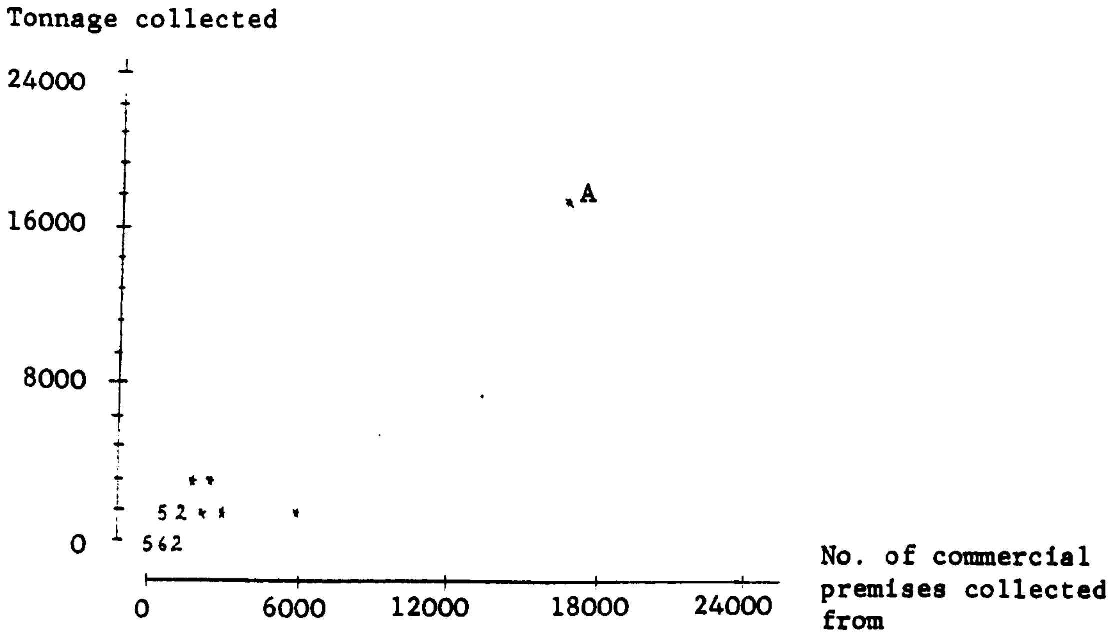
II.2.6 Correlation of total collected tonnage with the number of premises

Correlation analysis were used to investigate if any linear relation existed between the tonnage collected and the number of premises collected from.

	With number of domestic premises collected from	With number of commercial premises collected from	With total number of premises(both domestic and commercial
Correlation of tonnage (r)	0.101	0.956	0.242

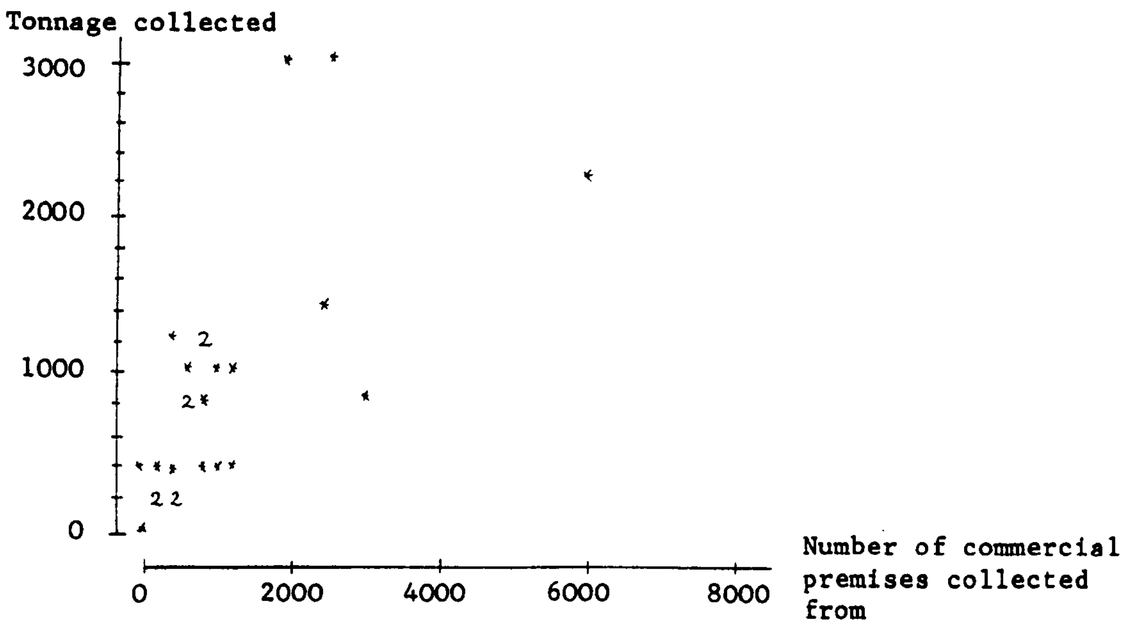
Except for the correlation with the number of commercial premises collected from, the rest have very low correlation coefficients. Plotting the total annual tonnage against the number of commercial premises produced a rather straight line. However the graph (Figure II.1) indicated a very extreme point (A) where collection was high and the number of premises was very high. It was though that this extreme point (A) could have bias the results of the correlation. So a correlation was computed without this point. Without the point A, a graph of the remaining points (Figure II.2) did not indicate any linear behaviour and the correlation coefficient this time was only

Figure II.1 - Graph of tonnage against number of commercial premises



(Where more than 1 point appeared in the same location, a number was used to indicate the number of points at that location)

Figure II.2 - Replot of tonnage against number of commercial premises covered, with the extreme point A omitted



0.425 which did not indicate that any linear relation existed between total tonnage and the number of commercial premises collected from.

II.2.7 Relation of tonnage collected with population

No significant influence of population density on collection tonnage was found. Correlation coefficient for total tonnage collected with population density was only 0.49. Although correlation of tonnage with population was 0.886, but the plot of the two variables did not show any linear relation.

II.2.8 Possibility of increasing collection tonnage

Eleven of the local authorities felt that they could increase their collection from domestic premises. The potential increase estimated varied from 20 tonnes to 10,000 tonnes.

Only 5 local authorities felt that they could collect another 550 tonnes or so from the commercial premises. This indicated that collection from the commercial premises was already near saturation point. If all the extra tonnages were collected there would be a 42 percent increase in collection.

Various reasons have been offered by the local authorities for not collecting the extra 42 percent waste paper. The more common ones were :

a) lack of collection facilities to cover the rural areas;
b) these tonnages were collected intermittently by voluntary organisations;
c) insufficient baling facilities for the extra tonnages; and
d) market situation did not warrant the increased commitment of capital expenditure to collect the extra tonnage.

II.2.9 Bonus for collection workers

Sixteen of the local authorities gave a bonus or monetary incentive of some kind to their workers involved in waste paper collection. The system may be either one of the following :

a) a 33.3 percent on the basic wages;
b) a share of the sales revenue; or
c) an amount based on the number of premises served during the collection rounds.

II.2.10 Profitability of the operating scheme in the opinion of the local authority

Contribution per premise per week	Very profitable	Marginally profitable	Break-even	Marginally unprofitable	Very unprofitable	Row Total
0 - 1 kg	-	3	2	5	1	11
1 - 2 kg	2	1	1	-	-	4
2 - 3 kg	-	1	-	-	-	1
3 - 4 kg	-	-	-	1	-	1
4 - 5 kg	-	-	-	1	-	1
5 kg	-	3	-	2	3	8
Unknown contribution	1	4	-	-	-	5
Column total	3	12	3	9	4	31

Three local authorities regarded their own scheme as very profitable. One of these local authorities claimed that there was no cost in waste paper collection since free vehicles and labour on a week day, which would be idle anyway, were deployed for waste paper collection. The second local authority was collecting from the whole of the area covering both domestic and commercial premises, besides salvaging waste paper at the tip site thus recovering one of the highest tonnages among the local authorities. The third local authority collected a rather small amount, about 600 tonnes, but the collection covered only the whole of the commercial area which was concentrated in the town itself, thus making collection easy and kept collection cost down.

Out of the 31 local authorities, only 13 local authorities (or 42 percent) viewed their own recovery operation as losing money. It may be interesting to note that the 3 'very profitable' local authorities collected from commercial premises in the whole area. Of the 11 'marginally profitable' ones all, except 2, also collected from commercial premises in the whole area. It did not seem that high collection will definitely result in high profitability. In fact, out of 8 of those collecting about 5 kg per premise per week, 5 were losing money. Out of the 15 who claimed to be making money, 6 of them were collecting less than 2 kg per premise per week. While high contribution may not mean high profitability, low contributions of less than 1 kg per premise per week seem to lose money since only 3 out of 11 local authorities collecting this contribution claimed to be making money.

Although the questionnaire had asked the local authorities to indicate any special features which accounted for their profitability or otherwise, the brief comments provided were inconclusive.

The relatively, simplistic criterion of 'profitability' as assessed by the respondents themselves did not allow any firm conclusions to be drawn. Each local authority used a different costing systems and since the questionnaire did not specify what cost items to consider in the assessment of the profitability, there were many un-explainable variations in their profitability assessments. There were almost certainly personal bias in assessing the profitability of their own scheme since no cost data need be provided along to varify the profitability of the operation.

II.2.11 Markets for the waste papers

For a waste paper recovery operation to be successful and on-going the local authority must have a guaranteed outlet for the recovered waste papers. 25 of the 31 local authorities sold their baled waste paper to a paper and board mill and the rest of them sold to merchants. But only

20 of them have secured markets by maintaining a long term contract with their buyers and all of them sold to the same Scottish board mill. Since these 20 mills were spread all over Scotland, it was not possible to assess whether proximity to a mill encourages more waste paper recycling. However, one local authority in the same location as the mill to which it sold its waste paper to, did recovered a very high amount of 3,000 tonnes per annum and did describe its own operation as 'very profitable'.

II.2.12 Conclusions

The analysis was not able to provide any firm conclusions although certain interesting factors of local authority waste paper recovery operation were revealed. An interesting point was that these 31 local authorities were really committed to waste paper recovery and believed in doing it as a service.

II.2.13 Epilogue

After the 1974/75 local government re-organisation the new district councils in Scotland absorbed many of the waste paper recovery equipment and plant of the pre-re-organisation councils and many of the new district councils continued with waste paper recovery operations and did not stop salvaging waste paper even though the waste paper market suffered a very severe slump in 1975/76 and another minor decline in 1978, against a background of ever-increasing labour and fuel costs. The rather severe recession in 1980, however, terminated the operation of only two of these local authorities.

REF WS/5/7/7/1

SCOTTISH DEVELOPMENT DEPARTMENT
WASTE PAPER SALVAGE BY LOCAL AUTHORITIES

1. Name of council ....
(Delete as appropriate) County/Burgh

2. Do the council take part in the salvaging of waste paper ?

Yes Permanent	
Yes Trial	
No	

3. If the answer to question 2 is 'Yes trial' please give starting and finishing dates

	To	

4. Have the council rejected the possibility of salvaging waste paper ?

Yes	
No	

5. If the answer to the preceding question was 'Yes', please say why. ....

....

....

....

The following questions should be answered only if the answer to question 2 was 'Yes Permanent' or 'Yes Trial'.

In the case of trial schemes please give answers as far as possible.

6. Do the council have equipment for sorting and baling waste paper salvaged ?

Yes	
No	

7. Is collection made from domestic premises in the whole or part of the area ?

None	
Part	
Whole	

8. Is collection made from commercial premises in the whole or part of the area ?

None	
Part	
Whole	

9. Please indicate approximate number of premises covered by collection scheme.

Domestic	
Commercial	

10. Please indicate whether the council use trailers behind refuse collection vehicles or separate vehicles.

Domestic	Trailers	
	Separate vehicles	
Commercial	Trailers	
	Separate vehicles	

11. Please indicate whether the council salvage any waste paper at tips, or refuse disposal plant.

Yes
No

12. Please give an estimate of the weight of waste paper collection, expressed as tonnes per annum

	Separate Col- lection	Salvaged at tip plant
Newspapers		
Fibre board containers		
Mixed waste paper		
Other		
Total		

13. Where collection is partial (see questions 7 & 8) give estimates of additional quantity which could reasonably be collected.

Tonnes per annum	
Domestic	
Commercial	

Please indicate why this additional quantity is not collected.

....

....

....

....

14. Please indicate the extent to which you regard your waste paper operations as profitable or otherwise.

Very profitable	
Marginally profitable	
Breaks even	
Marginally unprofitable	
Very unprofitable	

Please indicate any special features which account for this profitability or otherwise.

....

....

....

....

15. Is waste paper supplied to a mill, merchant or both ?

Mill	
Merchant	
Both	

Please give name(s) and address(es)

....

....

....

....

16. Please state the place to which your waste paper is delivered (if different from 15).

....

....

....

17. Is a bonus scheme for waste paper collection by refuse collectors in operation ?

Yes	
No	

If yes please give a brief description of any such bonus scheme (eg whether based on tonnage or number of premises served), with a reference to any difficulties experienced.

....

....

....

18. Do the council have a contract with a mill or merchant ?

Yes	
No	

If so, please state length of contract.

....

19. Please give details of any other financial arrangements, such as financial arrangements with charities for collected paper, or arrangements with other councils.

....

....

....

....

Signed ....

Name in block capitals ....

Official position ....

Telephone No. .... Extension ....

Date ....

Appendix III

Local authority loans rate[1]: Public Works Loan Board

Per cent per annum   Operating from date shown

	Repayable by equal instalments of principal[2]					Repayable by instalments of equal repayments of principal and interest combined[2]					Repayable at maturity		
	Up to 5 years	Over 5 and up to 10 years	Over 10 and up to 15 years	Over 15 and up to 25 years	Over 25 years	Up to 5 years	Over 5 and up to 10 years	Over 10 and up to 15 years	Over 15 and up to 25 years	Over 25 years	Up to 5 years	Over 5 and up to 10 years	Over 10 and up to 15 years
1979 Jan 6	13	13¼	13⅜	13⅜	13½	13	13⅜	13⅛	13½	13½	13¼	13⅜	13½
Jan 20	13⅛	13⅛	13⅝	13⅝	13¾	13⅛	13½	13⅝	13⅜	13¾	13⅜	13⅝	13¾
Feb 3	13¾	14	14	14⅛	14⅛	13¾	14	14⅛	14⅛	14⅛	14	14⅛	14⅛
Feb 17	14	14⅜	14½	14⅝	14⅝	14⅛	14½	14⅝	14⅝	14⅝	14⅜	14⅝	14⅝
Mar 3	12¾	13⅛	13½	13⅝	13⅝	12¾	13⅜	13⅝	13¾	13¾	13⅛	13⅝	13¾
Mar 10	11¾	11⅞	12⅜	12⅝	12¾	11¾	12⅛	12⅝	12¾	12⅞	11⅞	12⅝	12¾
Mar 24	11⅝	11⅞	12⅜	12⅝	12¾	11⅝	12	12½	12¾	12⅞	11¾	12½	12¾
Apr 7	10½	10½	11⅛	11⅝	11¾	10½	10¾	11⅜	11¾	11⅞	10½	11⅜	11⅝
Apr 28	10⅞	11	11½	11¾	11⅞	10⅞	11⅛	11⅝	11⅞	12	11	11¾	11⅞
May 12	10⅝	10⅝	11¼	11⅝	11¾	10⅝	10⅞	11½	11¾	11⅞	10⅝	11½	11⅝
May 26	11¾	11⅜	12⅛	12⅜	12⅜	11⅜	12	12¼	12⅜	12⅜	11¾	12¼	12⅜
June 9	11½	11⅝	12⅛	12⅜	12½	11½	11⅜	12¼	12⅜	12½	11⅝	12¼	12⅜
June 23	12⅝	12⅝	13	13⅛	13⅛	12⅝	12¾	13	13⅛	13⅛	12⅝	13	13⅛
July 7	12⅛	12⅛	12½	12⅝	12¾	12	12¼	12⅝	12⅝	12¾	12¼	12⅝	12⅝
July 21	12⅝	12⅝	12¾	12¾	12¾	12½	12⅝	12¾	12¾	12¾	12½	12¾	12¾
Aug 4	12¾	12⅝	12¾	12¾	12⅝	12¾	12⅝	12¾	12⅝	12⅝	12⅝	12¾	12⅝
Aug 18	12¼	12¼	12½	12½	12½	12¼	12¼	12½	12½	12½	12¼	12½	12½
Sept 8	12½	12⅜	12⅝	12⅝	12¾	12½	12½	12⅝	12⅝	12¾	12⅜	12⅝	12⅝
Sept 22	12¾	12¾	13	13	13	12¾	12¾	13	13	13	12⅝	13	13
Oct 6	12½	12½	12¾	12¾	12¾	12½	12⅝	12¾	12¾	12⅞	12½	12¾	12¾
Oct 20	13⅛	13⅛	13¼	13¼	13¼	13⅛	13⅛	13¼	13¼	13¼	13	13¼	13¼
Nov 3	13⅝	13⅝	13¾	13⅝	13⅝	13⅝	13⅝	13¾	13⅝	13⅝	13½	13¾	13⅝
Nov 17	15¼	15¼	15⅛	14⅞	14¾	15¼	15¼	15	14¾	14¾	15¼	15	14⅞
Dec 1	15⅞	16⅛	15⅝	15¼	15	15⅞	15⅞	15⅞	15	15	16⅛	15⅜	15⅛
Dec 15	16⅛	16¼	15⅞	15½	15⅜	16⅛	16⅛	15⅝	15⅜	15¼	16¼	15⅝	15⅜
1980 Jan 5	15¼	15¼	15¼	15	14⅞	15¼	15⅜	15	15⅞	14¾	15¼	15⅛	14⅞
Jan 19	14⅞	15	14⅝	14¼	14⅛	14⅞	14⅞	14⅜	14⅛	14	15	14⅜	14⅛
Feb 9	15⅝	15⅝	15⅛	14¾	14⅝	15⅝	15½	14⅞	14⅝	14½	15⅝	14⅞	14⅝
Feb 23	15⅝	15½	15¼	14⅞	14¾	15½	15½	15	14¾	14⅝	15⅝	15	14¾
Mar 8	15⅝	15½	15¼	15	14⅞	15½	15½	15⅛	14⅞	14¾	15½	15⅛	14⅞
Mar 22	15½	15⅜	15¼	15	14⅞	15½	15⅜	15⅛	14⅞	14⅞	15⅜	15⅛	15
Apr 19	14⅝	14⅝	14½	14⅜	14¼	14⅝	14⅝	14⅜	14¼	14¼	14⅝	14⅜	14¼
May 3	14¾	14¾	14¾	14½	14½	14¾	14¾	14⅝	14½	14½	14¾	14⅝	14½
May 17	14⅜	14⅜	14⅜	14¼	14¼	14¼	14⅜	14⅜	14¼	14¼	14⅜	14⅜	14¼
May 31	14⅛	14⅛	14⅛	14⅛	14	14⅛	14⅛	14⅛	14	14	14⅛	14⅛	14⅛
1980 June 14	13⅞	14	14⅛	14⅛	14⅛	13⅞	14⅛	14⅛	14⅛	13⅞	14⅛	14⅛	14⅛
June 28	13⅛	13⅛	13½	13⅝	13⅝	13⅛	13¼	13⅝	13⅝	13¾	13	13⅝	13⅝
July 12	13	12⅞	13⅜	13½	13½	12⅞	13⅛	13½	13½	13½	12⅞	13½	13½
July 26	12¾	12⅝	12⅞	12⅞	12¾	12⅝	12¾	12⅞	12¾	12¾	12⅝	12⅞	12⅞
Aug 9	13⅝	13½	13⅝	13½	13⅜	13½	13⅝	13½	13⅜	13⅜	13½	13½	13⅜
Aug 23	13¾	15⅝	13⅞	13⅞	13¾	13⅝	13⅞	13⅞	13¾	13¾	13⅝	13⅞	13¾
Sept 6	14	14⅛	14⅛	14	14	14	14⅛	14⅛	14	14	14	14⅛	14
Sept 20	12⅞	13	13½	13⅜	13⅜	12⅞	13¼	13⅜	13⅜	13⅜	13	13⅜	13⅜
Oct 4	13¼	13¼	13¾	13⅝	13⅝	13¼	13½	13¾	13⅝	13⅝	13¼	13¾	13⅝
Oct 18	13	13	13⅜	13⅜	13⅜	13	13¼	13⅜	13⅜	13¼	13	13⅜	13⅜
Nov 1	13⅛	13⅛	13⅜	13¼	13⅛	13⅛	13¼	13¼	13⅛	13⅛	13⅛	13¼	13⅛
Nov 15	13⅝	13⅝	13⅞	13⅝	13½	13⅝	13¾	13¾	13½	13½	13⅝	13¾	13⅝
Nov 29	13⅛	13⅛	13½	13⅜	13⅜	13⅛	13⅜	13½	13⅜	13¼	13⅛	13½	13⅜
Dec 6	13	13⅛	13⅝	13½	13½	13	13⅜	13½	13½	13⅜	13⅛	13½	13½
Dec 20	13⅝	13⅞	14⅜	14¼	14⅛	13⅝	14⅛	14¼	14⅛	14⅛	13¾	14¼	14⅛
1981 Jan 3	13⅜	13½	14⅛	14	14	13⅜	13⅞	14⅛	14	14	13½	14⅛	14
Jan 17	13⅜	13⅝	14¼	14¼	14¼	13⅜	14	14¼	14¼	14¼	13⅝	14¼	14¼
Jan 31	13¼	13½	14⅛	14⅛	14⅛	13¼	13⅞	14⅛	14⅛	14⅛	13½	14⅛	14⅛
Feb 14	13¼	13½	14⅛	14⅛	14⅛	13¼	13⅞	14⅛	14⅛	14⅛	13½	14⅛	14⅛
Feb 28	12⅞	13¼	14	14⅛	14⅛	12⅞	13⅝	14	14⅛	14⅛	13⅛	14	14⅛
Mar 14	12¾	13	13⅝	13⅞	14	12¾	13⅞	13¾	14	14	13	13¾	14
Mar 28	12¾	13⅛	13⅝	13⅝	13½	12¾	13⅞	13⅝	13½	13½	13⅛	13⅝	13⅝

[1] The rates are those applicable to the quota of loans which are available to local authorities from the National Investment and Loans Office. [2] Repayable by half-yearly instalments.

Source: HM Treasury

Appendix IV

Raw data of case studies in Chapter 5

<u>Table AIV.1a</u> - Estimates of Case SA

1)	Collection cost is only transport cost, using 2 vehicles, 1 day per week for 52 weeks	= 2 x 47* x 52
		= £4888
2)	Baling wire cost for 3241 tonnes based on the cost of baling wires of £2.88 per tonne of baled waste paper	= £9334.08
	Sacks used for collection based on £1.04 per tonne of waste paper	= £3370.64
	Power for baler based on £0.97 per tonne of waste paper	= £3143.77
	Total supplies & services cost :	£15848.49
3)	Labour cost of 4 men directly employed in waste paper collection & baling based on £6051 per man per year	= £24204
	20% of shared labour of street orderlies working 1 day per week collecting waste paper	= £11930.4
	Total labour cost :	£36134.4
4)	Overheads :	
	Protective clothing = 20% of £589	= £ 117.80
	Repair & maintenance = 20% of £52064	= £8412.80
	Workshop charges = 20% of £4454	= £ 890.80
	Total :	£9421.40

* Average cost of running a refuse collection vehicle in a district council is £47 per day, inclusive of licence, insurance, depreciation, fuel, replacement tyres, repair and maintenance. (FTA,1981)

Table AIV.1b

Local Authority Waste Paper Salvage

Cost statement for financial year 1979/80 (Case SA)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	36134**	
Supplies and services - equipment, tools, sacks	3371	
Transport - Operating cost	4888	
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		44393
Baling cost		
Labour cost -	-**	
Supplies and services - equipment, tools, baling wires	9452	
Baling plant - Electric power	3144	
Repairs and maintenance	8413	
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*	891***	
Central & departmental charges*		
Total baling costs		21900
Gross expenditure c/f		66293

	£	£
Gross expenditure b/f		66293
Income		
Sale of salvaged paper -	91585	
Contribution to reflect disposal savings -		
Gross income		91585
Net ~~expenditure/~~income		25292
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		-
Notional profit/~~loss~~-		25292
Tonnes of waste paper baled during the period		3241
Profit/~~loss~~ per tonne of waste paper recovered		7.80

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

** inclusive

*** workshop charges

Table AIV.2

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case SB)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	224000	
Supplies and services - equipment, tools, sacks	19500	
Transport - Operating cost	31500	
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*	-**	
Central & departmental charges*		
Publicity*		
Total paper collection costs		275000
Baling cost		
Labour cost -		
Supplies and services - equipment, tools, baling wires		
Baling plant - Electric power		
Repairs and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*	-***	
Central & departmental charges*		
Total baling costs		
Gross expenditure c/f		275000

	£	£
Gross expenditure b/f		275000
Income		
Sale of salvaged paper -	180000	
Contribution to reflect disposal savings -	90000	
Gross income		270000
Net expenditure/~~income~~		5000
Indirect cost and savings		
Cost		
Loss of income from trade collection -	60000	
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -	65000	
Net indirect ~~cost~~/savings		5000
Notional profit/loss		0
Tonnes of waste paper baled during the period		6500
Profit/~~loss~~ per tonne of waste paper recovered		0

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

** included in refuse collection cost

*** included in refuse disposal cost

Table AIV.3

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case SC)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	10000	
Supplies and services - equipment, tools, sacks	100	
Transport - Operating cost	3000	
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*	300	
Total paper collection costs		13400
Baling cost		
Labour cost -	8000	
Supplies and services - equipment, tools, baling wires	1000	
Baling plant - Electric power	1500	
Repairs and maintenance		
Loan charges (or Renewals fund contribution)	1000	
Premises* -		
Establishment expenses - Depot charges*	500	
Central & departmental charges*		
Total baling costs		12000
Gross expenditure c/f		25400

	£	£
Gross expenditure b/f		25400
Income		
Sale of salvaged paper -	16900[1]	
Contribution to reflect disposal savings -	8531	
Gross income		25431
Net ~~expenditure~~/income		31
Indirect cost and savings		
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		
Notional profit/~~loss~~		31
Tonnes of waste paper baled during the period		780
Profit/~~loss~~ per tonne of waste paper recovered		0.04

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

1 260 tonnes of mixed waste at £7 per tonne = 1820
(£22 less £15 paid to voluntary organisation)
520 tonnes of container waste @ £29/tonne = 15080
£ 16900

Table AIV.4

Local Authority Waste Paper Salvage

Cost statement for financial year 1981/82 (Case SD)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	18153	
Supplies and services - equipment, tools, sacks	-*	
Transport - Operating cost	13410	
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		33458
Baling cost		
Labour cost -	12102	
Supplies and services - equipment, tools, baling wires	6035 ±	
Baling plant - Electric power		
Repairs and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Total baling costs		16242
Gross expenditure c/f		49700

	£	£
Gross expenditure b/f		49700
Income		
Sale of salvaged paper -	44712[1]	
Contribution to reflect disposal savings -		
Gross income		44712
Net expenditure/~~income~~		4988
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		
Notional-~~profit~~/loss		4988
Tonnes of waste paper baled during the period		1440
~~Profit~~/loss per tonne of waste paper recovered		3.46

inclusive

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

[1] 1008 tonnes of waste paper @ £29.25 = 29484
432 tonnes of container waste @ £35.25 = 15228
44712

Table AIV.5

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case SE)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers		
Supplies and services - equipment, tools, sacks	no details available	
Transport - Operating cost		
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		7751.52
Baling cost		
Labour cost -		
Supplies and services - equipment, tools, baling wires	no details available	
Baling plant - Electric power		
Repairs and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Total baling costs		7091.04
Additional loading costs		549.60
Gross expenditure c/f		15392.16

	£	£
Gross expenditure b/f		15392.16
Income		
Sale of salvaged paper -	4300.80	
Contribution to reflect disposal savings -		
Gross income		4300.80
Net expenditure/~~income~~		11091.36
Indirect cost and savings		
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		
Notional ~~profit~~/loss		11091.36
Tonnes of waste paper baled during the period		145
~~Profit~~/loss per tonne of waste paper recovered		76.49

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

Table AIV.6

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case EA)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	12540	
Supplies and services - equipment, tools, sacks		
Transport - Operating cost	4500	
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		17040
Baling cost		
Labour cost -	8610	
Supplies and services - equipment, tools, baling wires	1200	
Baling plant - Electric power	1000	
Repairs and maintenance	100	
Loan charges (or Renewals fund contribution)	10700	
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Total baling costs		21610
Gross expenditure c/f		38650

	£	£
Gross expenditure b/f		38650
Income		
Sale of salvaged paper -	28000	
Contribution to reflect disposal savings -		
Gross income		28000
Net expenditure/~~income~~		10650
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		
Notional ~~profit~~/loss		10650
Tonnes of waste paper baled during the period		1030
~~Profit~~/loss per tonne of waste paper recovered		10.34

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

Table AIV.7

Local Authority Waste Paper Salvage

Cost statement for financial year 1979/80 (Case EB)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	59968**	
Supplies and services - equipment, tools, sacks	1228	
Transport - Operating cost	13789	
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -	3038	
Establishment expenses - Depot charges*	3111	
Central & departmental charges*		
Publicity*		
Total paper collection costs		81134
Baling cost		
Labour cost -	-**	
Supplies and services - equipment, tools, baling wires	1690	
Baling plant - Electric power		
Repairs and maintenance	2496	
Loan charges (or Renewals fund contribution)		
Premises* -	3039	
Establishment expenses - Depot charges*	3111	
Central & departmental charges*		
Total baling costs		10336
Gross expenditure c/f		91470

	£	£
Gross expenditure b/f		91470
Income		
Sale of salvaged paper -	35879	
Contribution to reflect disposal savings -		
Gross income		35879
Net expenditure/~~income~~ -		55591
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -	4000	
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -	26000	
Net indirect ~~cost~~/savings		22000
Notional ~~profit~~/loss		33591
Tonnes of waste paper baled during the period		1300
~~Profit~~/loss per tonne of waste paper recovered		25.84

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

** inclusive

Table AIV.8

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case EC)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - ~~wages~~, bonuses of collection crew and drivers	24537	
Supplies and services - equipment, tools, sacks		
Transport - ~~Operating cost~~ Trailer licensing	1500	
Repair and maintenance (Trailers)	2500	
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		28537
Baling cost		
Labour cost -	39925	
Supplies and services - equipment, tools, baling wires	4551	
Baling plant - Electric power	3579	
Repairs and maintenance	1820	
Loan charges (or Renewals fund contribution)	1730	
Premises* -		
Establishment expenses - Depot charges*	10000	
Central & departmental charges*		
Total baling costs		61615
Gross expenditure c/f		90152

	£	£
Gross expenditure b/f		90152
Income		
Sale of salvaged paper -	58381	
Contribution to reflect disposal savings -	2146	
Gross income		60527
Net expenditure/~~income~~ -		29625
Indirect cost and savings		
Cost		
Loss of income from trade collection -	Not available	
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -	Not available as vehicle size is adequate	
Net indirect cost/savings		
Notional ~~profit~~/loss		29625
Tonnes of waste paper baled during the period		2146
~~Profit~~/loss per tonne of waste paper recovered		13.80

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

Table AIV.9

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case ED)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers		
Supplies and services - equipment, tools, sacks	Absorbed under refuse collection cost	
Transport - Operating cost		
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		
Baling cost		
Labour cost -	92169	
Supplies and services - equipment, tools, baling wires	8225	
Baling plant - Electric power	56746	
Repairs and maintenance		
Loan charges (or Renewals fund contribution)	36100	
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*		
Total baling costs		193240
Gross expenditure c/f		193240

	£	£
Gross expenditure b/f		193240
Income		
Sale of salvaged paper -	88028	
Contribution to reflect disposal savings -		
Gross income		88028
Net expenditure/~~income~~ -		105212

<u>Indirect cost and savings</u>

	£	£
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		
Notional ~~profit~~/loss		105212
Tonnes of waste paper baled during the period		3115
~~Profit~~/loss per tonne of waste paper recovered		33.78

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

Table AIV.10

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case EE)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	55055	
Supplies and services - equipment, tools, sacks	5717	
Transport -		
Operating cost	10474	
Repair and maintenance	19343	
Loan charges (or Renewals fund contribution)	11996	
Premises* -		
Establishment expenses -		
Depot charges*	7990	
Central & departmental charges*	8503	
Publicity*		
Total paper collection costs		119078
Baling cost		
Labour cost -	13113	
Supplies and services - equipment, tools, baling wires	89	
Baling plant - Electric power	4992	
Repairs and maintenance		
Loan charges (or Renewals fund contribution)	2800	
Premises* -		
Establishment expenses -		
Depot charges*	1899	
Central & departmental charges*	2020	
Total baling costs		24913
Gross expenditure c/f		143991

	£	£
Gross expenditure b/f		143991
Income		
Sale of salvaged paper -	55586	
Contribution to reflect disposal savings -		
Gross income		55586
Net expenditure/~~income~~		88405
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -	Not available	
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -	Not available	
Net indirect cost/savings		
Notional ~~profit~~/loss		143991
Tonnes of waste paper baled during the period		1805
~~Profit~~/loss per tonne of waste paper recovered		48.99

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

Table AIV.11a

Local Authority Waste Paper Salvage

Cost statement for financial year 1/4/80 - 30/9/80 (Case EF)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers	37198	
Supplies and services - equipment, tools, sacks		
Transport -		
Operating cost	11116	
Repair and maintenance	1580@	
Loan charges (or Renewals fund contribution)	-**	
Premises* -		
Establishment expenses -		
Depot charges*		
Central & departmental charges*		
Publicity*		
Total paper collection costs		49894
Baling cost		
Labour cost -	- #	
Supplies and services - equipment, tools, baling wires	1030	
Baling plant -		
Electric power	400	
Repairs and maintenance	-@	
Loan charges (or Renewals fund contribution)	470**	
Premises* -	750	
Establishment expenses -		
Depot charges*		
Central & departmental charges*		
Total baling costs		2650
Gross expenditure c/f		52544

	£	£
Gross expenditure b/f		52544
Income		
Sale of salvaged paper -	28750	
Contribution to reflect disposal savings -		
Gross income		28750
Net expenditure/~~income~~		23794
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -		
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -		
Net indirect cost/savings		
Notional ~~profit~~/loss		23794
Tonnes of waste paper baled during the period		918
~~Profit~~/loss per tonne of waste paper recovered		25.92

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage.

\# inclusive

@ inclusive

** inclusive

Table AIV.11b - Statement of Income and Expenditure for the half-year 1/4/80 to 30/9/80 compare to the 1980-81 budgeted provision

Expenditure	1980-81 budgeted provision				Actual 1/4/80 to 30/9/80 figures	
	whole year		half year			
	£		£		£	
Labour cost						
Basic wages	41920		20960		22505	
Bonus	13380		6690		7264	
Overtime	2120		1060		1269	
Employer's NI	6340		3170		3183	
Employer's Super	5520		2760		2977	
		69280		34640		37198
Premises						
Repairs & maintenance	2700		1350		1580	
Rates	1220		610		750	
Electricity	1100		550		400	
Debt charges	940		470		470	
		5960		2980		3200
Supplies & Services						
Baling wires		1500		750		1030
Transport						
Vehicle costs	10720			5360	10698	
Hired vehicles	-			-	418	
		10720		5360		11116
Total Expenditure		87460		43730		52544
Incomes						
Sales of waste paper		70000		35000		28750
Tonnages of waste paper		2290 tonnes		1145 tonnes		918 tonnes
Deficit		17460		8730		23794

Table AIV.12a - 1977 to 1981 summary of SWAP operation

	1977/78	1978/79	1979/80	1980/81
Cash raised (£)	14465	7642	14330	13298
Tonnages recovered (tonnes)				
Waste paper	1090.00	874.00	879.00	1017.41
Glass	-	410.00	881.00	1344.68
Textiles	6.70	12.14	10.77	12.38
Aluminium foil	1.30	2.05	2.42	2.74
Food & Drink cans	-	-	35.00	71.30
Total tonnages recovered	1098.00	1298.00	1908.00	2448.31

Table AIV.12b - Prices of secondary materials in 1980 and in 1981 paid to SWAP

	1980 July	1981 July
Waste paper	£6 to £10	£5 to £6
Textiles	£65	£65
Aluminium foil	£200	£176
Food & Drink cans	£5	£5
Glass	£16	£15.50 to £19

Table AIV.12c - SWAP operation for August 1980 to July 1981
Source : Leeds Recycling for Charity Committee

	First Quarter 1980 Aug, Sept, Oct		2nd Quarter 1980 Nov, Dec 1981 Jan		3rd Quarter 1981 Feb, Mar, April		4th Quarter 1981 May, June, July	
	Tonne	£	Tonne	£	Tonne	£	Tonne	£
Public Donations:								
Waste paper	251.28	2138.43	275.54	1475.25	272.73	1426.57	217.86	1169.14
Textiles	2.44	158.28	3.35	217.75	3.46	224.90	2.93	190.45
Aluminium foil	0.67	134.01	0.81	154.59	0.70	123.60	0.56	98.40
Food & Drink cans	19.42	97.10	19.50	97.50	18.64	93.19	13.74	68.71
Bottles & Jars	281.24	4513.60	340.00	5753.77	379.98	6499.18	343.46	5914.08
Total	555.05	7041.42	639.20	7698.86	675.51	8367.44	578.55	7440.78
Less cost for bottle bank skips		3391.00		4254.75		4453.70		4450.90
Net income		3650.42		3444.11		3913.74		2989.88
Less 5%*		182.51		172.22		195.69		149.48
Balance		3467.91		3271.89		3718.05		2840 40
Amount due**		1155.97		1090.63		1239.35		946.80
Average 'profit' per tonne of salvaged material to SWAP		£6.24		£5.12		£5.50		£4.19

Note : * held by the Committee for skip maintenance, publicity and administration costs

** balance divided between 3 charities in each quarter to arrive at the amount due to each charity

Table AIV.12d

Local Authority Waste Paper Salvage

Cost statement for financial year 1980/81 (Case EG)

Direct costs and revenue	£	£
Collection of waste paper		
Labour cost - wages, bonuses of collection crew and drivers		
Supplies and services - equipment, tools, sacks		
Transport - Operating cost		
Repair and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*	10000[1]	
Publicity*		
Total paper collection costs		10000
Baling cost		
Labour cost -		
Supplies and services - equipment, tools, baling wires		
Baling plant - Electric power		
Repairs and maintenance		
Loan charges (or Renewals fund contribution)		
Premises* -		
Establishment expenses - Depot charges*		
Central & departmental charges*	-[1]	
Total baling costs		
Gross expenditure c/f		10000

	£	£
Gross expenditure b/f		10000
Income	-[2]	
Sale of salvaged paper -	6904.23	
Contribution to reflect disposal savings -		
Gross income		6904.23
Net expenditure/~~income~~-		3095.77
<u>Indirect cost and savings</u>		
Cost		
Loss of income from trade collection -	42502.66	
Savings		
Savings in refuse collection costs that results from smaller quantity of domestic refuse with separate waste paper collection -	60620.16	
Net indirect ~~cost~~/savings		18117.50
~~Notional profit/loss~~ Net Savings		15021.73
Tonnes of ~~waste paper baled during the period~~ recovered material -		2448.31
~~Profit/loss per tonne of waste paper recovered~~ Savings per tonne of secondary material recovered through SWAP		6.14

Note : * indicates expenses which should be included only if they have been due to the waste paper recovery operation, i.e. these expenses would not have been incurred had there been no waste paper salvage

[1] inclusive, based on salary of 1½ officers

[2] sale revenue not received by the Council

Appendix V

WASTE PAPER SALVAGE BY LOCAL AUTHORITIES - CASE STUDY

1(a) Name of local authority ______________________________

(b) Appn area ______________________ (c) Popn ____________

(d) No. of domestic premises _________________

(e) No of commercial premises ________________

2 Do the local authority take part in the salvaging of waste paper ?

(a)	Yes, permanent	
(b)	Yes (Trial)	
(c)	Yes, but suspended	
(d)	No	

3(a) If the answer to question 2 is '(b) Yes (Trial)', please give starting and finishing dates

_____________ to _____________

(b) If the answer to question 2 is '(c) Yes, but suspended', please give the period when the salvage scheme was in operation

_____________ to _____________

(c) If the answer to question 2 is '(d) No', please state if the local authority have rejected the possibility of salvaging waste paper

Yes	
No	

4 If the answer to question 3(c) was 'yes', please state why ?

____

____

____

____

____

____

____

If the answer to question 2 was 'No', please go to question 17.

If the question 2 answer was '(a) Yes, permanent', or '(b) Yes, (Trial)', or '(c) Yes, but suspended', please answer question 5 onwards below. In the case of trial schemes, please give answers as far as possible.

5 Do the local authority have equipment for sorting and baling waste paper salvaged in the district ?

Yes	
No	

If yes, what is the throughput of the baler ? ______________

(a) When was the baler installed ? ______________

(b) How long is the write-off period for the baler ? ______________

(c) What is the new capital investment for the baler ? ______________

(d) Where does this capital come from ? ______________

6 Is collection made from domestic premises in the whole or part of the district ?

None	
Part	
Whole	

7 Is collection made from commercial premises in whole or part of the district ?

None	
Part	
Whole	

8 Please give the approximate number of premises covered by the collection scheme.

Domestic	
Commercial	

9 Please indicate whether the council use trailers behind refuse collection vehicles or separate vehicles

Domestic	Trailers	
	separate vehicles	
Commer-cial	Trailers	
	separate vehicles	

10(a) Please give an estimate of the weight of waste paper collected separately, expressed as tonnes per annum.

Newspapers	
Fibreboard containers	
Mixed waste paper	
Other (please specify)	
Total	

(b) Do the local authority issue sacks or plastic bags for waste paper collection ?

Yes	
No	

(c) If answer is yes, is there an increase in waste paper collected ?

Yes	% increase	
No		

11(a) Where collection is partial (see question 6 and 7), give estimates of additional quantity which could reasonably be collected.

Domestic	
Commercial	

(b) Please indicate why this additional quantity is not collected ?

____

____

____

____

12(a) Please indicate the extent to which you regard your waste paper operations as profitable or otherwise

Very Profitable	
Marginally profitable	
Breaks even	
Marginally unprofitable	
Very unprofitable	

(b) Please indicate any special features which account for this profitability or otherwise.

____

____

____

____

13 Is the collected waste paper supplied to a mill, merchant or both ?

Mill	
Merchant	
Both	

14 Please state the place to which your waste paper is delivered (if different from 13) ______________________________

15 Is a bonus scheme for waste paper collection by refuse collectors in operation ?

Yes	
No	

If the answer is 'yes', please give a brief description of any such bonus scheme (eg. whether based on tonnage or number of premises served), with a reference to any difficulties experienced :

____

____

____

____

____

____

16(a) Do the district council have a contract with a mill or merchant ?

Yes	
No	

If the answer is 'yes', please continue, otherwise go to question 17.

(b) If 'yes', please state the length of the contract.

____

(c) Does your long term contract contain the following basic elements, recommended by LAMSAC in 1975 ?

i) 5 year period,

Yes	
No	

ii) a datum tonnage,

Yes		Tonnage =
No		

iii) any quota tonnage,

Yes		Quota =
No		

iv) a starting price to be agreed annually,

Yes	
No	

v) a guaranteed minimum price for the datum tonnage fixed for the period of the contract.

Yes	
No	

Minimum Price £ ____________

17(a) Are there any charity or voluntary organisations collecting in the dictrict ?

Yes	
No	

If the answer to question 17(a) is 'yes', please continue.
If the answer to question 17(a) is 'no', please go to cost statements.

(b) Please state the organisation/s :

____

____

(c) Do they collect as a continuing basis or do they collect intermittently, ceasing to collect at times of low demand ?

continuing	
intermittently	

(d) How do they sell their collected waste papers ?

____

____

THANK YOU.

Appendix VI

Statistics of Scottish Local Authorities

Authority	Area (Hectare)	Population	Population density (per hectare)
Borders			
Berwickshire	87553	17537	0.20
Ettrick & Lauderdale	135618	32963	0.24
Roxburgh	154048	35255	0.23
Tweeddale	89939	13764	0.15
Central			
Clackmannan	16099	48003	2.98
Falkirk	30058	91071	3.03
Stirling	216989	50120	0.23
Dumfires & Galloway			
Annandale & Eskdale	155342	35131	0.23
Nithsdale	143313	55674	0.39
Stewarty	167076	22259	0.13
Wigtown	171275	29401	0.17
Fife			
Dunfermline	30106	125796	4.18
Kirkcaldy	24835	149499	6.02
NE Fife	75824	65046	0.86
Grampian			
Aberdeen	18447	208889	11.33
Banff & Buchan	152634	79707	0.52
Gordon	221444	60166	0.27
Kincardine & Deeside	254804	39998	0.16
Moray	223080	83184	0.37
Highland			
Badenoch & Strathspey	231721	9386	0.04
Caithness	177576	27033	0.15
Inverness	278875	56407	0.20
Lochaber	446830	19962	0.04
Nairn	42243	10391	0.25
Ross & Cromarty	497582	44720	0.09
Skye & Lochalsh	269103	10121	0.04
Sutherland	586518	13168	0.02
Lothian			
Edinburgh	26064	452806	17.37
East Lothian	71332	78592	1.10
Mid Lothian	35808	84802	2.37
West Lothian	42314	132403	3.13
Strathclyde			
Argll & Bute	649730	64286	0.10
Bearsden & Milngavie	3647	39182	10.74

Authority	Area (Hectare)	Population	Population density (per hectare)
Strathclyde			
Clydebank	3561	51866	14.57
Clydebank (Lanark)	132505	56726	0.43
Cumbernauld & Kilgyth	9481	64622	6.82
Cumnock & Doon Valley	80105	45823	0.57
Cunninghame	87859	135983	1.55
Dumbarton	47703	79571	1.67
East Kilbride	28490	82759	2.90
Eastwood	11563	51940	4.49
Glasgow	19757	781694	39.57
Hamilton	13103	107515	8.21
Inverclyde	15779	100858	6.39
Kilmarnoch & Loudoun	37342	81595	2.19
Kyle & Carrick	132156	112358	0.85
Monklands	16378	109358	6.68
Motherwell	17256	150757	8.74
Renfrew	30742	214567	6.98
Stathkelvin	16398	87359	5.33
Tayside			
Angus	202288	91790	0.45
Dundee	23504	188732	8.03
Perth & Kinross	523505	118669	0.23
Islands			
Orkney	97581	18030	0.18
Shetland	143268	22309	0.15
Western Isles	289798	29681	0.10

Scotland is divided into 56 local authorities, including the islands. 64 percent of the local authorities have population density below 2.5 per hectare. Of these 64 percent, 16 percent has population ranging between 75,000 to 85,000 and 28 percent has areas of responsibility lying between 125,000 to 175,000 hectares.

Histogram of Population density

Middle of Interval	Number of Observations		
0	36	************************************	64% under 2.50/hec.
5.00	12	************	21% > 2.50, < 7.50/hec.
10.00	5	*****	9% > 7.50, < 12.50/hec.
15.00	2	**	4% > 12.50, < 17.50/hec.
20.00	0		
25,00	0		
30.00	0		
35.00	0		
40.00	1	*	2% > 37.50, < 42.50/hec.

Histogram of population for the 36 local authorities with population density less than 2.50/hectare

Middle of Interval	Number of Observations	
10000	5	*****
20000	5	*****
30000	4	****
40000	4	****
50000	2	**
60000	5	*****
70000	1	*
80000	6	******
90000	1	*
100000	0	
110000	1	*
120000	1	*
130000	0	
140000	1	*

Histogram of the area of the 36 local authorities with population density less than 2.50/hectare

Middle of Interval	Number of Observations	
50000	5	*****
100000	6	******
150000	10	**********
200000	5	*****
250000	3	***
300000	2	**
350000	0	
400000	0	
450000	1	*
500000	2	**
550000	0	
600000	1	*
650000	1	*

Appendix VII

Waste collection statistics in England and Wales,1979/80

The Chartered Institute of Public Finance and Accountancy (CIPFA) has published waste collection statistics since 1979 and the 1979 to 1980 statistics was the third in this series. Details covered 31 London boroughs, 35 metropolitan districts, 230 non-metropolitan districts in England and 32 non-metropolitan districts in Wales. In all, some 328 authorities in England and Wales were represented in the survey.

No similiar statistics has been compiled and published for Scotland. However, the total tonnages of waste collection for some Scottish local authorities were published in the Municipal Year Book.

The only way to get some idea of the national average cost of waste collection was to compile the information from the 1979 to 1980 Waste Collection Statistics published by CIPFA in June 1981. Out of the 328 local authorities in England and Wales covered by the survey, only 285 provided all the information requested for by CIPFA. The analysis resulted in the following tables.

Population density	Absolute frequency	Relative frequency (Percent)
Less than 12 per hectare	187	65.6
12.01 to 24.00 per hectare	36	12.6
24.01 to 36.00 per hectare	31	10 9
36.01 to 48.00 per hectare	18	6.3
48.01 to 60.00 per hectare	4	1.4
60.01 to 72.00 per hectare	2	0.7
72.01 to 84.00 per hectare	3	1.1
84.01 to 96.00 per hectare	-	-
96.01 to 108.00 per hectare	3	1.1
108.01 to 120.00 per hectare	-	-
Greater than 120 per hectare	1	0.4
Total	285	100.0

Waste generation and collection cost

Population density	Domestic waste generated per capita (tonnes per annum)		Commercial waste generated per capita (tonnes per annum		Net cost for collecting domestic waste (£/tonne)		Net charge for collecting commercial waste (£/tonne)	
	mean	std error	mean	std error	mean	std error	mean	std error
less than 12/ha	0.29	0.007	0.04	0.002	19.33	0.44	7.30	0.75
12.01 to 24.00/ha	0.31	0.070	0.05	0.008	21.49	0.84	13.26	2.01
24.01 to 24.00/ha	0.25	0.010	0.05	0.004	19.98	0.90	12.39	1.93
36.01 to 48.00/ha	0.26	0.012	0.04	0.007	25.18	1.36	13.22	1.69
48.01 to 60.00/ha	0.23	0.020	0.05	0.015	25.05	4.27	14.21	3.10
60.01 to 72.00/ha	0.28	0.021	0.01	0.0	30.90	1.03	61.79	18.63
72.01 to 84.00/ha	0.30	0.035	0.04	0.017	33.13	5.53	17.50	6.11
84.01 to 96.00/ha	-	-	-	-	-	-	-	-
96.01 to 108.00/ha	0.31	0.035	0.18	0.144	28.43	1.99	69.01	65.86
108.01 to 120.00/ha	-	-	-	-	-	-	-	-
greater than 120/ha	0.28	0.0	0.03	0.0	33.28	0	82.89	0

Domestic waste generated per capita (in tonnes per annum) $= 0.282 \pm 0.010$
Commercial waste generated per capita (tonnes per annum) $= 0.046 \pm 0.002$
Net cost for collecting domestic waste £/tonne $= 20.50 \pm 0.37$
Net cost for collecting commercial waste £/tonne $= 10.48 \pm 0.99$

Waste generation and collection cost for the local authorities with population density less than 12/ha

Population density	Domestic waste generated per capita (tonnes per annum)		Commercial waste generated per capita (tonnes per annum)		Net cost for collecting domestic waste (£/tonne)		Net charge for collecting commercial waste (£/tonne)	
	mean	std error	mean	std error	mean	std error	mean	std error
less than 12/ha	0.30	0.011	0.04	0.003	18.46	0.61	5.57	0.52
2.01 to 4.00/ha	0.27	0.013	0.05	0.005	19.73	0.96	7.15	1.59
4.01 to 6.00/ha	0.28	0.015	0.04	0.004	21.40	1.16	11.97	3.79
6.01 to 8.00/ha	0.30	0.025	0.05	0.008	17.91	1.66	5.97	1.41
8.01 to 10.00/ha	0.25	0.015	0.05	0.009	20.90	1.65	7.17	2.35
10.01 to 12.00/ha	0.28	0.021	0.04	0.009	20.00	2.21	11.48	3.96

Population density for the local authorities with population density less than 12 per hectare

Population density	Sample size	Relative frequency (percent)
less than 12/ha	83	44.4
2.01 to 4.00/ha	39	20.9
4.01 to 6.00/ha	27	14.4
6.01 to 8.00/ha	16	8.6
8.01 to 10.00/ha	11	5.9
10.01 to 12.00/ha	11	5.9
Total	187	100.0

Appendix VIII

Costs and utilisation of refuse collection vehicles in 1980 (April to December)
Source : Dunkelmann (1981)

Operating statistics	London BC	Other BC	District Councils
No of vehicles in sample	217	170	118
No of vehicles used 60 days or less pa	3	3	1
No of councils in sample	5	7	8
Operating costs			
Standing costs (£ p a)			
Vehicle licence	851	838	805
Vehicle insurance	176	91	100
Depreciation	3536	4132	4011
Total standing cost	4563	5061	4916
Running costs (£ p a)			
Fuel	1185	1268	1613
Replacement tyres	191	391	321
Repairs and maintenance	4188	3128	2360
Total running cost	5564	4787	4294
Total cost	10127	9848	9210
Utilisation			
Days used p a	?	205	194
Mileages p a	4399	5900	7412
Cost/Utilisation			
Repair and maintenance cost per day used	?	£15	£12
Repair and maintenance cost per mile	£0.95	£0.53	£0.32
Total cost per day used	?	£48	£47
Total cost per mile	£2.30	£1.70	£1.20

Appendix IX

Program listing of the viability model

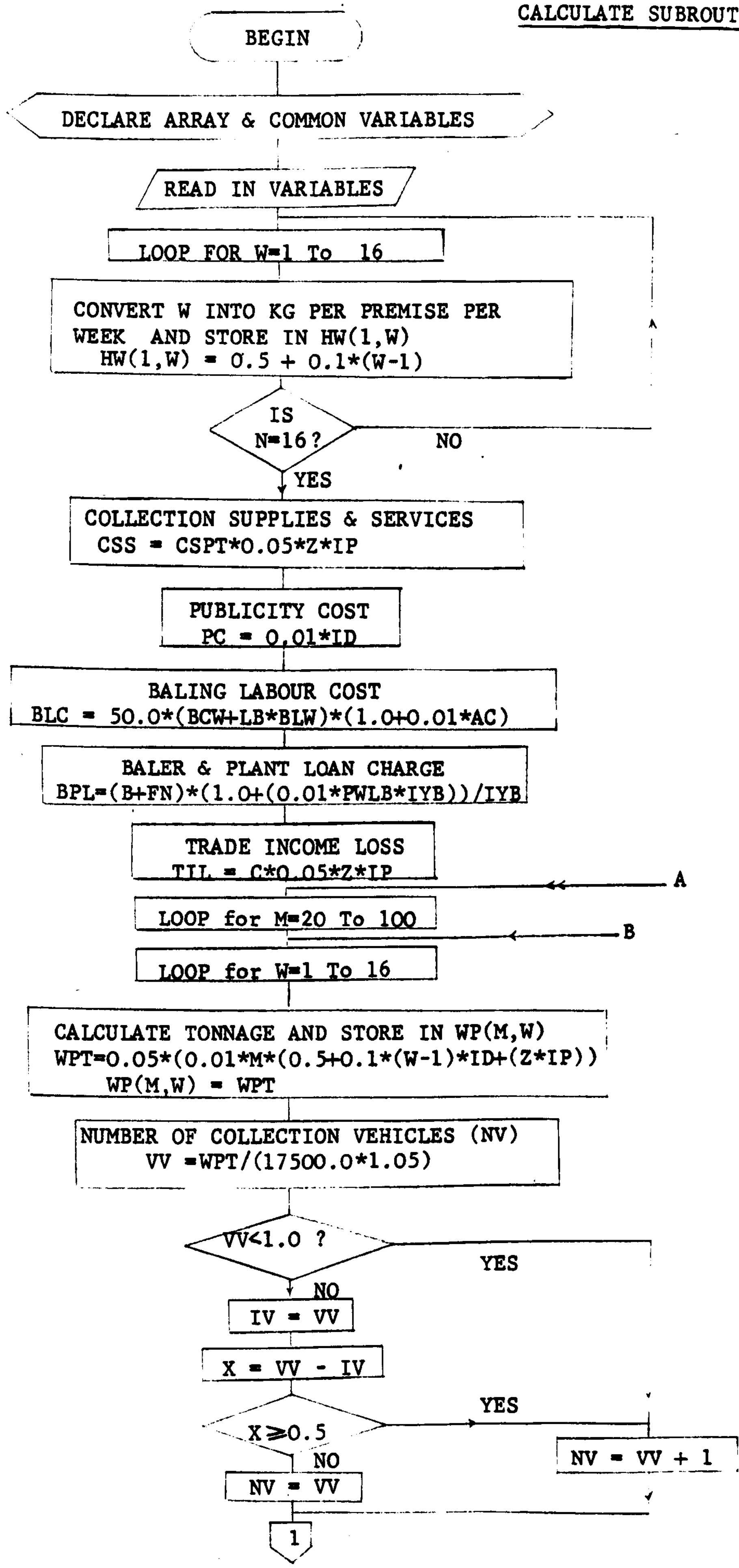
```
C       LOCAL AUTHORITY WASTE PAPER RECOVERY VIABILITY MODEL
C       USED FOR ASSESSING THE VIABILITY OF AN ON GOING OPERATION
        DIMENSION PPT(100,20),BEP(100,20),HW(1,20),WP(100,20)
        COMMON PPT,BEP,HW,WP,S1,S2
        INTEGER W,AC
        READ(5,130)I
130     FORMAT(I1)
C       I IS INPUT TO DECIDE PRINT OUT OPTIONS
C       ENTER 0 FOR PROFITS PRINT OUT ONLY
C       ENTER 1 FOR TONNAGES AND BREAK EVEN PRINT OUTS
C       ENTER 2 FOR ALL PRINT OUTS
        IF (I-1)4,5,6
4       CALL CALCULATE
        CALL PROFITS
        GO TO 999
5       CALL CALCULATE
        CALL TONNAGE
        CALL BREAK EVEN
        GO TO 999
6       CALL CALCULATE
        CALL TONNAGE
        CALL BREAK EVEN
        CALL PROFITS
999     STOP
        END
        SUBROUTINE CALCULATE
        DIMENSION PPT(100,20),BEP(100,20),HW(1,20),WP(100,20)
        COMMON PPT,BEP,HW,WP,S1,S2
        INTEGER W,AC
        READ(5,100)ID,IP,DW,CW,Y,C,R,CSPT,BSPT,Z
100     FORMAT(2I7,5F6.2,3F5.2)
C       ID IS NO OF DOMESTIC PREMISES
C       IP IS SIZE OF POPULATION
C       DW IS BASIC WAGE PER WEEK PER DRIVER
C       CW IS BASIC WAGE PER WEEK PER COLLECTOR
C       Y IS REFUSE DISPOSAL COST IN POUNDS PER TONNE
C       C IS COLLECTION CHARGE FOR COMMERCIAL WASTE(POUNDS/TONNE)
C       R IS COLLECTION COST OF DOMESTIC WASTE IN POUNDS PER TONNE
C       CSPT IS COLLECTION SUPPLIES & SERVICES COST PER TONNE COLLECTED
C       BSPT IS BALING SUPPLIES & SERVICES COST PER TONNE BALED
C       Z IS TONNE OF TRADE WASTE PER 1000 POPULATION PER WEEK
        READ(5,110)T,V,B,FN,AC,IYV,IYB,NC,LB,BCW,BLW
110     FORMAT(4F9.2,5I3,2F6.2)
C       T IS TRANSPORT COST TO COVER 100 PREMISES
C       V IS CAPITAL INVESTMENT PER VEHICLE
C       B IS CAPITAL INVESTMENT FOR BALING SYSTEM
C       FN IS CAPITAL INVESTMENT FOR BALING PLANT
C       AC IS ADD-ON COST FOR LABOUR IN PERCENT
C       IYV IS ECONOMIC LIFE OF A VEHICLE
C       IYB IS ECONOMIC LIFE OF BALING PLANT
C       NC IS NO OF COLLECTORS DEPLOYED IN 1 COLLECTION VEHICLE
C       LB IS NO OF LOADERS PER BALER
C       BCW IS BASIC WAGE PER WEEK PER BALER CHARGEHAND
C       BLW IS BASIC WAGE PER WEEK PER BALER LOADER
```

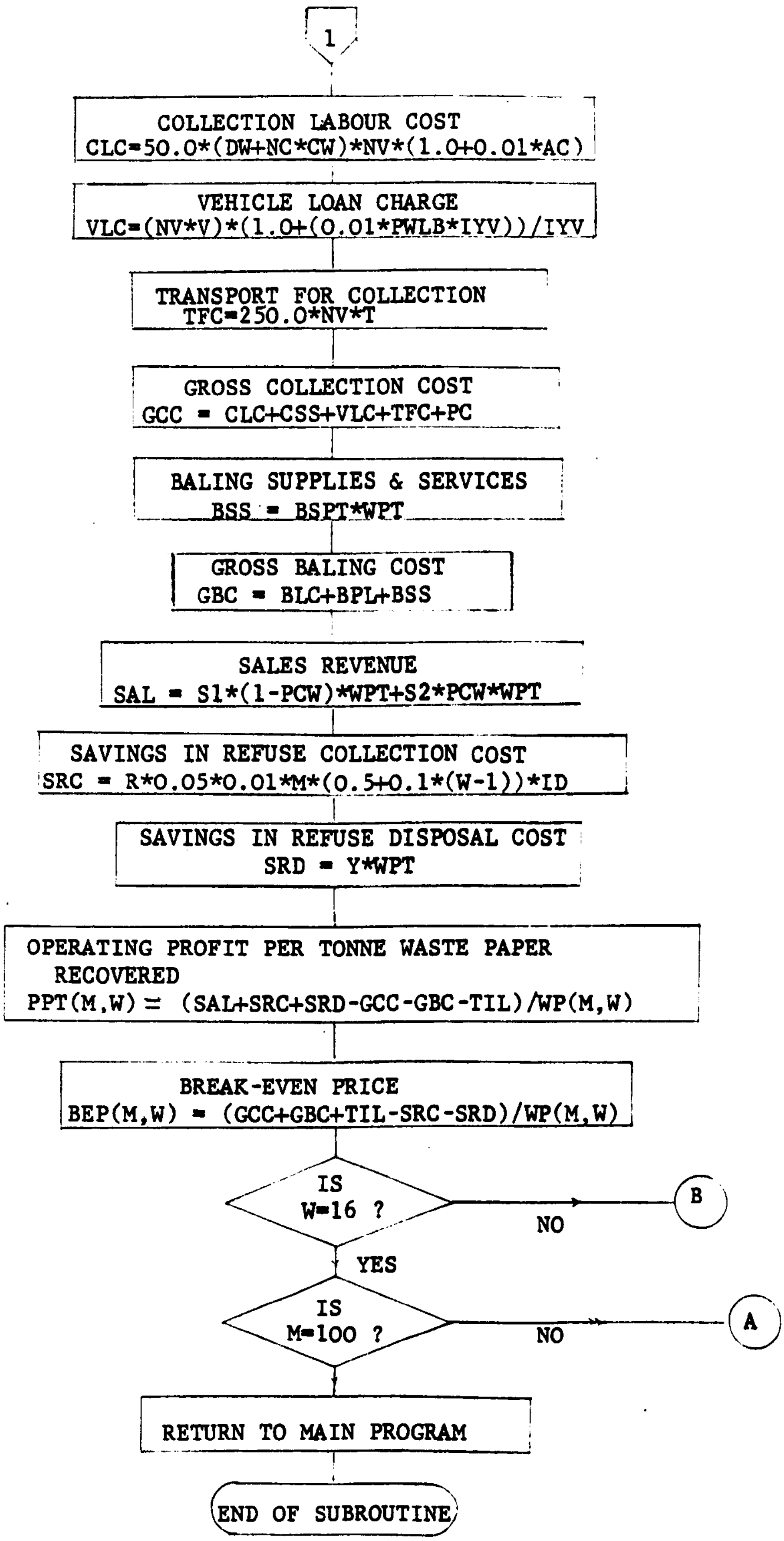
```
      READ(5,120)S1,S2,PCW,PWLB
120   FORMAT(2F6.2,F6.3,F6.2)
C     S1 IS PRICE OF MIXED WASTE PAPER IN POUNDS PER TONNE
C     S2 IS PRICE OF CONTANIER WASTE IN POUNDS PER TONNE
C     PCW IS PERCENTAGE OF CONTAINER WASTE IN TOTAL TONNAGE
C     OF WASTE PAPER SALVAGED, EXPRESSED IN DECIMALS
C     PWLB IS PUBLIC WORKS LOAN BOARD RATE IN PERCENT PER ANNUM
C     STORE HOUSEHOLD CONTRIBUTIONS PER WEEK FOR PRINT HEADING
      DO 8 W=1,16
      HW(1,W)=0.5+0.1*(W-1)
8     CONTINUE
C     COLLECTION SUPPLIES AND SERVICES(CSS)
      CSS=CSPT*0.05*Z*IP
C     PUBLICITY COST(PC)
      PC=0.01*ID
C     BALING LABOUR COST(BLC)
      BLC=50.0*(BCW+LB*BLW)*(1.0+0.01*AC)
C     BALING SYSTEM AND PLANT LOAN CHARGE(BPL)
      BPL=(B+FN)*(1.0+(0.01*PWLB*IYB))/IYB
C     TRADE COLLECTION INCOME LOSS(TIL)
      TIL=C*0.05*Z*IP
C     M IS PERCENTAGE OF PARTICIPATION OF HOUSEHOLDS
C     W IS A CODE TO REPRESENT CONTRIBUTION PER HOUSEHOLD PER WEEK
C     W IS CONVERTED TO KG PER HOUSEHOLD PER WEEK IN CALCULATION
      DO 10 M=20,100
      DO 20 W=1,16
C     WASTE PAPER TONNAGE RECOVERED(WPT)
      WPT=0.05*(0.01*M*(0.5+0.1*(W-1))*ID+(Z*IP))
      WP(M,W)=WPT
C     NUMBER OF VEHICLES(NV)
      VV=WPT/(17500.0*1.05)
      IF (VV.LT.1.0) GO TO 200
      IV=VV
      X=(VV-IV)
      IF (X.GE.0.5) GO TO 200
      NV=VV
      GO TO 250
200   NV=VV+1
C     COLLECTION LABOUR COST(CLC)
250   CLC=50.0*(DW+NC*CW)*NV*(1.0+0.01*AC)
C     VEHICLE LOAN CHARGE(VLC)
      VLC=(NV*V)*(1.0+(0.01*PWLB*IYV))/IYV
C     TRANSPORT COST FOR COLLECTION(TFC)
      TFC=250.0*NV*T
C     GROSS COLLECTION COST(GCC)
      GCC=CLC+CSS+VLC+TFC+PC
C     BALING SUPPLIES AND SERVICES(BSS)
      BSS=BSPT*WPT
C     GROSS BALING COST(GBC)
      GBC=BLC+BPL+BSS
C     SALES REVENUE(SAL)
      SAL=S1*(1-PCW)*WPT+S2*PCW*WPT
C     SAVINGS IN REFUSE COLLECTION COST(SRC)
      SRC=R*0.05*0.01*M*(0.5+0.1*(W-1))*ID
C     SAVINGS IN REFUSE DISPOSAL COST(SRD)
      SRD=Y*WPT
```

```
C       OPERATING PROFIT PER TONNE OF WASTE PAPER COLLECTED(PPT)
        PPT(M,W)=(SAL+SRC+SRD-GCC-GBC-TIL)/WP(M,W)
C       BREAK EVEN PRICE(BEP)
        BEP(M,W)=(GCC+GBC+TIL-SRC-SRD)/WP(M,W)
20      CONTINUE
10      CONTINUE
        RETURN
        END
        SUBROUTINE PROFITS
        DIMENSION PPT(100,20),BEP(100,20),HW(1,20),WP(100,20)
        COMMON PPT,BEP,HW,WP,S1,S2
        INTEGER W,AC
C       PRINT OUT OF OPERATING PROFITS OR LOSS
        WRITE(6,500)
500     FORMAT('1','LOCAL AUTHORITY WASTE PAPER RECOVERY VIABILITY MODEL')
        WRITE(6,510)
510     FORMAT('0','PROFIT OR LOSS PER TONNE WASTE PAPER RECOVERED')
        WRITE(6,520)S1
520     FORMAT('0','MIXED WASTE PRICE PER TONNE    = ',F5.2)
        WRITE(6,530)S2
530     FORMAT(' ','CONTAINER WASTE PRICE PER TONNE= ',F5.2)
        WRITE(6,540)
540     FORMAT('   ')
        WRITE(6,550)
550     FORMAT(' ','WASTE PAPER PER DOMESTIC PREMISE PER WEEK(KG)')
        WRITE(6,560)(HW(1,W),W=1,16)
560     FORMAT(' ',6X,16F7.1)
        WRITE(6,570)
570     FORMAT(' ','PERCENTAGE')
        WRITE(6,580)
580     FORMAT(' ','OF')
        WRITE(6,585)
585     FORMAT(' ','PARTICIPATION')
        DO 60 M=20,100
        WRITE(6,700)M
700     FORMAT('0',I3)
        WRITE(6,710)(PPT(M,W),W=1,16)
710     FORMAT('+',6X,16F7.1)
60      CONTINUE
        RETURN
        END
        SUBROUTINE BREAK EVEN
        DIMENSION PPT(100,20),BEP(100,20),HW(1,20),WP(100,20)
        COMMON PPT,BEP,HW,WP,S1,S2
        INTEGER W,AC
C       PRINT OUT OF BREAK-EVEN PRICES
        WRITE(6,800)
800     FORMAT('1','BREAK-EVEN PRICES FOR DIFFERENT TONNAGES RECOVERED')
        WRITE(6,810)
810     FORMAT('   ')
        WRITE(6,850)
850     FORMAT(' ','WASTE PAPER PER DOMESTIC PREMISE PER WEEK(KG)')
        WRITE(6,860)(HW(1,W),W=1,16)
860     FORMAT(' ',6X,16F7.1)
        WRITE(6,870)
870     FORMAT(' ','PERCENTAGE')
```

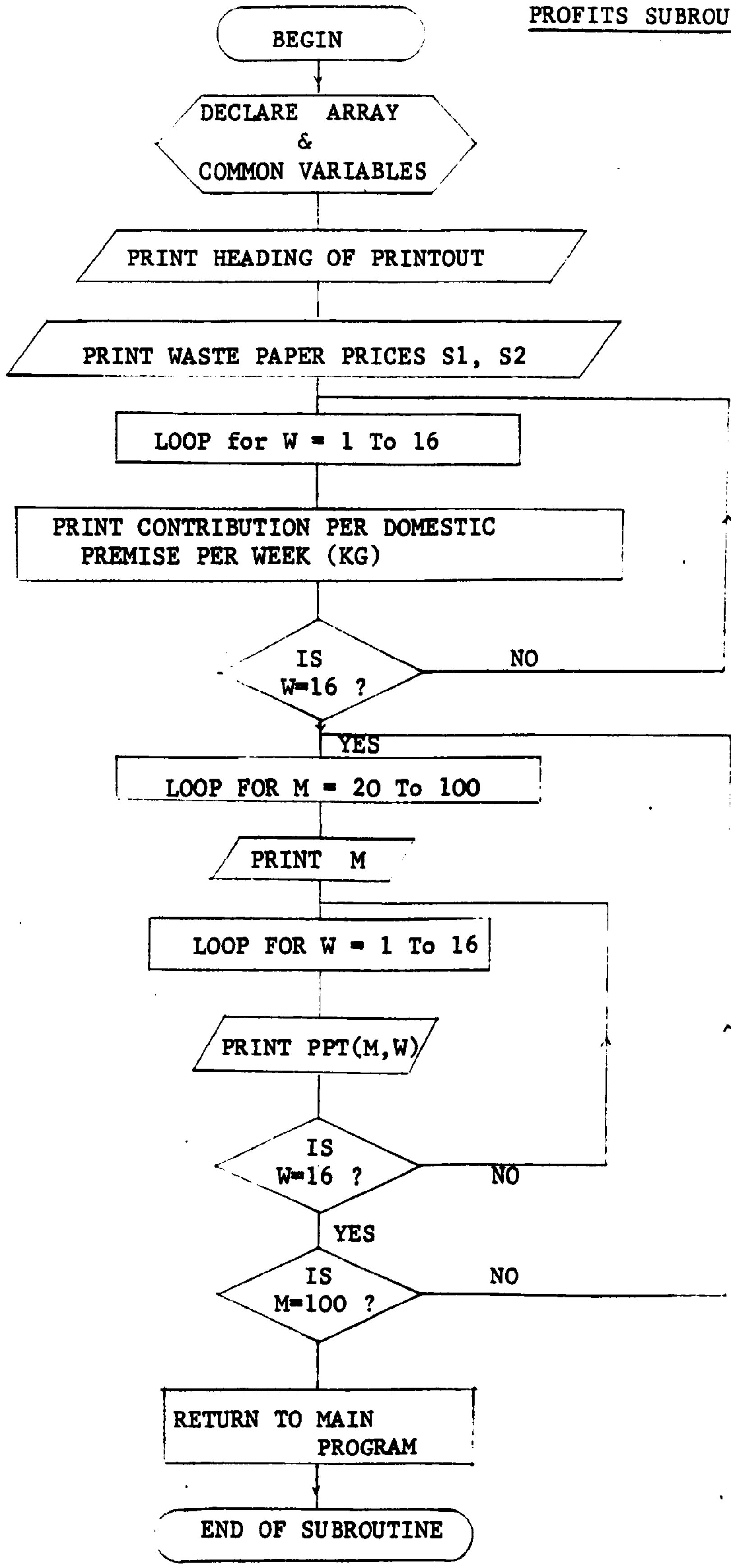
```
      WRITE(6,875)
875   FORMAT(' ','OF')
      WRITE(6,880)
880   FORMAT(' ','PARTICIPATION')
      DO 80 M=20,100
      WRITE(6,900)M
900   FORMAT('0',I3)
      WRITE(6,910)(BEP(M,W),W=1,16)
910   FORMAT('+',6X,16F7.1)
80    CONTINUE
      RETURN
      END
      SUBROUTINE TONNAGE
      DIMENSION PPT(100,20),BEP(100,20),HW(1,20),WP(100,20)
      COMMON PPT,BEP,HW,WP,S1,S2
      INTEGER W,AC
C     PRINT OUT OF TONNAGES CULLECTED
      WRITE(6,920)
920   FORMAT('1','TONNES OF WASTE PAPER RECUVERED PER ANNUM')
      WRITE(6,925)
925   FORMAT('   ')
      WRITE(6,930)
930   FORMAT(' ','WASTE PAPER PER DOMESTIC PREMISE PER WEEK(KG)')
      WRITE(6,940)(HW(1,W),W=1,16)
940   FORMAT(' ',6X,16F7.1)
      WRITE(6,950)
950   FORMAT(' ','PERCENTAGE')
      WRITE(6,955)
955   FORMAT(' ','OF')
      WRITE(6,960)
960   FORMAT(' ','PARTICIPATION')
      DO 90 M=20,100
      WRITE(6,970)M
970   FORMAT('0 ',I3)
      WRITE(6,980)(WP(M,W),W=1,16)
980   FORMAT('+',6X,16F7.1)
90    CONTINUE
      RETURN
      END
```

CALCULATE SUBROUTINE

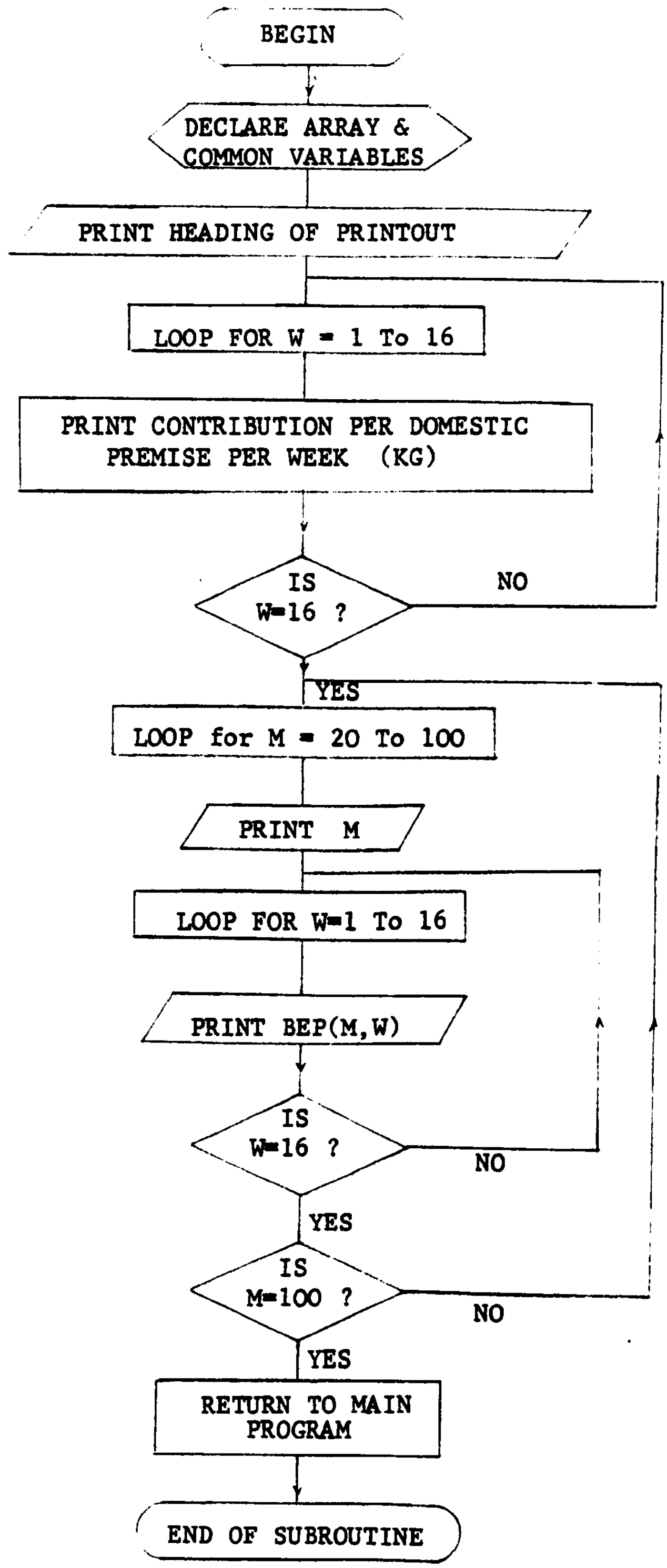



1
COLLECTION LABOUR COST
CLC=50.0*(DW+NC*CW)*NV*(1.0+0.01*AC)
VEHICLE LOAN CHARGE
VLC=(NV*V)*(1.0+(0.01*PWLB*IYV))/IYV
TRANSPORT FOR COLLECTION
TFC=250.0*NV*T
GROSS COLLECTION COST
GCC = CLC+CSS+VLC+TFC+PC
BALING SUPPLIES & SERVICES
BSS = BSPT*WPT
GROSS BALING COST
GBC = BLC+BPL+BSS
SALES REVENUE
SAL = S1*(1-PCW)*WPT+S2*PCW*WPT
SAVINGS IN REFUSE COLLECTION COST
SRC = R*0.05*0.01*M*(0.5+0.1*(W-1))*ID
SAVINGS IN REFUSE DISPOSAL COST
SRD = Y*WPT
OPERATING PROFIT PER TONNE WASTE PAPER RECOVERED
PPT(M,W) = (SAL+SRC+SRD-GCC-GBC-TIL)/WP(M,W)
BREAK-EVEN PRICE
BEP(M,W) = (GCC+GBC+TIL-SRC-SRD)/WP(M,W)
IS W=16 ?
NO
B
YES
IS M=100 ?
NO
A
RETURN TO MAIN PROGRAM
END OF SUBROUTINE

PROFITS SUBROUTINE



BREAK EVEN SUBROUTINE



TONNAGE SUBROUTINE

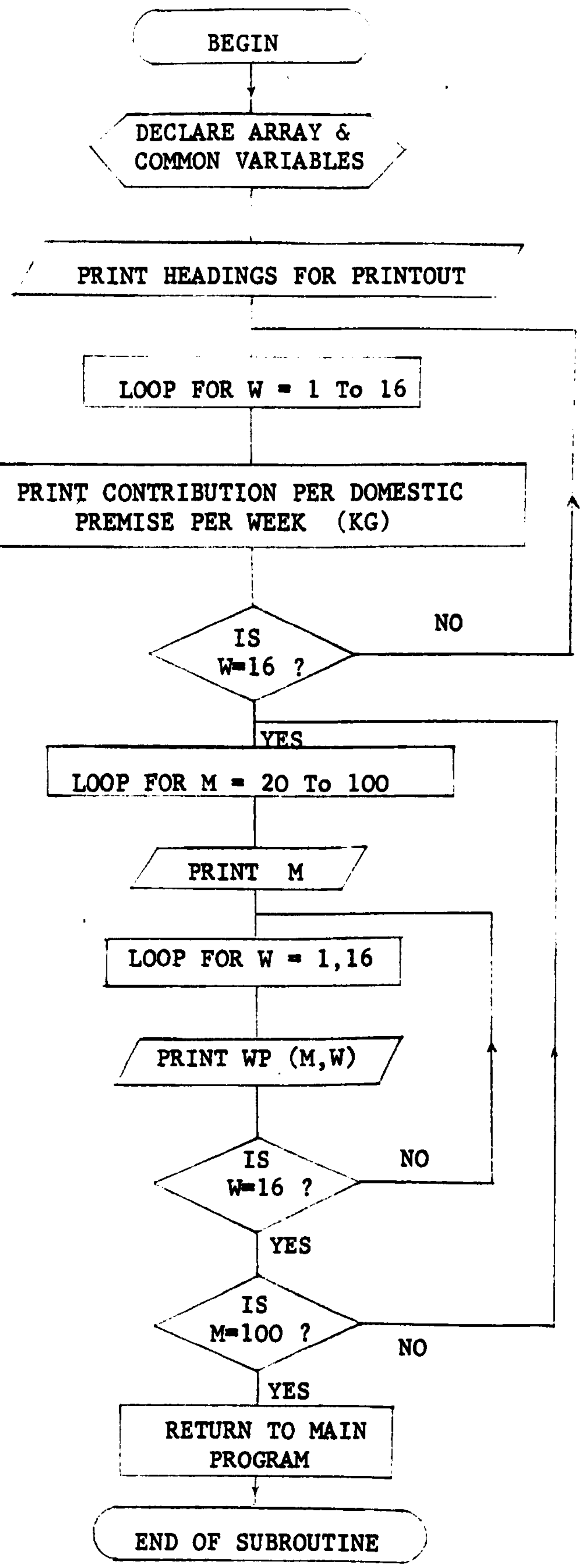


Table AIX.4 - Data input for the viability model

VARIABLE	I
FORMAT	I1
VALUE	2

VARIABLE	ID	IP	DW	CW	Y	C	R	CSPT	BSPT	2
FORMAT	I7	I7	F6.2	F6.2	F6.2	F6.2	F6.2	F5.2	F5.2	F5.2
VALUE	ɓɓ28070	ɓɓ80000	ɓ66.11	ɓ62.89	ɓɓ1.86	ɓ10.48	ɓ19.00	ɓ0.19	ɓ3.64	ɓ0.18

VARIABLE	T	V	B	FN	AC	IYV	IYB	NC	LB	BCW	BLW
FORMAT	F9.2	F9.2	F9.2	F9.2	I3	I3	I3	I3	I3	F6.2	F6.2
VALUE	ɓɓɓɓ47.00	ɓ31000.00	ɓ30000.00	ɓ30000.00	ɓ60	ɓ10	ɓ10	ɓɓ2	ɓɓ1	ɓ66.11	ɓ62.89

VARIABLE	S1	S2	PCW	PWLB
FORMAT	F6.2	F6.2	F6.3	F6.2
VALUE	ɓ22.00	ɓ22.00	ɓ0.125	ɓ13.82

Waste paper prices used in subsequent runs (£/tonne)

	Mixed waste	Container waste	
Run 1	22	22	minimum guaranteed price
2	29	35	highest prices paid in 1980
3	22	29	lowest prices paid in 1980/81
4	32	39	highest prices paid + 10% increase
5	35	42	highest prices paid + 20% increase

ɓ stands for blank space

Table AIX.1

LOCAL AUTHORITY WASTE PAPER RECOVERY VIABILITY MODEL

PROFIT OR LOSS PER TONNE WASTE PAPER RECOVERED

MIXED WASTE PRICE PER TONNE = 22.00
CONTAINER WASTE PRICE PER TONNE= 22.00

WASTE PAPER PER DOMESTIC PREMISE PER WEEK(KG)

PERCENTAGE OF PARTICIPATION	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
20	-54.6	-51.7	-48.9	-46.3	-43.8	-41.5	-39.3	-37.2	-35.2	-33.3	-31.5	-29.8	-28.2	-26.7	-25.2	-23.8
21	-53.9	-50.8	-47.9	-45.3	-42.7	-40.3	-38.1	-36.0	-34.0	-32.1	-30.3	-28.5	-26.9	-25.3	-23.9	-22.4
22	-53.1	-50.0	-47.0	-44.3	-41.7	-39.3	-37.0	-34.8	-32.8	-30.9	-29.0	-27.3	-25.6	-24.1	-22.6	-21.1
23	-52.4	-49.1	-46.1	-43.3	-40.7	-38.2	-35.9	-33.7	-31.6	-29.7	-27.8	-26.1	-24.4	-22.8	-21.3	-19.9
24	-51.7	-48.3	-45.3	-42.4	-39.7	-37.2	-34.8	-32.6	-30.5	-28.5	-26.7	-24.9	-23.2	-21.7	-20.1	-18.7
25	-50.9	-47.5	-44.4	-41.5	-38.7	-36.2	-33.8	-31.5	-29.4	-27.4	-25.6	-23.8	-22.1	-20.5	-19.0	-17.6
26	-50.2	-46.8	-43.6	-40.6	-37.8	-35.2	-32.8	-30.5	-28.4	-26.4	-24.5	-22.7	-21.0	-19.4	-17.9	-16.5
27	-49.6	-46.0	-42.7	-39.7	-36.9	-34.3	-31.8	-29.5	-27.4	-25.3	-23.4	-21.7	-20.0	-18.4	-16.8	-15.4
28	-48.9	-45.3	-41.9	-38.8	-36.0	-33.3	-30.9	-28.5	-26.4	-24.3	-22.4	-20.6	-18.9	-17.3	-15.8	-14.4
29	-48.2	-44.5	-41.1	-38.0	-35.1	-32.4	-29.9	-27.6	-25.4	-23.4	-21.5	-19.7	-18.0	-16.4	-14.8	-13.4
30	-47.5	-43.8	-40.3	-37.2	-34.3	-31.5	-29.0	-26.7	-24.5	-22.4	-20.5	-18.7	-17.0	-15.4	-13.9	-12.5
31	-46.9	-43.1	-39.6	-36.4	-33.4	-30.7	-28.1	-25.8	-23.6	-21.5	-19.6	-17.8	-16.1	-14.5	-13.0	-11.6
32	-46.3	-42.4	-38.8	-35.6	-32.6	-29.8	-27.3	-24.9	-22.7	-20.6	-18.7	-16.9	-15.2	-13.6	-12.1	-10.7
33	-45.6	-41.7	-38.1	-34.8	-31.8	-29.0	-26.5	-24.1	-21.8	-19.8	-17.9	-16.0	-14.3	-12.7	-11.2	-9.8
34	-45.0	-41.0	-37.4	-34.1	-31.0	-28.2	-25.6	-23.2	-21.0	-18.9	-17.0	-15.2	-13.5	-11.9	-10.4	-9.0
35	-44.4	-40.3	-36.7	-33.3	-30.3	-27.4	-24.8	-22.4	-20.2	-18.1	-16.2	-14.4	-12.7	-11.1	-9.6	-8.2
36	-43.8	-39.7	-36.0	-32.6	-29.5	-26.7	-24.1	-21.7	-19.4	-17.3	-15.4	-13.6	-11.9	-10.3	-8.8	-7.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-8.1	-6.7

Table AIX.2

BREAK-EVEN PRICES FOR DIFFERENT TONNAGES RECOVERED

PERCENTAGE OF PARTICIPATION	WASTE PAPER PER DOMESTIC PREMISE PER WEEK(KG) 0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
20	76.6	73.7	70.9	68.3	65.8	63.5	61.3	59.2	57.2	55.3	53.5	51.8	50.2	48.7	47.2	45.8
21	75.9	72.8	69.9	67.3	64.7	62.3	60.1	58.0	56.0	54.1	52.3	50.5	48.9	47.3	45.9	44.4
22	75.1	72.0	69.0	66.3	63.7	61.3	59.0	56.8	54.8	52.9	51.0	49.3	47.6	46.1	44.6	43.1
23	74.4	71.1	68.1	65.3	62.7	60.2	57.9	55.7	53.6	51.7	49.8	48.1	46.4	44.8	43.3	41.9
24	73.7	70.3	67.3	64.4	61.7	59.2	56.8	54.6	52.5	50.5	48.7	46.9	45.2	43.7	42.1	40.7
25	72.9	69.5	66.4	63.5	60.7	58.2	55.8	53.5	51.4	49.4	47.6	45.8	44.1	42.5	41.0	39.6
26	72.2	68.8	65.6	62.6	59.8	57.2	54.8	52.5	50.4	48.4	46.5	44.7	43.0	41.4	39.9	38.5
27	71.6	68.0	64.7	61.7	58.9	56.3	53.8	51.5	49.4	47.3	45.4	43.7	42.0	40.4	38.8	37.4
28	70.9	67.3	63.9	60.8	58.0	55.3	52.9	50.5	48.4	46.3	44.4	42.6	40.9	39.3	37.8	36.4
29	70.2	66.5	63.1	60.0	57.1	54.4	51.9	49.6	47.4	45.4	43.5	41.7	40.0	38.4	36.8	35.4
30	69.5	65.8	62.3	59.2	56.3	53.5	51.0	48.7	46.5	44.4	42.5	40.7	39.0	37.4	35.9	34.5
31	68.9	65.1	61.6	58.4	55.4	52.7	50.1	47.8	45.6	43.5	41.6	39.8	38.1	36.5	35.0	33.6
32	68.3	64.4	60.8	57.6	54.6	51.8	49.3	46.9	44.7	42.6	40.7	38.9	37.2	35.6	34.1	32.7
33	67.6	63.7	60.1	56.8	53.8	51.0	48.5	46.1	43.8	41.8	39.9	38.0	36.3	34.7	33.2	31.8
34	67.0	63.0	59.4	56.1	53.0	50.2	47.6	45.2	43.0	40.9	39.0	37.2	35.5	33.9	32.4	31.0
35	66.4	62.3	58.7	55.3	52.3	49.4	46.8	44.4	42.2	40.1	38.2	36.4	34.7	33.1	31.6	30.2
36	65.8	61.7	58.0	54.6	51.5	48.7	46.1	43.7	41.4	39.3	37.4	35.6	33.9	32.3	30.8	29.4
37	65.2	61.0	57.3	53.9	50.8	47.9	45.3	42.9	40.7	38.6	36.6	34.8	33.2	31.6	30.1	28.7
38	64.6	60.4	56.6	53.2	50.1	47.2	44.6	42.1	39.9	37.8	35.9	34.1	32.4	30.8	29.4	28.0
39	64.0	59.8	56.0	52.5	49.4	46.5	43.8	41.4	39.2	37.1	35.2	33.4	31.7	30.1	28.7	27.3

Table AIX.3

TONNES OF WASTE PAPER RECOVERED PER ANNUM

PERCENTAGE OF PARTICIPATION	WASTE PAPER PER DOMESTIC PREMISE PER WEEK(KG) 0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
20	860.4	888.4	916.5	944.6	972.6	1000.7	1028.8	1056.8	1084.9	1113.0	1141.1	1169.1	1197.2	1225.3	1253.3	1281.4
21	867.4	896.8	926.3	955.8	985.3	1014.7	1044.2	1073.7	1103.2	1132.6	1162.1	1191.6	1221.0	1250.5	1280.0	1309.5
22	874.4	905.3	936.1	967.0	997.9	1028.8	1059.6	1090.5	1121.4	1152.3	1183.2	1214.0	1244.9	1275.8	1306.7	1337.5
23	881.4	913.7	946.0	978.2	1010.5	1042.8	1075.1	1107.4	1139.6	1171.9	1204.2	1236.5	1268.8	1301.0	1333.3	1365.6
24	888.4	922.1	955.8	989.5	1023.2	1056.8	1090.5	1124.2	1157.9	1191.6	1225.3	1258.9	1292.6	1326.3	1360.0	1393.7
25	895.4	930.5	965.6	1000.7	1035.8	1070.9	1106.0	1141.1	1176.1	1211.2	1246.3	1281.4	1316.5	1351.6	1386.7	1421.8
26	902.5	938.9	975.4	1011.9	1048.4	1084.9	1121.4	1157.9	1194.4	1230.9	1267.4	1303.9	1340.3	1376.8	1413.3	1449.8
27	909.5	947.4	985.3	1023.2	1061.1	1098.9	1136.8	1174.7	1212.6	1250.5	1288.4	1326.3	1364.2	1402.1	1440.0	1477.9
28	916.5	955.8	995.1	1034.4	1073.7	1113.0	1152.3	1191.6	1230.9	1270.2	1309.5	1348.8	1368.1	1427.4	1466.7	1506.0
29	923.5	964.2	1004.9	1045.6	1086.3	1127.0	1167.7	1208.4	1249.1	1289.8	1330.5	1371.2	1411.9	1452.6	1493.3	1534.0
30	930.5	972.6	1014.7	1056.8	1098.9	1141.1	1183.2	1225.3	1267.4	1309.5	1351.6	1393.7	1435.8	1477.9	1520.0	1562.1
31	937.5	981.1	1024.6	1068.1	1111.6	1155.1	1198.6	1242.1	1285.6	1329.1	1372.6	1416.1	1459.6	1503.2	1546.7	1590.2
32	944.6	989.5	1034.4	1079.3	1124.2	1169.1	1214.0	1258.9	1303.9	1348.8	1393.7	1438.6	1483.5	1528.4	1573.3	1618.2
33	951.6	997.9	1044.2	1090.5	1136.8	1183.2	1229.5	1275.8	1322.1	1368.4	1414.7	1461.0	1507.4	1553.7	1600.0	1646.3
34	958.6	1006.3	1054.0	1101.8	1149.5	1197.2	1244.9	1292.6	1340.3	1388.1	1435.8	1483.5	1531.2	1578.9	1626.7	1674.4
35	965.6	1014.7	1063.9	1113.0	1162.1	1211.2	1260.3	1309.5	1358.6	1407.7	1456.8	1506.0	1555.1	1604.2	1653.3	1702.5
36	972.6	1023.2	1073.7	1124.2	1174.7	1225.3	1275.8	1326.3	1376.8	1427.4	1477.9	1528.4	1578.9	1629.5	1680.0	1730.5
37	979.6	1031.6	1083.5	1135.4	1187.4	1239.3	1291.2	1343.2	1395.1	1447.0	1498.9	1550.9	1602.8	1654.7	1706.7	1756.6
38	986.7	1040.0	1093.3	1146.7	1200.0	1253.3	1306.7	1360.0	1413.3	1466.7	1520.0	1573.3	1626.7	1680.0	1733.3	1786.7
39	993.7	1048.4	1103.2	1157.9	1212.6	1267.4	1322.1	1376.8	1431.6	1486.3	1541.0	1595.8	1650.5	1705.3	1760.0	1814.7

Program listing of the investment appraisal model

```
C       INVESTMENT APPRAISAL FOR A PROPOSED WASTE PAPER RECOVERY OPERATION
C       LABOUR COST INCREASE AT A RATE RLI FASTER THAN GENERAL PRICES
        COMMON CF(20,20),TABLE(20,20)
        INTEGER AC
        COMMON ID,IP,DW,CW,Y,C,R,CSPT,BSPT,Z
        COMMON T,V,B,FN,AC,IYV,IYB,NC,LB,BCW,BLW
        COMMON S1,S2,PCW,PWLB
        COMMON MP,WGG,DFP,RLI,M,WG
        COMMON CSS,PC,BLC,TIL,WPT,VV,NV,CLC,TFC,BSS,SAL,SRC,SRD
        READ(5,100)ID,IP,DW,CW,Y,C,R,CSPT,BSPT,Z
100     FORMAT(2I7,5F6.2,3F5.2)
C       ID IS NO OF DOMESTIC PREMISES
C       IP IS SIZE OF POPULATION
C       DW IS BASIC WAGE PER WEEK PER DRIVER
C       CW IS BASIC WAGE PER WEEK PER COLLECTOR
C       Y IS REFUSE DISPOSAL COST IN POUNDS PER TONNE
C       C IS COLLECTION CHARGE FOR COMMERCIAL WASTE (POUNDS PER TONNE)
C       R IS COLLECTION COST OF DOMESTIC WASTE IN POUNDS PER TONNE
C       CSPT IS COLLECTION SUPPLIES & SERVICES COST PER TONNE
C       BSPT IS BALING SUPPLIES & SERVICES COST PER TONNE
C       Z IS TONNE OF TRADE WASTE PER 1000 POPULATION PER WEEK
        READ(5,110)T,V,B,FN,AC,IYV,IYB,NC,LB,BCW,BLW
110     FORMAT(4F9.2,5I3,2F6.2)
C       T IS TRANSPORT COST TO COVER 100 PREMISES
C       V IS CAPITAL INVESTMENT PER VEHICLE
C       B IS CAPITAL INVESTMENT FOR BALER
C       FN IS CAPITAL INVESTMENT FOR BALING PLANT
C       IYV IS ECONOMIC LIFE OF A VEHICLE
C       IYB IS ECONOMIC LIFE OF BALING PLANT
C       NC IS NO OF COLLECTORS DEPLOYED IN 1 COLLECTION VEHICLE
C       LB IS NO OF LOADERS PER BALER
C       BCW IS BASIC WAGE PER WEEK PER BALER CHARGEHAND
C       BLW IS BASIC WAGE PER WEEK PER BALER LOADER
        READ(5,120)S1,S2,PCW,PWLB
120     FORMAT(2F6.2,F6.3,F6.2)
C       S1 IS PRICE OF MIXED WASTE PAPER IN POUNDS PER TONNE
C       S2 IS PRICE OF CONTANIER WASTE IN POUNDS PER TONNE
C       PCW IS PERCENTAGE OF CONTAINER WASTE IN TOTAL TONNAGE
C       OF WASTE PAPER SALVAGED, EXPRESSED IN DECIMALS
C       PWLB IS PUBLIC WORKS LOAN BOARD RATE IN PERCENT PER ANNUM
        READ(5,125)MP,WGG,DFP,RLI
125     FORMAT(I3,3F5.1)
C       MP IS THE PERCENTAGE OF PARTICIPATION
C       WGG IS THE CONTRIBUTION PER PREMISE PER WEEK(KG)
C       DATA OF WGG IS ALREADY CONVERTED TO KG
C       DFP IS THE DISCOUNT FACTOR IN REAL TERMS, IN PERCENTAGE
C       RLI IS LABOUR COST INCREASE ABOVE GENERAL PRICES IN REAL TERMS
        M=MP
        WG=WGG
        CALL CALCULATE
        CALL CASH FLOW
        DO 8 I=1,3
        M=(MP-5)+5*(I-1)
        DO 9 L=1,3
        WG=(WGG-0.2)+0.2*(L-1)
        CALL CALCULATE
        CALL SENSITIVITY ANALYSIS
9       CONTINUE
8       CONTINUE
        STOP
        END
```

```
      SUBROUTINE CALCULATE
      COMMON CF(20,20),TABLE(20,20)
      INTEGER AC
      COMMON ID,IP,DW,CW,Y,C,R,CSPT,BSPT,Z
      COMMON T,V,B,FN,AC,IYV,IYB,NC,LB,BCW,BLW
      COMMON S1,S2,PCW,PWLB
      COMMON MP,WGG,DFP,RLI,M,WG
      COMMON CSS,PC,BLC,TIL,WPT,VV,NV,CLC,TFC,BSS.SAL.SRC.SRD
C     COLLECTION SUPPLIES AND SERVICES(CSS)
      CSS=CSPT*0.05*Z*IP
C     PUBLICITY COST(PC)
      PC=0.01*ID
C     BALING LABOUR COST(BLC)
      BLC=50.0*(BCW+LB*BLW)*(1.0+0.01*AC)
C     TRADE COLLECTION INCOME LOSS(TIL)
      TIL=C*0.05*Z*IP
C     WASTE PAPER TONNAGE RECOVERED(WPT)
      WPT=0.05*(0.01*M*WG*ID+(Z*IP))
C     NUMBER OF VEHICLES(NV)
      VV=WPT/(17500.0*1.05)
      IF(VV.LT.1.0)GO TO 200
      IV=VV
      X=(VV-IV)
      IF (X.GE.0.5) GO TO 200
      NV=VV
      GO TO 250
200   NV=VV+1
C     COLLECTION LABOUR COST(CLC)
250   CLC=50.0*(DW+NC*CW)*NV*(1.0+0.01*AC)
C     TRANSPORT COST FOR COLLECTION(TFC)
      TFC=250.0*NV*T
C     BALING SUPPLIES AND SERVICES(BSS)
      BSS=BSPT*WPT
C     SALES REVENUE(SAL)
      SAL=S1*(1-PCW)*WPT+S2*PCW*WPT
C     SAVINGS IN REFUSE COLLECTION COST(SRC)
      SRC=R*0.05*0.01*M*WG*ID
C     SAVINGS IN REFUSE DISPOSAL COST(SRD)
      SRD=Y*WPT
      RETURN
      END
      SUBROUTINE CASH FLOW
      COMMON CF(20,20),TABLE(20,20)
      INTEGER AC
      COMMON ID,IP,DW,CW,Y,C,R,CSPT,BSPT,Z
      COMMON T,V,B,FN,AC,IYV,IYB,NC,LB,BCW,BLW
      COMMON S1,S2,PCW,PWLB
      COMMON MF,WGG,DFP,RLI,M,WG
      COMMON CSS,PC,BLC,TIL,WPT,VV,NV,CLC,TFC,BSS,SAL.SRC.SRD
C     CALCULATE CASH FLOW AND INSERT INTO TABLE
      CF(1,1)=NV*V*(-1)
      CF(5,1)=(-1)*(B+FN)
      DO 20 J=2,11
      CF(2,J)=(-1)*CLC*((1.0+0.01*RLI)**(J-2))
      CF(3,J)=CSS*(-1)
      CF(4,J)=PC*(-1)
      CF(6,J)=(-1)*BLC*((1.0+0.01*RLI)**(J-2))
      CF(7,J)=BSS*(-1)
20    CONTINUE
```

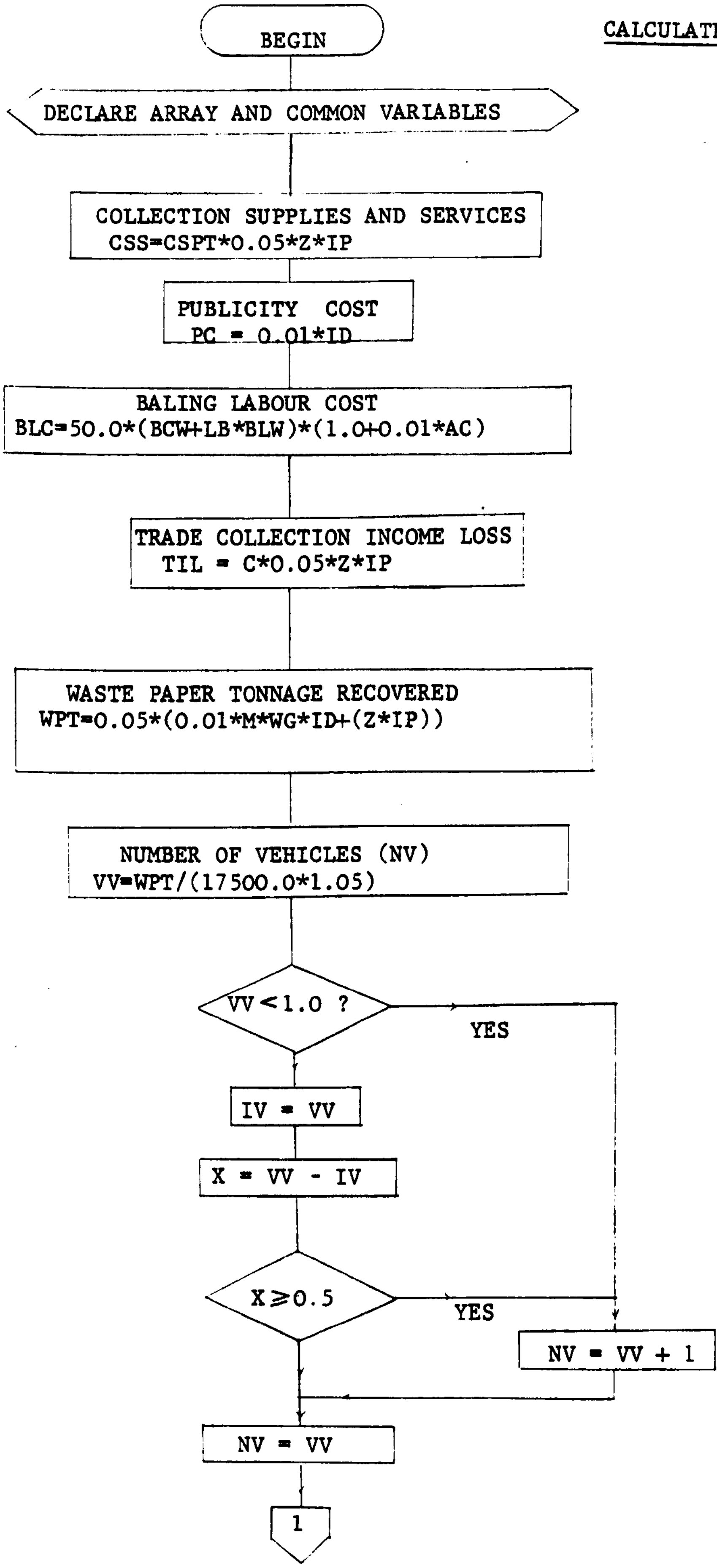
```
C       SUM UP TOTAL OPERATING COST
        DO 30 J=1,11
30      CF(8,J)=CF(1,J)+CF(2,J)+CF(3,J)+CF(4,J)+CF(5,J)+CF(6,J)+CF(7,J)
C       CALCULATE INCOME AND INDIRECT COST AND SAVINGS
        DO 50 J=2,11
        CF(9,J)=SAL
        CF(10,J)=SRD
        CF(11,J)=TIL*(-1)
        CF(12,J)=SRC
50      CONTINUE
C       CALCULATE PROFIT OR LOSS FOR EACH YEAR
        DO 60 J=1,11
        CF(13,J)=CF(9,J)+CF(10,J)+CF(11,J)+CF(12,J)+CF(8,J)
        CF(14,J)=1/(1.0+0.01*DFP)**(J-1)
        CF(15,J)=CF(13,J)*CF(14,J)
60      CONTINUE
        RNPV=0
        DO 70 J=1,11
70      RNPV=RNPV+CF(15,J)
C       PRINT CASH FLOW TABLE AND NET PRESENT VALUE
        WRITE(6,275)
275     FORMAT(' ','INVESTMENT APPRAISAL FOR A PROPOSED WASTE')
        WRITE(6,278)
278     FORMAT('+',42X,'PAPER RECOVERY SCHEME')
        WRITE(6,285)
285     FORMAT('0','CASH FLOW TABLE AND NET PRESENT VALUE')
        WRITE(6,284)
284     FORMAT('+',96X,'(IN POUNDS STERLING)')
        WRITE(6,300)(J,J=0,10)
300     FORMAT('0',32X,11('YEAR',I2,3X))
        WRITE(6,400)
400     FORMAT('0','COLLECTION COSTS')
        WRITE(6,410)CF(1,1)
410     FORMAT('0','  VEHICLES INVESTMENT',9X,F8.1)
        WRITE(6,420)(CF(2,J),J=2,11)
420     FORMAT('0','  LABOUR COST',26X,10(F8.1,1X))
        WRITE(6,430)(CF(3,J),J=2,11)
430     FORMAT('0','  SUPPLIES & SERVICES',18X,10(F8.1,1X))
        WRITE(6,440)(CF(4,J),J=2,11)
440     FORMAT('0','  PUBLICITY COST',23X,10(F8.1,1X))
        WRITE(6,500)
500     FORMAT('0','BALING COSTS')
        WRITE(6,510)CF(5,1)
510     FORMAT('0','  BALER/PLANT INVESTMENT',6X,F8.1)
        WRITE(6,520)(CF(6,J),J=2,11)
520     FORMAT('0','  LABOUR COST',26X,10(F8.1,1X))
        WRITE(6,530)(CF(7,J),J=2,11)
530     FORMAT('0','  SUPPLIES & SERVICES',18X,10(F8.1,1X))
        WRITE(6,540)(CF(8,J),J=1,11)
540     FORMAT('0','TOTAL OPERATING COST',10X,11(F8.1,1X))
        WRITE(6,550)
550     FORMAT('0','INCOME')
        WRITE(6,560)(CF(9,J),J=2,11)
560     FORMAT('0','SALES REVENUE',26X,10(F8.1,1X))
        WRITE(6,570)(CF(10,J),J=2,11)
570     FORMAT('0','SAVINGS IN REFUSE DISPOSAL',13X,10(F8.1,1X))
        WRITE(6,580)
580     FORMAT('0','INDIRECT COST AND SAVINGS')
        WRITE(6,590)(CF(11,J),J=2,11)
590     FORMAT('0','TRADE INCOME LOSS',22X,10(F8.1,1X))
```

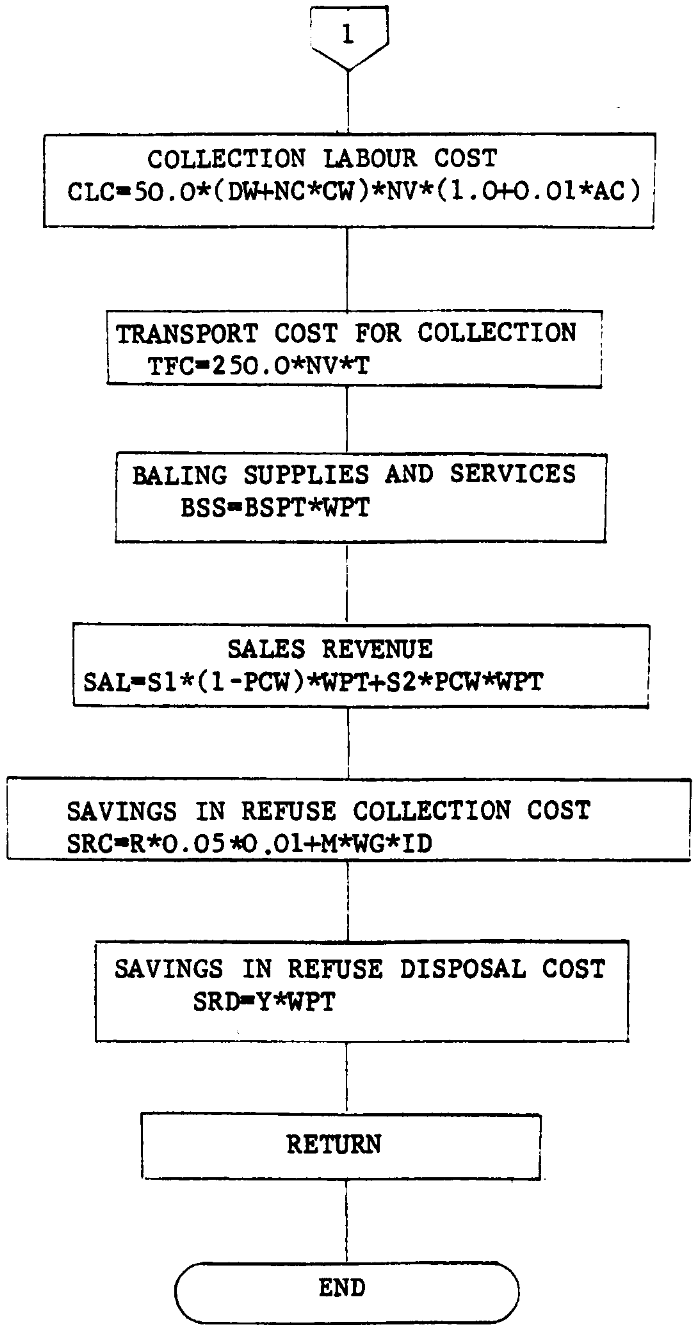
```
      WRITE(6,600)(CF(12,J),J=2,11)
600   FORMAT('0','SAVINGS IN REFUSE COLLECTION',11X,10(F8.1,1X))
      WRITE(6,610)(CF(13,J),J=1,11)
610   FORMAT('0','NET PROFIT/LOSS',15X,11(F8.1,1X))
      WRITE(6,620)DFP,1.000
620   FORMAT('0','DISCOUNT FACTOR AT ',F4.1,' PERCENT ',1X,F5.3,1X)
      WRITE(6,625)(CF(14,J),J=1,11)
625   FORMAT('+',30X,11(F8.3,1X))
      WRITE(6,630)(CF(15,J),J=1,11)
630   FORMAT('0','PRESENT VALUE',17X,11(F8.1,1X))
      WRITE(6,640)RNPV
640   FORMAT('0','NET PRESENT VALUE= ',F12.2)
      WRITE(6,641)M
641   FORMAT('0','HOUSEHOLDERS PARTICIPATION RATE= ',I3,' PERCENT')
      WRITE(6,642)WG
642   FORMAT('+',46X,'AVERAGE WEIGHT/HOUSEHOLD/WEEK= ',F5.1,' KG')
      IF (IYV.EQ.IYB) GO TO 900
      WRITE(6,643)
643   FORMAT('0',' ')
      WRITE(6,644)IYV
644   FORMAT('0','WORKING LIFE OF VEHICLE EXTENDED FROM ',I3)
      WRITE(6,646)IYB
646   FORMAT('+',43X,' TO ',I3,' YEARS')
900   WRITE(6,650)
650   FORMAT('0','INFLATION EFFECT:')
      IF(RLI.EQ.0.0) GO TO 1000
      WRITE(6,660)RLI
660   FORMAT(' ','LABOUR COST INCREASES AT ',F4.1,' PERCENT')
      WRITE(6,665)
665   FORMAT('+',38X,'FASTER THAN GENERAL PRICES')
      GO TO 1020
1000  WRITE(6,670)
670   FORMAT(' ','LABOUR COST INCREASES AT SAME RATE AT GEN PRICES')
1020  RETURN
      END
      SUBROUTINE SENSITIVITY ANALYSIS
      COMMON CF(20,20),TABLE(20,20)
      INTEGER AC
      COMMON ID,IP,DW,CW,Y,C,R,CSPT,BSPT,Z
      COMMON T,V,B,FN,AC,IYV,IYB,NC,LB,BCW,BLW
      COMMON S1,S2,PCW,PWLB
      COMMON MP,WGG,DFP,RLI,M,WG
      COMMON CSS,PC,BLC,TIL,WPT,VV,NV,CLC,TFC,BSS,SAL,SRC,SRD
      COMMON CSS,PC,BLC,TIL,WPT,VV,NV,CLC,TFC,BSS,SAL,SRC,SRD
C     SENSITIVITY ANALYSIS OF THE INVESTMENT APPRAISAL
C     CALCULATE NPV FOR DIFFERENT INTEREST RATES IN REAL TERMS
      IDFP=3*DFP
C     K REPRESENTS INTEREST RATE IN REAL TERMS
C     N REPRESENTS DIFFERENCE BETWEEN LABOUR AND GEN PRICES INCREASE
C     NN GIVES REAL DIFFERENCE BETWEEN LABOUR AND GEN PRICES INCREASE
      DO 140 K=1,IDFP
      DO 150 N=1,16
      NN=N-6
      RK=K/2.0
C     RK GIVES THE INTEREST RATES IN REAL TERMS IN 0.5% INTERVALS
C     CALCULATE CASH FLOW AND STORE INTO TABLE
      CF(1,1)=NV*V*(-1)
      CF(5,1)=(-1)*(B+FN)
      DO 820 J=2,11
      CF(2,J)=(-1)*CLC*((1.0+0.01*NN)**(J-2))
```

```
      CF(3,J)=CSS*(-1)
      CF(4,J)=PC*(-1)
      CF(6,J)=(-1)*BLL*((1.0+0.01*NN)**(J-2))
      CF(7,J)=BSS*(-1)
820   CONTINUE
C     SUM UP TOTAL OPERATING COST
      DO 830 J=1,11
830   CF(8,J)=CF(1,J)+CF(2,J)+CF(3,J)+CF(4,J)+CF(5,J)+CF(6,J)+CF(7,J)
C     CALCULATE INCOME AND INDIRECT COST AND SAVINGS
      DO 850 J=2,11
      CF(9,J)=SAL
      CF(10,J)=SRD
      CF(11,J)=TIL*(-1)
      CF(12,J)=SRC
850   CONTINUE
C     CALCULATE PROFIT OR LOSS FOR EACH YEAR
      DO 860 J=1,11
      CF(13,J)=CF(9,J)+CF(10,J)+CF(11,J)+CF(12,J)+CF(8,J)
      CF(14,J)=1/(1.0+0.01*RK)**(J-1)
      CF(15,J)=CF(13,J)*CF(14,J)
860   CONTINUE
      RNPV=0
      DO 870 J=1,11
870   RNPV=RNPV+CF(15,J)
      TABLE(K,N)=0.001*RNPV
150   CONTINUE
140   CONTINUE
C     PRINT THE TABLE OF NPV FOR DIFFERENT INTEREST RATES
      WRITE(6,1290)
1290  FORMAT('1','SENSITIVITY ANALYSIS OF THE INVESTMENT APPRAISAL')
      WRITE(6,1295)
1295  FORMAT('+',49X,'FOR A PROPOSED WASTE PAPER RECOVERY SCHEME')
      WRITE(6,1300)
1300  FORMAT('0','NPV AT DIFFERENT INTEREST RATES IN REAL TERMS')
      WRITE(6,1310)
1310  FORMAT('+',96X,'(IN 1000 POUNDS STERLING)')
      WRITE(6,1350)
1350  FORMAT('0','PERCENTAGE OF')
      WRITE(6,1360)
1360  FORMAT(' ','LABOUR COST')
      WRITE(6,1370)
1370  FORMAT(' ','INCREASE ABOVE')
      WRITE(6,1380)
1380  FORMAT(' ','GEN PRICES')
      WRITE(6,1385)
1385  FORMAT(' ','IN REAL TERMS')
      WRITE(6,1390)((N-6),N=1,16)
1390  FORMAT('+',13X,16I7)
      WRITE(6,1400)
1400  FORMAT('0','DISCOUNT')
      WRITE(6,1410)
1410  FORMAT(' ','FACTOR')
      WRITE(6,1420)
1420  FORMAT(' ','IN')
      WRITE(6,1430)
1430  FORMAT(' ','PERCENTAGE')
```

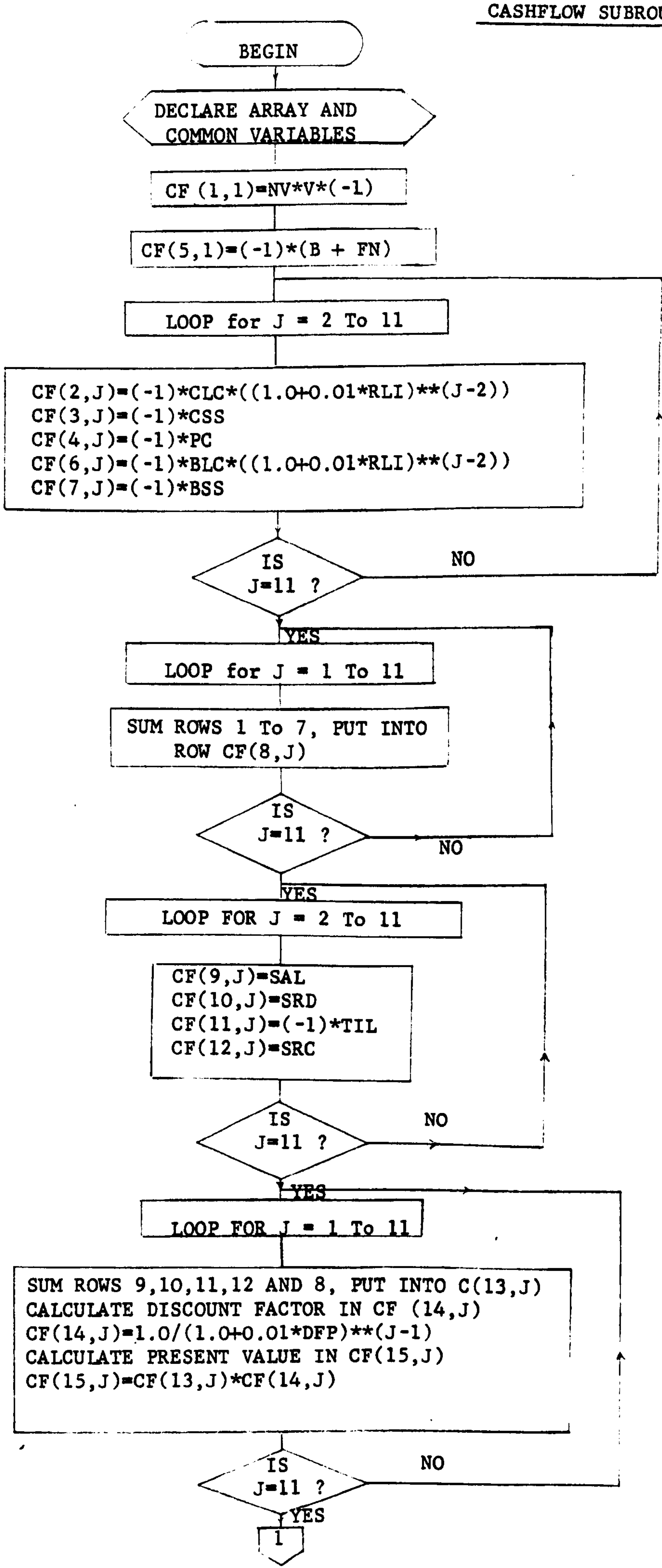
```
      DO 700 K=1,IDFP
      RK=K/2.0
      WRITE(6,1500)RK
1500  FORMAT('0',F10.1)
      WRITE(6,1550)(TABLE(K,N),N=1,16)
1550  FORMAT('+',13X,16F7.1)
700   CONTINUE
      WRITE(6,1600)
1600  FORMAT('0',' ')
      WRITE(6,1700)PWLB
1700  FORMAT('0','PUBLIC WORKS LOAN BOARD RATE= ',F6.2,' PERCENT')
      WRITE(6,1800)M
1800  FORMAT('0','HOUSEHOLDERS PARTICIPATION RATE= ',I3,' PERCENT')
      WRITE(6,1900)WG
1900  FORMAT('+',46X,' AVERAGE WEIGHT/HOUSEHOLD/WEEK= ',F5.1,' KG')
      WRITE(6,1950)WPT
1950  FORMAT('0','TOTAL TONNAGE COLLECTED PER ANNUM= ',F7.1,' TONNES')
      WRITE(6,2000)S1
2000  FORMAT('0','PRICE OF MIXED WASTE= ',F6.2)
      WRITE(6,2100)S2
2100  FORMAT('+',29X,' AND PRICE OF CONTAINER WASTE= ',F6.2)
      RETURN
      END
```

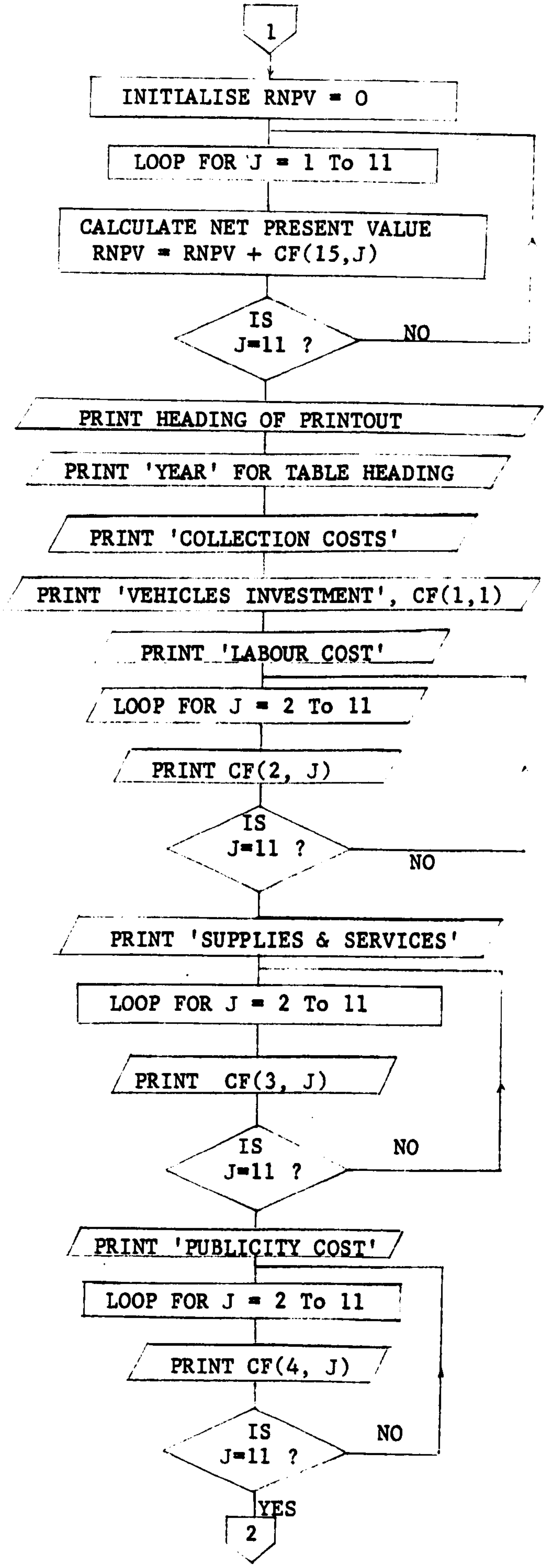
CALCULATE SUBROUTINE

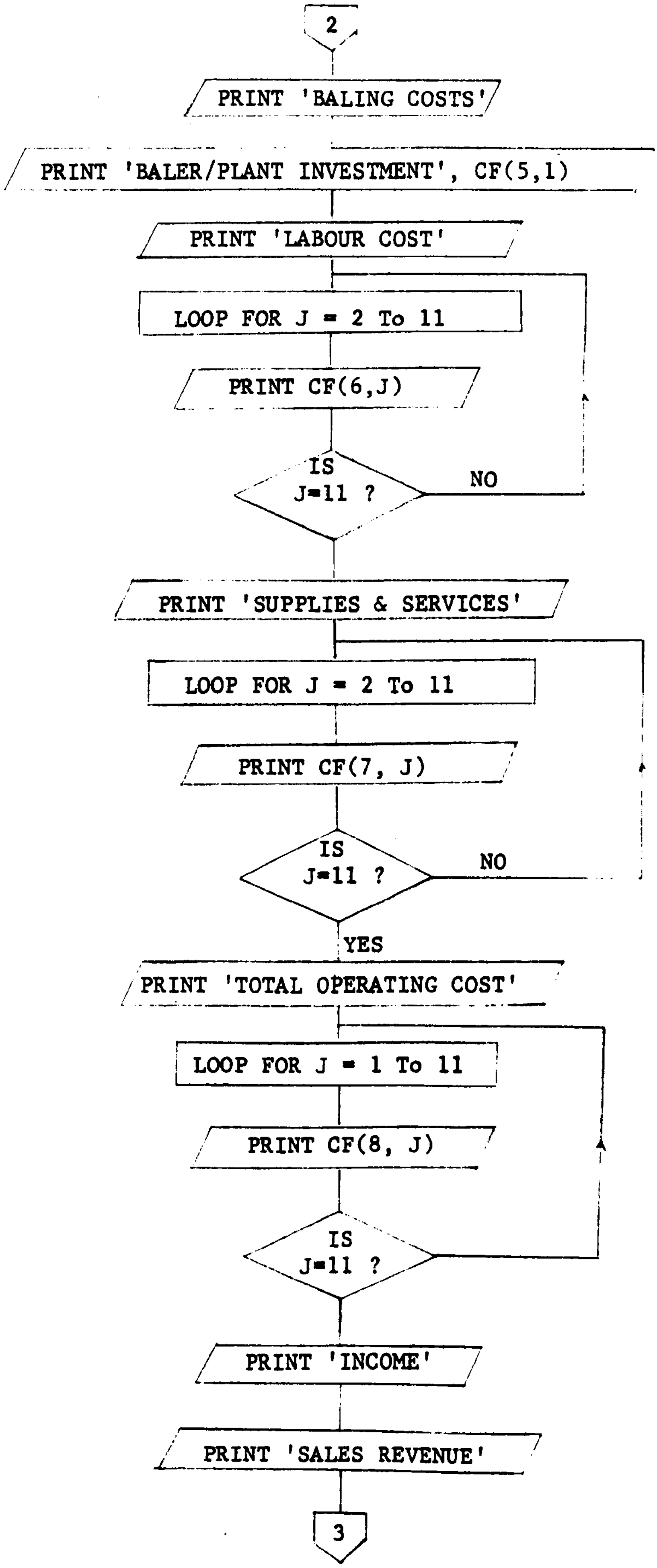


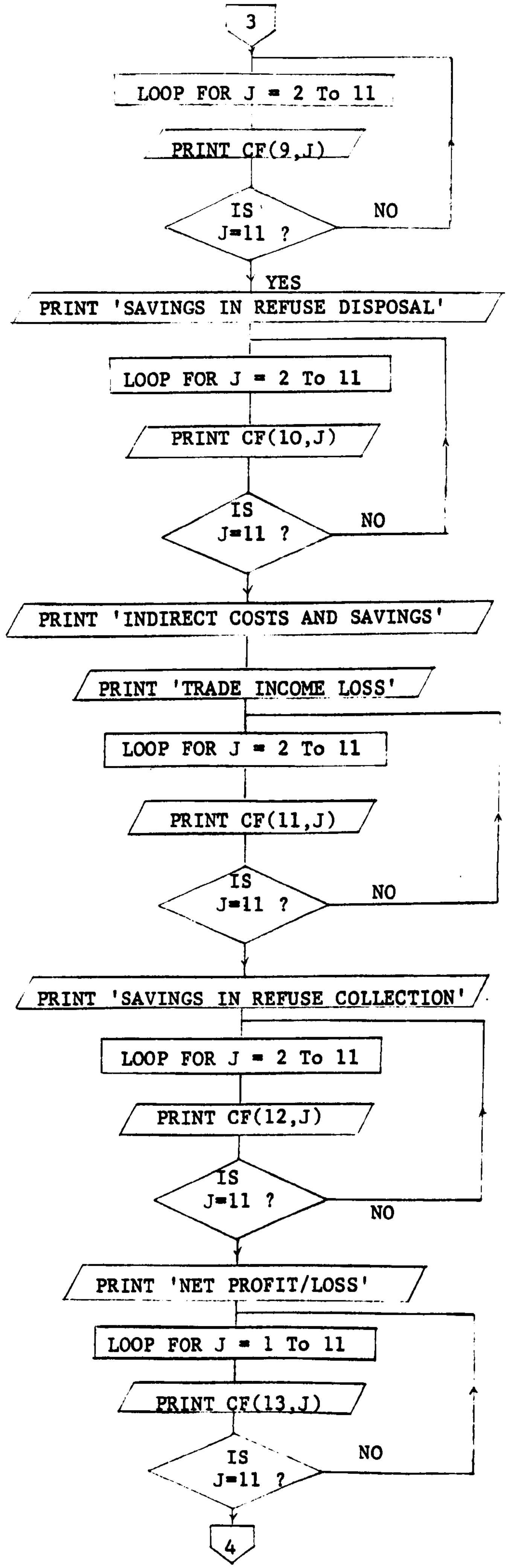

1
COLLECTION LABOUR COST
CLC=50.0*(DW+NC*CW)*NV*(1.0+0.01*AC)
TRANSPORT COST FOR COLLECTION
TFC=250.0*NV*T
BALING SUPPLIES AND SERVICES
BSS=BSPT*WPT
SALES REVENUE
SAL=S1*(1-PCW)*WPT+S2*PCW*WPT
SAVINGS IN REFUSE COLLECTION COST
SRC=R*0.05*0.01+M*WG*ID
SAVINGS IN REFUSE DISPOSAL COST
SRD=Y*WPT
RETURN
END

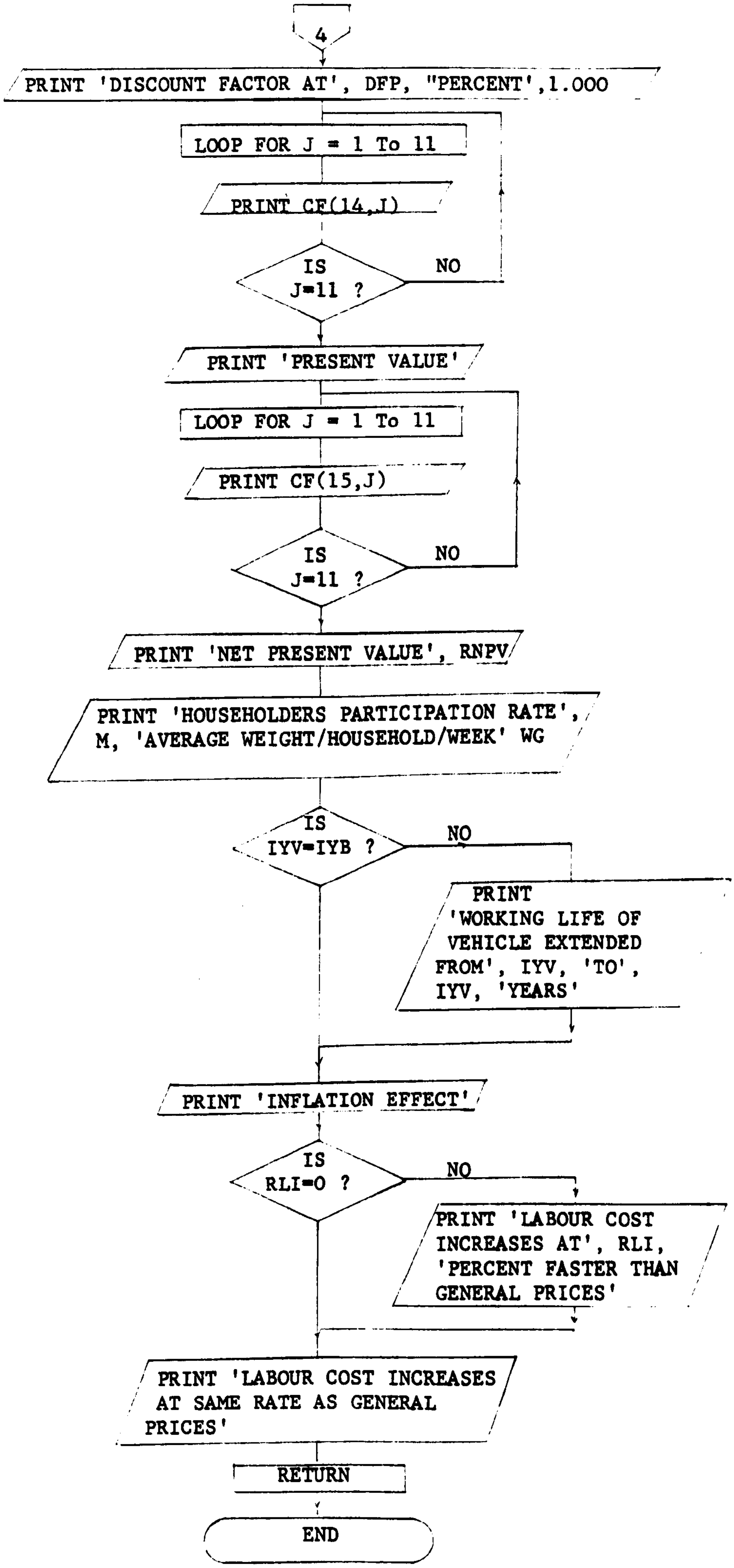
CASHFLOW SUBROUTINE



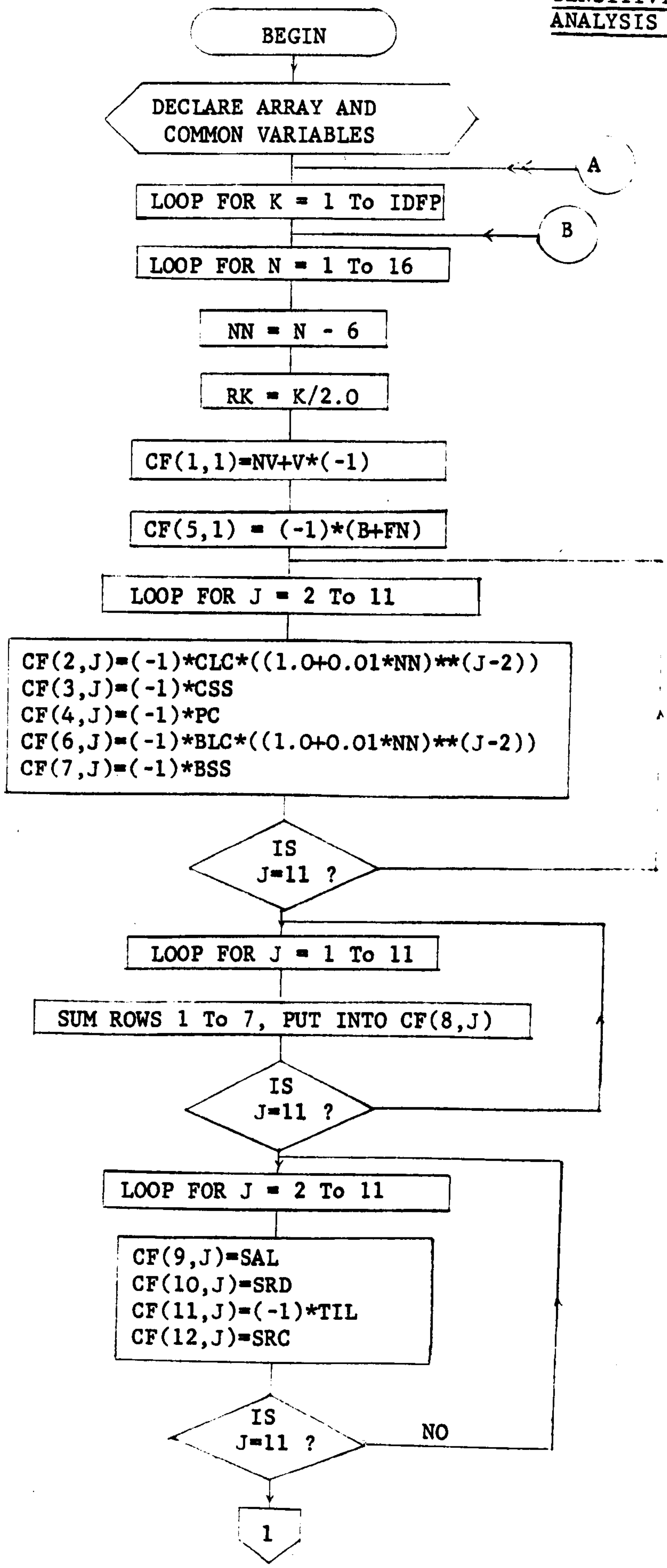

1
INITIALISE RNPV = 0
LOOP FOR J = 1 To 11
CALCULATE NET PRESENT VALUE
RNPV = RNPV + CF(15,J)
IS
J=11 ?
NO
PRINT HEADING OF PRINTOUT
PRINT 'YEAR' FOR TABLE HEADING
PRINT 'COLLECTION COSTS'
PRINT 'VEHICLES INVESTMENT', CF(1,1)
PRINT 'LABOUR COST'
LOOP FOR J = 2 To 11
PRINT CF(2, J)
IS
J=11 ?
NO
PRINT 'SUPPLIES & SERVICES'
LOOP FOR J = 2 To 11
PRINT CF(3, J)
IS
J=11 ?
NO
PRINT 'PUBLICITY COST'
LOOP FOR J = 2 To 11
PRINT CF(4, J)
IS
J=11 ?
NO
YES
2

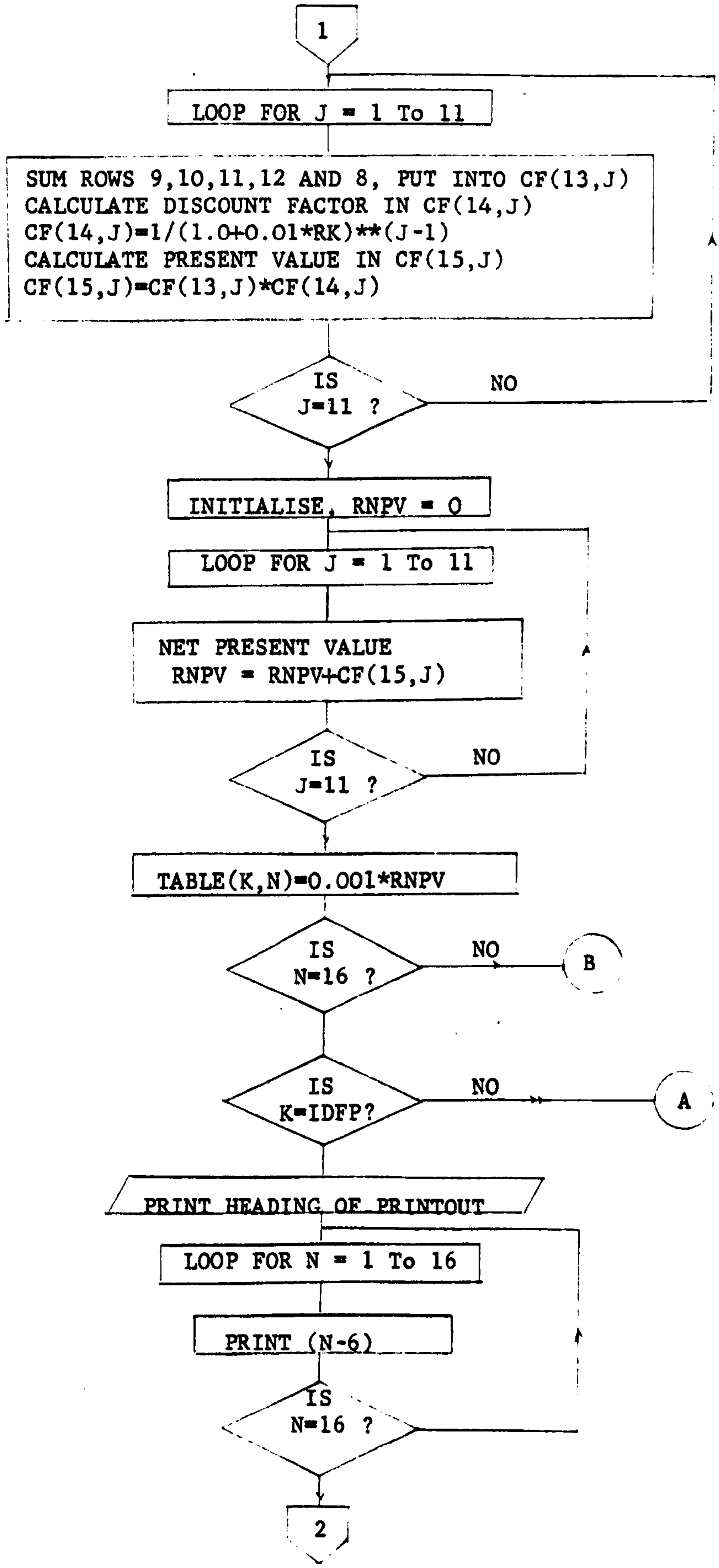

2
PRINT 'BALING COSTS'
PRINT 'BALER/PLANT INVESTMENT', CF(5,1)
PRINT 'LABOUR COST'
LOOP FOR J = 2 To 11
PRINT CF(6,J)
IS J=11 ?
NO
PRINT 'SUPPLIES & SERVICES'
LOOP FOR J = 2 To 11
PRINT CF(7, J)
IS J=11 ?
NO
YES
PRINT 'TOTAL OPERATING COST'
LOOP FOR J = 1 To 11
PRINT CF(8, J)
IS J=11 ?
PRINT 'INCOME'
PRINT 'SALES REVENUE'
3


3
LOOP FOR J = 2 To 11
PRINT CF(9,J)
IS
J=11 ?
NO
YES
PRINT 'SAVINGS IN REFUSE DISPOSAL'
LOOP FOR J = 2 To 11
PRINT CF(10,J)
IS
J=11 ?
NO
PRINT 'INDIRECT COSTS AND SAVINGS'
PRINT 'TRADE INCOME LOSS'
LOOP FOR J = 2 To 11
PRINT CF(11,J)
IS
J=11 ?
NO
PRINT 'SAVINGS IN REFUSE COLLECTION'
LOOP FOR J = 2 To 11
PRINT CF(12,J)
IS
J=11 ?
NO
PRINT 'NET PROFIT/LOSS'
LOOP FOR J = 1 To 11
PRINT CF(13,J)
IS
J=11 ?
NO
4


4
PRINT 'DISCOUNT FACTOR AT', DFP, "PERCENT',1.000
LOOP FOR J = 1 To 11
PRINT CF(14,J)
IS J=11 ?
NO
PRINT 'PRESENT VALUE'
LOOP FOR J = 1 To 11
PRINT CF(15,J)
IS J=11 ?
NO
PRINT 'NET PRESENT VALUE', RNPV
PRINT 'HOUSEHOLDERS PARTICIPATION RATE', M, 'AVERAGE WEIGHT/HOUSEHOLD/WEEK' WG
IS IYV=IYB ?
NO
PRINT 'WORKING LIFE OF VEHICLE EXTENDED FROM', IYV, 'TO', IYV, 'YEARS'
PRINT 'INFLATION EFFECT'
IS RLI=0 ?
NO
PRINT 'LABOUR COST INCREASES AT', RLI, 'PERCENT FASTER THAN GENERAL PRICES'
PRINT 'LABOUR COST INCREASES AT SAME RATE AS GENERAL PRICES'
RETURN
END

SENSITIVITY ANALYSIS SUBROUTINE




1
LOOP FOR J = 1 To 11
SUM ROWS 9,10,11,12 AND 8, PUT INTO CF(13,J)
CALCULATE DISCOUNT FACTOR IN CF(14,J)
CF(14,J)=1/(1.0+0.01*RK)**(J-1)
CALCULATE PRESENT VALUE IN CF(15,J)
CF(15,J)=CF(13,J)*CF(14,J)
IS J=11 ?
NO
INITIALISE, RNPV = 0
LOOP FOR J = 1 To 11
NET PRESENT VALUE
RNPV = RNPV+CF(15,J)
IS J=11 ?
NO
TABLE(K,N)=0.001*RNPV
IS N=16 ?
NO
B
IS K=IDFP?
NO
A
PRINT HEADING OF PRINTOUT
LOOP FOR N = 1 To 16
PRINT (N-6)
IS N=16 ?
2

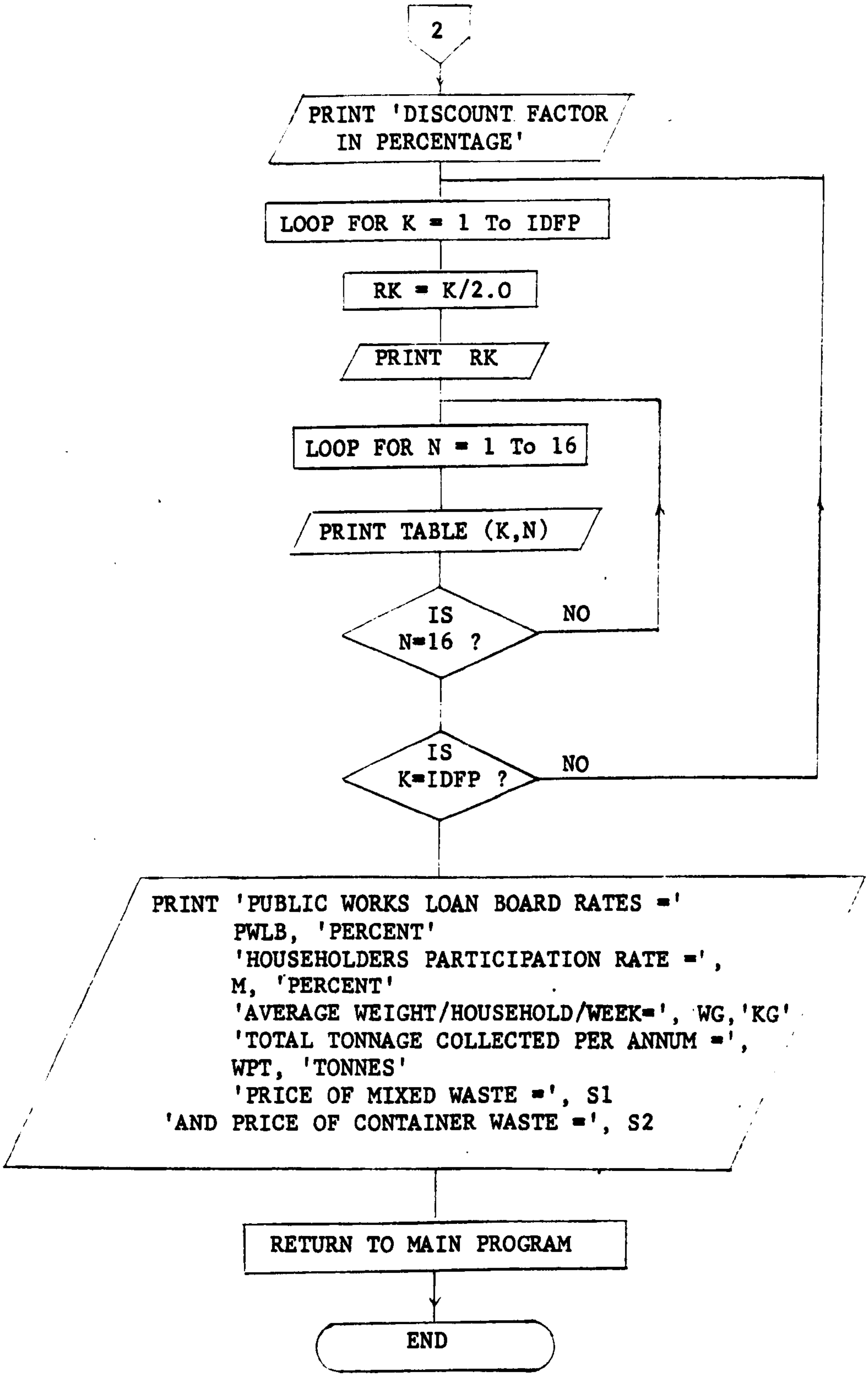

2
PRINT 'DISCOUNT FACTOR IN PERCENTAGE'
LOOP FOR K = 1 To IDFP
RK = K/2.0
PRINT RK
LOOP FOR N = 1 To 16
PRINT TABLE (K,N)
IS N=16 ?
NO
IS K=IDFP ?
NO
PRINT 'PUBLIC WORKS LOAN BOARD RATES =' PWLB, 'PERCENT' 'HOUSEHOLDERS PARTICIPATION RATE =', M, 'PERCENT' 'AVERAGE WEIGHT/HOUSEHOLD/WEEK=', WG, 'KG' 'TOTAL TONNAGE COLLECTED PER ANNUM =', WPT, 'TONNES' 'PRICE OF MIXED WASTE =', S1 'AND PRICE OF CONTAINER WASTE =', S2
RETURN TO MAIN PROGRAM
END

Table AIX.5 - Data input for the investment appraisal model

VARIABLE	ID	IP	DW	CW	Y	C	R	CSPT	BSPT	Z
FORMAT	I7	I7	F6.2	F6.2	F6.2	F6.2	F6.2	F5.2	F5.2	F5.2
VALUE	ƀƀ28070	ƀƀ80000	ƀ66.11	ƀƀ62.89	ƀƀ1.86	ƀ10.48	ƀ19.00	ƀ0.19	ƀ3.64	ƀ0.18

VARIABLE	T	V	B	FN	AC	IYV	IYB	NC	LB	BCW	BLW
FORMAT	F9.2	F9.2	F9.2	F9.2	I3	I3	I3	I3	I3	F6.2	F6.2
VALUE	ƀƀƀƀ47.00	ƀ31000.00	ƀ30000.00	ƀ30000.00	ƀ60	ƀ10	ƀ10	ƀƀ2	ƀƀ1	ƀ66.11	ƀ62.89

VARIABLE	S1	S2	PCW	PWLB
FORMAT	F6.2	F6.2	F6.3	F6.2
VALUE	ƀ22.00	ƀ22.00	ƀ0.125	ƀ13.82

VARIABLE	MP	WGG	DFP	RLI
FORMAT	I3	F5.1	F5.1	F5.1
VALUE	ƀ40	ƀƀ1.2	ƀƀ5.0	ƀƀ0.0

ƀ stands for blank space

Table AIX.6

INVESTMENT APPRAISAL FOR A PROPOSED WASTE PAPER RECOVERY SCHEME

CASH FLOW TABLE AND NET PRESENT VALUE (IN POUNDS STERLING)

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR10
COLLECTION COSTS											
VEHICLES INVESTMENT	-31000.0										
LABOUR COST		-15351.2	-15351.2	-15351.2	-15351.2	-15351.2	-15351.2	-15351.2	-15351.2	-15351.2	-15351.2
SUPPLIES & SERVICES		-136.8	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8	-136.8
PUBLICITY COST		-280.7	-280.7	-280.7	-280.7	-280.7	-280.7	-280.7	-280.7	-280.7	-280.7
BALING COSTS											
BALER/PLANT INVESTMENT	-60000.0										
LABOUR COST		-10320.0	-10320.0	-10320.0	-10320.0	-10320.0	-10320.0	-10320.0	-10320.0	-10320.0	-10320.0
SUPPLIES & SERVICES		-5073.0	-5073.0	-5073.0	-5073.0	-5073.0	-5073.0	-5073.0	-5073.0	-5073.0	-5073.0
TOTAL OPERATING COST	-91000.0	-31161.7	-31161.7	-31161.7	-31161.7	-31161.7	-31161.7	-31161.7	-31161.7	-31161.7	-31161.7
INCOME											
SALES REVENUE		30661.0	30661.0	30661.0	30661.0	30661.0	30661.0	30661.0	30661.0	30661.0	30661.0
SAVINGS IN REFUSE DISPOSAL		2592.2	2592.2	2592.2	2592.2	2592.2	2592.2	2592.2	2592.2	2592.2	2592.2
INDIRECT COST AND SAVINGS											
TRADE INCOME LOSS		-7545.6	-7545.6	-7545.6	-7545.6	-7545.6	-7545.6	-7545.6	-7545.6	-7545.6	-7545.6
SAVINGS IN REFUSE COLLECTION		12799.9	12799.9	12799.9	12799.9	12799.9	12799.9	12799.9	12799.9	12799.9	12799.9
NET PROFIT/LOSS	-91000.0	7345.8	7345.8	7345.8	7345.8	7345.8	7345.8	7345.8	7345.8	7345.8	7345.8
DISCOUNT FACTOR AT 5.0 PERCENT	1.000	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614
PRESENT VALUE	-91000.0	6996.0	6662.9	6345.6	6043.4	5755.7	5481.6	5220.5	4971.9	4735.2	4509.7

NET PRESENT VALUE= -34277.43

HOUSEHOLDERS PARTICIPATION RATE= 40 PERCENT AVERAGE WEIGHT/HOUSEHOLD/WEEK= 1.2 KG

Table AIX.7

SENSITIVITY ANALYSIS OF THE INVESTMENT APPRAISAL FOR A PROPOSED WASTE PAPER RECOVERY SCHEME

NPV AT DIFFERENT INTEREST RATES IN REAL TERMS (IN 1000 POUNDS STERLING)

PERCENTAGE OF LABOUR COST INCREASE ABOVE GEN PRICES IN REAL TERMS / DISCOUNT FACTOR IN PERCENTAGE	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
0.5	29.4	20.6	11.4	1.6	-8.7	-19.5	-31.0	-43.0	-55.7	-69.2	-83.3	-98.2	-113.9	-130.5	-147.9	-166.3
1.0	25.8	17.3	8.4	-1.0	-11.0	-21.4	-32.5	-44.1	-56.3	-69.3	-82.9	-97.2	-112.4	-128.3	-145.1	-162.8
1.5	22.3	14.1	5.5	-3.6	-13.2	-23.3	-33.9	-45.1	-56.9	-69.4	-82.5	-96.3	-110.9	-126.3	-142.4	-159.5
2.0	19.0	11.1	2.7	-6.0	-15.3	-25.0	-35.3	-46.1	-57.5	-69.5	-82.2	-95.5	-109.5	-124.3	-139.9	-156.3
2.5	15.8	8.1	0.1	-8.4	-17.3	-26.7	-36.6	-47.1	-58.1	-69.6	-81.8	-94.7	-108.2	-122.5	-137.5	-153.3
3.0	12.7	5.3	-2.4	-10.6	-19.3	-28.3	-37.9	-48.0	-58.6	-69.8	-81.5	-93.9	-107.0	-120.7	-135.2	-150.4
3.5	9.8	2.6	-4.9	-12.8	-21.1	-29.9	-39.1	-48.9	-59.1	-69.9	-81.3	-93.2	-105.8	-119.0	-133.0	-147.7
4.0	6.9	0.0	-7.2	-14.9	-22.9	-31.4	-40.3	-49.7	-59.6	-70.0	-81.0	-92.5	-104.7	-117.5	-130.9	-145.1
4.5	4.2	-2.5	-9.5	-16.9	-24.7	-32.9	-41.5	-50.6	-60.1	-70.2	-80.8	-91.9	-103.6	-115.9	-128.9	-142.6
5.0	1.6	-4.9	-11.7	-18.8	-26.4	-34.3	-42.6	-51.4	-60.6	-70.3	-80.5	-91.3	-102.6	-114.5	-127.0	-140.2
5.5	-0.9	-7.2	-13.8	-20.7	-28.0	-35.6	-43.7	-52.2	-61.1	-70.5	-80.3	-90.7	-101.6	-113.1	-125.2	-137.9
6.0	-3.3	-9.4	-15.8	-22.5	-29.5	-36.9	-44.7	-52.9	-61.5	-70.6	-80.1	-90.2	-100.7	-111.8	-123.5	-135.7
6.5	-5.7	-11.5	-17.7	-24.2	-31.0	-38.2	-45.7	-53.7	-62.0	-70.8	-80.0	-89.7	-99.8	-110.6	-121.8	-133.6
7.0	-7.9	-13.6	-19.6	-25.9	-32.5	-39.4	-46.7	-54.4	-62.4	-70.9	-79.6	-89.2	-99.0	-109.4	-120.2	-131.7
7.5	-10.1	-15.6	-21.4	-27.5	-33.9	-40.6	-47.6	-55.1	-62.9	-71.1	-79.7	-88.7	-98.2	-108.2	-118.7	-129.8

PUBLIC WORKS LOAN BOARD RATE= 13.82 PERCENT

HOUSEHOLDERS PARTICIPATION RATE= 40 PERCENT AVERAGE WEIGHT/HOUSEHOLD/WEEK= 1.2 KG

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TEXT IN ORIGINAL IS CLOSE TO THE EDGE OF THE PAGE

21 Robert Fletcher & Son Ltd
Kearsley Paper Works, P.O.Box 10, Stoneclough, Nr.Manchester M26 9EH

22 Fourstones Paper Mill Co Ltd
South Tyne Mill, Warden, Hexham, Northumberland NE46 3SD

23 P Garnett & Son Ltd
Associated Paper Mills, Wharfeside, Otley, Yorkshire LS21 1QJ

24 G H Hedley Ltd
Hedge Mill, Loudwater, High Wycombe, Buckinghamshire HP10 9QT

25 C Townsend Hook & Co Ltd
Snodland, Kent ME6 5AX

26 James Inglis & Co (Paper) Ltd
Bonnington Bridge Paper Mills, 72, Newhaven Road, Edinburgh EH6 5QG

27 Inveresk Paper Co Ltd
Woodhall Board Mill, Juniper Green, Midlothian EH14 5DL

28 Jacksons Bourne End Ltd
Bourne End, Buckinghamshire

29 Limehouse Paperboard Mills Ltd
67, Narrow Street, London E14 8DB

30 J & J Makin Ltd
Disley Paper Mill, Disley, Nr. Stockport, Cheshire

31 Monmouthshire Board Mills Ltd
Alexandra Docks, Newport, Monmouthshire

32 New Taplow Paper Mills Ltd
Mill Lane, Taplow, Maidenhead, Berkshire SL6 0AF

33 New Waterside Paper Mills Ltd
Grimshaw Bridge, Eccleshill, Darwen, Lancashire BB3 3PF

34 Pembertons (Gateshead) Ltd
Mirk Lane, Gateshead-on-Tyne, Co. Durham

35 P.I.M. Board Co Ltd
Sunbury-on-Thames, Middlesex, TW16 5DG

36 John Pitts & Sons Ltd
Trew's Weir Paper Mills, Exeter, Devon

37 Reed & Smith Ltd
Higher Kings Mill, Cullompton, Devon

38 Silverton Mills, Hele, Exeter, Devon EX5 4PX

39 Reed Paper & Board (UL) Ltd
Aylesford Paper Mills, Aylesford, Maidstone, Kent ME20 7PA

40 Colthrop Board Mills, Thatcham, Newbury,Bershire RG13 4NJ

41 Hollins Paper Mills, Darwen, Lancashire BB3 0BE

42 Imperial Paper Mills, Gravesend, Kent

43 Lower Darwen Mill, Darwen, Lancashire BB3 0RW

44 Sun Paper Mill, Feniscowles, Nr. Blackburn, Lancashire

45 Tovil & Bridge Mills, Tovil, Maidstone, Kent ME15 6QU

46 Richmond Hill Paper Works Co Ltd
Regent Street, Blackburn, Lancashire BB1 6DR

47 John Roberts & Sons (Langcliffe) Ltd
Langcliffe Paper Mill, Settle, N. Yorkshire BD24 9NX

48 Adam Robertson & Co Ltd
New Calder Paper Mills, Livingston, West Lothian

49 John Rostron & Sons Ltd
Selby, Yorks

50 The Ruberoid Paper Co Ltd
Stockingswater Lane, Enfield, Middlesex EN3 7PP

51 St.Anne's Board Mill Co Ltd
St.Anne's Road, Bristol BS4 4AD

52 Smith Anderson & Co Ltd
Fettykil Mills, Leslie, Fife KY6 3AQ

53 Smith Stone & Knight Ltd
Union Mill, Cranemore Street, Nechells, Birmingham B7 5RE

54 T.P.T. Ltd
New Mill, Stainland, Halifax, W.Yorkshire HX4 9PY

55 Oakwood Mills, Romiley, Nr. Stockport, Cheshire SK6 4DY

56 Thames Board Mills Ltd
Mersey Works, Arpley, Warrington, Lancashire WA1 1LH

57 North Mill, Purfleet, Essex

58 South Mill, Purfleet, Essex

59 Thomas & Green Ltd.
Soho Mills, Wooburn Green, High Wycombe, Buckinghamshire
HP10 OPP

60 Thompson's Board Mills Ltd
Little Salkeld, Langwathby, Penrith

61 Trinity Paper Mills Ltd
Creams Paper Mill, Little Lever, Nr. Bolton, Lancashire

62 Holcome Mill, Peel Bridge, Ramsbottom, via Bury, Lancashire

63 Springfield Paper Mills, Bolton, Lancashire

64 Vale Board Mills Ltd
Denny, Stirlingshire FK6 6BL

65 Vulcanite Ltd
Lockview Road, Stranmillis, Belfast, N.Ireland BT9 5FP

66 Wansbrough Paper Co Ltd
St Decuman's Mills, Watchet, Somerset

67 B.S. & W Whiteley Ltd
Pool Paper Mills, Pool-in-Wharfedale, Otley, Yorkshire LS21 1RP

68 Western Board Mills Ltd
Treforest Industrial Estate, Nr. Pontypridd, Glamorgan

69 John Wild & Sons Ltd
P.O.Box No.8 Broad Dumers Mills, Radcliffe, Manchester M26 9GD

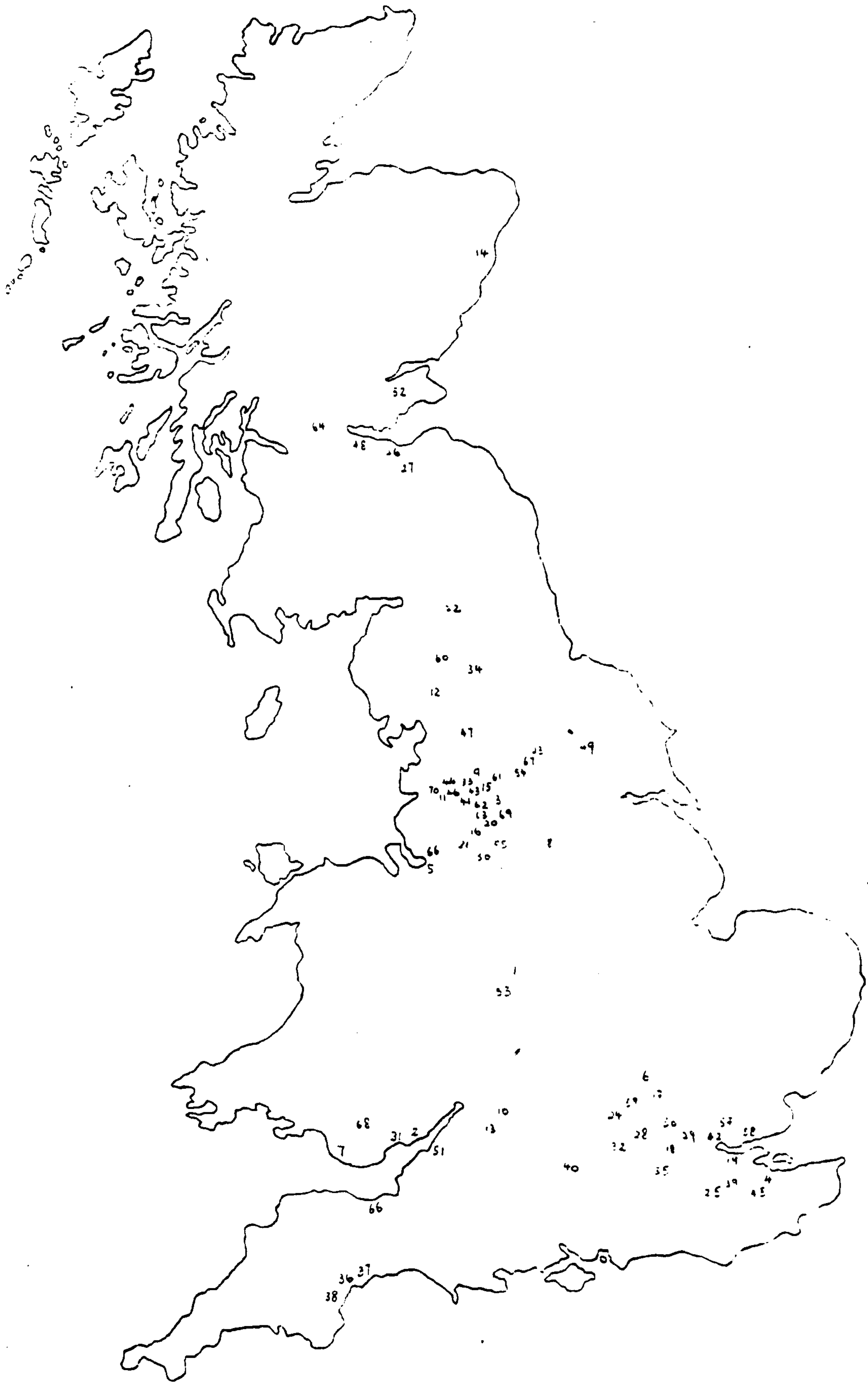
70 Thomas Witter & Co Ltd
Water Street, Chorley, Lancashire PR7 1EY

Mill closures and major machine closures during 1979,80,81

Brittains - Cheddleton	
Thomas Witter - Lancashire	-WP
Radcliffe - Lancashire	-WP
John Wild - Lancashire	-WP
Brittains - Arborfield	
J Dickinson - Croxley	-WP
Jacksons - Bourne End	-WP
Pembertons - Newcastle	-WP
Vale Board Mills - Denny, Stirlingshire	-WP
Thames Board Mills - Purfleet (South Mill)	-WP
DRG-Kent Kraft - Kent	-WP
Spaulding Russell - Eynesford, Kent	
Ribble - Lancashire	
Domtar - Sunderland	
Wiggins Teape - Fort William (Pulp mill)	
Bowaters - Mersey	-WP
St.Anne's Board Mills - Bristol	-WP
Cooke & Nuttall - Lancashire	-WP
Calder - Livingston, West Lothian	-WP
Hedley - High Wycombe, Buckinghamshire	-WP
Star - Barnsley	
Imperial	
Yates Duxbury	

(Mills recycling waste paper are indicated by WP)

Figure XI.1 - Location of paper and board mills using waste paper in England, Wales and Scotland (1974/75)



Appendix XI

Multiple regression analysis

If a forecaster has a model which indicates that the variable he is attempting to forecast (Y) may be influenced by a number of variables, multiple regression analysis enables him to study such relationships. For example the model may be

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3$$

The job of the forecast is to estimate a, b_1, b_2, and b_3 and to apply statistical tests on the relation and the coefficients to test their significance.

<u>F test</u>

The F test is used to test $b_1 = b_2 = b_3 = 0$, that is all the regression coefficients are the same and equal to zero and there is no relationship at all. The F value by itself is meaningless, it has to be used for comparing with the F table values. If the computed F value exceeds the table value at a certain confidence level, 95 percent say, then it is possible to reject the null hypothesis that $b_1 = b_2 = b_3 = 0$ at the 95 percent confidence level, and it may be said that a statistically significant relationship exists between the dependent and independent variables.

<u>T test</u>

The t statistic tests the statistical significant of each of the regression coefficients (a, b_1, b_2, b_3). Again the computed t values have to be used in conjunction with t table values. If the computed t value exceeds the t-table value at a certain confidence level, 95 percent say, then, without regard to the sign of the t-value, one can say that the coefficient differs from zero at better than 95 percent confidence level and is significant. But when the computed t value is less than the table value, the coefficient could not be said to differ significantly from zero at the 95 percent confidence level, which means that the relation may not have gained anything by including this variable.

R^2

The multiple coefficient of determination (R^2) measures the amount of 'explained' variation that is contributed by the independent variables. The higher the value of R^2 and the closer it is to 1, the better is the forecast relation.

DW statistic

In a regression relation an error term is included to account for 'unexplained variation' in the dependent variable . When this residual value is plotted against time it should ideally be random. The Durbin-Watson (DW) statistic is used to test this. If the residuals are random, the Durbin-Watson statistic, which must be between 0 and 4, should be close to 2. The value of the DW statistic may be tested for significance, and it can be established whether or not serial correlation exists in the residuals, that is, whether they are random or not. Tables for DW values gives two numbers, the lower limit and the upper limit for each different sample size, number of explanatory variables and significance level. If the computed DW is larger than the upper limit from the tables, there is no auto-correlation. If the computed DW is less than the lower limit from the tables there is positive correlation. If the computed DW falls between the two values the test is inconclusive.

Appendix XII

Functioning of a waste paper futures market

If a futures market for waste paper exists, waste paper merchants and dealers can hedge against possible loss in the future. Suppose a waste paper merchant has a stock of waste paper and he wants to hedge it against the risk of a fall in price. To do this he sells a futures contract in the delivery month that is nearest to the time in which he thinks he will sell his inventory. The process can be illustrated by Table AXII.1. In April, the merchant buys in the cash market a quantity of waste paper at £30 per tonne say, to be processed and stocked till November. At the same time he sells a November futures contract for £27 per tonne, as he expects the price of waste paper to fall. Prices start to fall throughout the summer and by October the merchant decides to sell his stock at the cash market price of £28 per tonne, incurring a loss of £2 per tonne. But futures contracts have also fallen in the futures market. So he buys back a futures contract for the same quantity at the lower price of £25 per tonne, thus making a profit of £2 per tonne. His net gain is therefore zero.

Similarly, buying hedge can be used as a protection against increasing raw material costs. Suppose in April a small mill enters into a contract with a merchant for a certain quantity of a grade of waste paper to be delivered to the mill in October/November at the market price prevailing at the time of delivery. If the cash market price in April is £30 per tonne say, and the mill expects the cash market price to increase but is not sure what the price will be he will try to protect himself from the risk that the price will be so high as to incur a heavy loss. He could hedge his forward contract in the cash market by buying a futures contract (Table AXII.1). Suppose in April after entering the cash market contract the mill buys a November futures contract at £27 per tonne say, if by October he takes delivery from the merchant but price of waste paper has gone up to £32 per tonne, his cost would have gone up by £2 per tonne. But at the same time futures contract prices has also gone up by £2 per tonne and he sells his futures contract

Table AXII.1 - Example of the hedging effect of futures contract

(£/tonne)

a) Selling hedge (to protect against falling price)

	Activity	Cash market	Futures market	
April				
	Buy	£30.00	-	
	Sell	-	(Nov)	£27.00
October				
	Buy	-	(Nov)	£25.00
	Sell	£28.00	-	
Profit/tonne		-		£2.00
Loss/tonne		(£2.00)	-	

Net loss = 0

b) Buying hedge (to protect against rising price)

	Activity	Cash market	Futures market	
April				
	Buy	-	(Nov)	£27.00
	Sell	-	-	
		(market price = £30.00)		
October				
	Buy	£32.00	-	
	Sell	-	(Nov)	£29.00
Increase in raw material cost/tonne		£2.00	-	
Profit/tonne		-		£2.00

Net increase in raw material cost/tonne = 0 for £29 to make £2 per tonne. The profit from the futures contract will be able to balance his extra cost in raw materials.

Futures market can help reduce waste paper market unstability in several ways. Futures market forces the dissemination of information through the futures market and both buyers and sellers are better informed. Reduce uncertainty will allow both buyers and sellers to make better decisions. With reduced uncertainty suppliers would be able to react more readily to price changes and allow supply to be more elastic which consequently will reduce the price fluctuations. Futures markets allow buyers and sellers of waste paper to shift the risk of doing business in an uncertain market environment by off-setting any losses with gains in the future market.

It is important that the market is not dominated by a single buyer and buyers and sellers should not know each other. Dower and Anderson's proposal was made in the USA, where conditions may be suitable for waste paper futures market to function. In the UK context, the few big consumers of waste paper and the already well established contact between buyers and sellers may not allow the futures market to operate smoothly. Although futures markets at present still raise many problems, with experts disagreeing on many issues such as its ability to stabilise prices, there is a case for much closer investigation.