ECONOMETRIC ESTIMATION OF ARMINGTON IMPORT ELASTICITIES FOR A REGIONAL CGE MODEL OF THE ILLINOIS ECONOMY

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One of the main concerns associated with the development and use of regional CGE models is the determination of key parameter values, particularly substitution and other price elasticities. A common problem is the lack of appropriate regional data for econometric estimation. Consequently, it is important to identify key parameters that are likely to be important in determining quantitative results and then to prioritize these for estimation where appropriate data are available. In this paper, the focus is on the estimation of the regional trade (import) substitution parameters, which tend to be important in analysis for regional economies (given their openness to trade). Here, commodity import elasticities for the Illinois economy are estimated and tested in a single region CGE model of the Illinois economy. In our econometric estimation, we apply a model that takes account of market size and distance in estimating the substitutability between commodities produced in Illinois and other US states.

Keywords: CGE models; Input-output tables; parameter estimates; regional modeling; Armington import elasticities

1. Introduction

Many variations of computable general equilibrium (CGE) models of the U.S. national economy have demonstrated the value of the approach in assessing the potential long-run effects of government policies, impacts of environmental actions as well as the effects of proposed and enacted free trade agreements. At the regional level, the analyses of those effects within countries have been more limited and problematic (Partridge and Rickman, 1998, 2010; Holland, 2010). A likely reason for the lack of regional CGE studies (examples include Dixon et al., 2007; Hoffmann et al., 2006; Seung et al., 2010) is that the necessary regional data in a suitable form are often not available. Moreover, a number of unresolved behavioral issues remain, including the extent of interregional factor mobility and the uniqueness of regional goods. As a result, the level of uncertainty and the magnitude of errors in regional CGE models may be higher than those in national-level models.

For example, although elasticities of import substitution have been extensively estimated for U.S. trade (Stern et al., 1976; Shiells et al., 1986; Shiells and Reinert, 1993), limited information is available for elasticities of substitution for regional imports. Therefore, regional CGE modelers often use elasticities estimated for national commodity or industry classifications that may not be consistent with those maintained in the model, outdated estimates from past literature, or only 'best guesses' when no published figures are available (for a review, see Partridge and Rickman, 1998, 2008). However, if parameters are specified without representing regional characteristics, any simulation results are likely to be inaccurate.

Recognizing this problem, CGE analysts have directed attention to the issue of uncertainty and error of behavioral parameters and many researchers have tested the uncertainty and errors surrounding these parameters in terms of their impact on the model (e.g. Hertel, 1985; Harrison and Vinod, 1992; Harrison et al., 1993; DeVuyst and Preckel, 1997). Such sensitivity analyses are considered as an important step in the application of CGE models to evaluate the variability of results of simulating policy and other disturbances to model specification.

Generally, knowledge of key parameters is important for CGE analysis of a small open economy because of the degree to which a policy change that will affect key macroeconomic variables will depend on the magnitude of key price elasticities and other parameters adopted in the model. Here, we focus on the estimation of regional trade (import) substitution parameters for the Illinois economy. These parameters are generally important in analysis for regional economies, which tend to be more open than national economies. Specifically, we estimate commodity import elasticities for the case of Illinois and the rest of the US (RUS). A model is applied where account is taken of market size and distance in estimating the substitutability between commodities produced in Illinois and other US states.

The remainder of the paper is organized as follows. Section 2 provides theoretical background for the regional import elasticity estimates. Section 3 explains the analytical model and data, with results of the parameter estimation following in section 4. Section 5 introduces the Illinois CGE model and tests the impact of introducing the estimated parameter values. Section 6 provides conclusions.

2. Regional import elasticities – theoretical background

Regional economic policy can affect the price of traded goods relative to domestically produced goods. For example, tax and subsidy policy or any type of government regulation that affects the behavior of firms or consumers may influence trade between regions. Even though differentiation by government agencies at the regional level may not be as pronounced as at the national level, at the margin, the differences may turn out to be important. The "cost of doing business" is often highlighted as an important discriminator in the choice of location by many firms. Furthermore, processes of fragmentation and hollowing out and changes in the nature of regional specialization have combined to generate increased interregional trade at the expense of intraregional trade (see Hewings and Parr, 2009; Romero et al., 2009). As a result, a key relationship for regional CGE analysis is the degree of substitution between intraregional and interregional traded goods, commonly identified as the Armington price elasticity (Armington, 1969). Commodities produced at different locations are seldom perfect substitutes. Because of real or apparent differences, discriminating buyers evaluate their willingness to substitute between imports and domestic goods within comparable product categories. Thus, there exists a potential for price differences between locally produced and imported products from comparable product categories (Reinert and Roland-Holst, 1992). The factors determining the different price of goods are various: the demand for consumption and industrial inputs, the supply of production (labor costs, costs of materials), and technological progress in the transportation sector as well as improvements in the efficiency of transactions.

The hypothetical representative consumer (be they an intermediate or final consumer) minimizes costs or maximizes utility from a composite (*Q*) of imported (*M*) and domestic (*D*) goods, and it is assumed there are continuous substitution possibilities between the two options. The individual consumer's decision problem is to choose a mix of *M* and *D* that minimizes expenditure, given respective prices p_m and p_d and the desired level of *Q*. In other words, *c*onsumers purchase quantities of domestic versus imported goods depending on their willingness to substitute and the ratio of the two prices. In the Armington specification, a CES functional form is chosen for *Q*:

$$Q = \alpha\left[\beta M^{(\sigma-1)/\sigma} + (1-\beta)D^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \qquad (1)$$

where α and β are calibrated parameters and σ is the elasticity of substitution between imports and domestic goods. The solution to the consumer's optimization problem will be to choose imports and domestic goods whose ratio satisfies the first-order condition:

$$M / D = \left[(\beta/(1-\beta))(p_D / p_M)\right]^{\sigma} \qquad (2)$$

which is the familiar equivalence between rates of substitution and relative prices. The parameter σ also can be interpreted as the compensated price elasticity of import demand. Commodity-level estimates of Armington elasticities for the US have appeared over the last few decades. For example, Stern et al. (1976) estimate US imports-demand elasticities for 28 commodities produced by industries identified at the three-digit SIC level and divide them into three categories, extremely import sensitive, moderately import sensitive, and import inelastic. Shiells and Reinert (1993) use quarterly data over the period 1980-1988 and obtain estimates for 128 mining and manufacturing sector outputs. One of the most widely cited studies in the literature, Reinert and Roland-Holst (1992) estimate Armington elasticities for 163 U.S. mining and manufacturing commodities using quarterly data from 1980 to 1988.

Application of the Armington assumption has mainly been at the international or country level because of the data limitation of commodity trade among regions. However, the U.S. Census Bureau, U.S. Department of Commerce, and the Bureau of Transportation Statistics have undertaken the Commodity Flow Survey (CFS). This survey produces interstate commodity flow data for the United States. It provides information on commodities shipped, their value, weight, and mode of transportation, as well as the origin and destination of shipments of selected manufacturing, mining, wholesale, and retail establishments. However, the data only cover physical commodities and no differentiation is made between intermediate and final demand flows. Further, commodity trade among states within the same country may also reflect quality differences among products or just the variety of consumption preferences. Differences in product mixes within the same category produced at each location may also provide an explanation for observation of imports and exports of the same category of goods. This has led to the common use of the uniform Constant Elasticity of Substitution (CES) class of function, in which a single nonnegative substitution elasticity is imposed across all pairs of factors.

3. Econometric model and data

To estimate regional import elasticities for Illinois, data are selected from published information on 2002 commodity flows data (Bureau of Transportation Statistics, 2005) Although a number of trade models have been developed, the CES structure is relatively easy to explain and estimate so that the analytical specification follows Bilgic et al. (2002) and Erkel-Rousse and Mirza (2002). For the first specification, a CES function is adopted to represent the direct commodity satisfaction (utility) index, which applies to all consumers, intermediate or final (data are not available to estimate for different consumers individually):

$$U_{ILk} = \left(\sum_j \beta_{ILk} X_{ILjk}^{\rho} \right) = \sum \left(\beta_{1k} X_{ILk}^{\rho} + \beta_{2k} X_{jk}^{\rho} \right) \qquad (3)$$

where j=1,…r for region (state); k=1,…n for commodity group; $\beta_{1k} + \beta_{2k} = 1$; ρ is a substitution parameter; X_{ILk} refers to (total) intraregional commodity consumption of Illinois for commodity k; and X_{jk} refers to (total) interregional commodity consumption by Illinois from other states j for commodity k. The CES is linear in parameters, and thus more easily estimated (Chung, 1994).

Maximizing Equation 3 subject to the total expenditure constraint yields:

$$M_{ILk} = \sum_j P_{ILijk} X_{ILjk} \qquad (4)$$

and produces a system of demands that estimates intraregional and interregional consumption:

$$\left[\frac{x_{ILk}}{x_{jk}} \right] = m^{\sigma} \left[\frac{p_{jk}}{p_{ILk}} \right]^{\sigma} \qquad (5)$$

where $m = [\beta_{1k} / \beta_{2k}]$, $\sigma = [1/(1-\rho)]$ is the elasticity of substitution; p_{ILk} = [Illinois intraregional commodity k value ($ millions) /Illinois intraregional commodity k weights (thousand ton)]*1000 is the unit price for Illinois and k^{th} commodity intraregional consumption; P_{jk} = [Interregional commodity k value ($ millions) /Interregional commodity k weights (thousand ton)]*1000 is the unit price for interregional consumption from the j^{th} region and k^{th} commodity. m is then defined as depending on states' characteristics defined as Q_{jk} and d_{ILj}, which represent market size and distance factor, respectively, and δ_s is the set of parameters associated with state *j* characteristics.[1]

$$m = \left[\frac{\beta_{1k}}{\beta_{2k}}\right] = \exp(\delta_0 + \delta_1 \ln Q_{jk} + \delta_2 \ln d_{ILj}) \tag{6}$$

The market size factor is included as an explanatory variable to capture the share of the amount of intraregional demand to interregional demand (larger markets are able to support more production and thus imports from larger market increase relative to intraregional goods). The market size variable is measured as the proportion of Illinois gross state product to the other region's gross state product by each industry sector. Owing to the potentially important influence of spatial effects, the distance factor is included in the price expression in order to indicate that the closer the state is located to Illinois, the more likely the volume of interregional goods increases. Distance is calculated as the centroid distance between Illinois and the other 49 states.

Taking natural logs of both sides of Equation 5 yields

$$\ln\left[\frac{X_{ILk}}{X_{jk}}\right] = \sigma \ln m + \sigma \ln\left[\frac{P_{jk}}{P_{ILk}}\right] \tag{7}$$

Substituting for the term *m* defined by Equation 6 into Equation 7 produces

$$\ln\left[\frac{X_{ILk}}{X_{jk}}\right] = \left[\alpha_0 + \alpha_1 \ln Q_{jk} + \alpha_2 \ln d_{ILj}\right] + \sigma \ln\left[\frac{P_{jk}}{P_{ILk}}\right] \tag{8}$$

where $\alpha_0 = \sigma\delta_0$, $\alpha_1 = \sigma\delta_1$, $\alpha_2 = \sigma\delta_2$, $\ln\left[P_{jk} / P_{ILk}\right]$ is the natural log of the price ratio for interregional goods to intraregional goods.

The estimated parameters capture the effects of market size and distance as well as the

[1] More details on the derivation of market size and distance factors may be found in Erkel-Rousse and Mirza (2002).

constant term. The left hand side of Equation 8 is the natural log of the ratio of the demand for intraregional consumption to the demand for interregional consumption.

In addition to Equation 8, which we will label Estimation Model 1, another testable specification is considered. A weighted distance has been applied using the same calculation method (Head and Mayer, 2000) for Illinois and the rest of states in U.S in order to give a more economically meaningful consideration of distance. Let the weighted distances be expressed as follows:

$$wd_{ILj} = s_{IL} s_j d_{ILj} \qquad (9)$$

where s_{IL} is population weight of Illinois in all states, s_j is employment weight of state j in all states and d_{ILJ} is the centroid distance between Illinois and state j (as in Model 1). As the earlier centroid distance between Illinois and other states in Equation 8 is replaced with a weighted distance expressed as Equation 9, another specification is proposed (which we will label Estimation Model 2):

$$\ln\left[\frac{X_{ILk}}{X_{jk}}\right] = \alpha_0 + \alpha_1 \ln Q_{jk} + \alpha_2 \ln wd_{ILj} + \sigma \ln \frac{P_{jk}}{P_{ILk}} \qquad (10)$$

where $\alpha_0 = \sigma\delta_0$, $\alpha_1 = \sigma\delta_1$, and $\alpha_2 = \sigma\delta_2$.

Based on the 2002 Commodity Flow Survey (Bureau of Transportation Statistics, 2005), the intraregional and interregional quantity and price variables are computed. The survey provides information on commodities shipped, their value, and weight as well as the origin state and destination state of shipments of manufacturing, mining, wholesale, and select retail establishments. The commodities shown in the CFS are classified by the Standard Classification of Transported Goods (SCTG) coding system that does not cover some industry/commodity categories such as government and retail activities captured in the CGE model (where both the domestic use and import use matrices are given in terms of industries/production sectors, under the assumption that one sector in Illinois and other US regions produces a single commodity). We are able to map 43 commodities by SCTG in CFS to 11 sectors among the 24 production sectors in the Illinois CGE model, with greater detail within some of these sectors possible (see Appendix 1 for the sector/commodity breakdown identified in the Illinois CGE model – estimates are made for commodities 1-4 and 9-15, with more detailed breakdown in the case of commodity 12, 14 and 15, but with aggregation across 2-4 in the estimation). Elasticities are not estimated for the remaining 13 commodities produced by the sectors identified in the CGE model. Annual wage data for each state are extracted from Quarterly Census of Employment and Wages (QCEW/ES-202) Data Files from the Bureau of Labor Statistics. Gross State Product and employment data for each state are derived from the REIS (Regional Economic Information System) data set from the Bureau of Economic Analysis.

4. Econometric Results

Tables 1 and 2 summarize the results of ordinary least squares estimation of Equation 8 and 10, or Estimation Models 1 and 2, respectively. All estimated elasticities are statistically significant at the 10 percent or lower probability level in the results of estimating Equation 8. For Equation 10, only the estimated elasticity for Textile, Apparel, and Leather Product Manufacturing is not statistically significant at the 10 percent level. The estimations for Estimation Model 1 present interregional price elasticities that range from 0.068 for Textile, Apparel, and Leather Product Manufacturing to 1.517 for Transportation Equipment. For nine out of the thirteen commodities in Tables 1 and 2 the estimations derived from Estimation Model 2 are higher than those resulting from Estimation Model 1. In Table 2, the elasticity estimates range from 0.186 for Medical, Precision and Optical Instruments to 2.169 for Non-Metallic Mineral Products. Four commodities are associated with import elasticities that are higher than unity in Model 1. This rises to six in Model 2 (where the estimate for Non-Metallic Mineral products rises from 1.357 in Model 1 to 2.169 in Model 2 and the estimates for Primary Metal and Metal Product Manufacturing and Miscellaneous Manufacturing rise above 1).

<<Insert Tables 1 and 2 around here>>

However, examination of the R-squared statistics in the final column of each table suggests that estimation of Equation 8 (Estimation Model 1) produces a much better fit with the data, with all but two (Food, Beverage and Tobacco Products Manufacturing and Wood Products and Furniture) above 0.9. The R-squared statistics for the estimations of Equation 10 (Estimation Model 2) have a much wider range, from 0.41 (Food, Beverage and Tobacco Products Manufacturing and Wood Products and Furniture) up to Non-Metallic Mineral Products (0.953), which is the only value above 0.9.

The coefficient for market size is statistically significant at the 10 percent probability level and positive. The interpretation of this elasticity is that market size is positively related to the ratio of intraregional to interregional goods demand, which suggests that the share of intraregional goods increases relative to interregional goods if total gross state product in terms of production of the k^{th} commodity in Illinois is larger. However, it should be noted that those commodities with relatively low price elasticities tend to have higher coefficients of market size. This may imply that market size is correlated with Illinois' capability to provide more intraregional goods relative to interregional goods in the case of commodities that have relatively lower price elasticities: for example, Agriculture, Forestry, Fishing & Hunting; Textile, Apparel, and Leather Product Manufacturing; and Medical, Precision and Optical Instruments.

The coefficient for the distance factor is statistically significant and positive for all but one of the commodities in Table 1 (Estimation Model 1). For the coefficient for the weighted distance factor, Table 2 shows that the result is statistically significant and positive for eight commodities. This result generally suggests that the closer the trading region or the lower the transport cost, the more interregional goods trade. In both estimations, the coefficient on the distance or transport cost is lower than the price elasticities in Food, Beverage, and Tobacco Product Manufacturing and Transportation Equipment. From this result, it could be inferred that these two commodities tend to be more affected by price differences in the Illinois case, although distance or transport cost effects do exist.

When comparing the price elasticities between commodities, Transportation Equipment (1.517 in Table 1 and 1.905 in Table 2), Non-Metallic Mineral Products

(1.375 and 2.169), Food, Beverage, and Tobacco Product Manufacturing (1.282 and 1.093), and Machinery and Electric Equipment (1.012 and 1.336) all have large price elasticities of interregional commodity trade relative to other commodities. This indicates that price differences between intraregional goods and interregional goods in Illinois are relatively important for these commodities as compared to commodities that have lower elasticities. Furthermore (see Table 3), the elasticities for these four commodities seem to be higher than the range of elasticities estimated for the same commodities in other US studies which focus on international trade (i.e. national level estimates)and also the those of Bilgic et al. (2002), which focuses on US interstate trade overall (rather than for individual states).

<<Insert Table 3 about here>>

On the other hand, Table 3 shows that our estimates for the other nine commodities tend to be lower than those estimated in the other studies for trade at the national level (i.e. international trade). Moreover, they tend to be lower or at the low end of ranges over commodities that US interstate trade elasticities are estimated by Bilgic et al. (2002). This would seem to reinforce the conclusion drawn by Bilgic et al that international trade elasticities should not be used as the lower bounds for regional trade elasticities for comparable goods, particularly where regional specialization may lead to lower levels of price sensitivity. Haddad and Hewings (2005), on the other hand, use a higher interregional trade elasticity for manufactured commodities as a whole in their CGE model for Brazil. This is close to the default value applied in the Illinois CGE model below (2.0), and also reflects the argument that interregional trade elasticities are generally higher than international ones.

In terms of the specific Illinois case reported here, note that Tobacco Products is a very small sector in Illinois and the elasticities here should not be interpreted as reflecting any significant market structure. On the other hand, transport equipment (especially the first level supply chain components) and Machinery and Electric Equipment are major sectors and produce products with a high degree of spatial substitutability. Further, many of the components in these sectors are also part of complex value chains; the process of fragmentation (see Jones and Kierzkowski, 2005) has witnessed a significant transformation in the spatial allocation of production with the result that there is a great deal of intra-industry trade in these sectors generating increased competition and thus sensitivity to prices.

5. Impact of introducing estimated import elasticities to a CGE model of the Illinois economy (AMOIL)

We have constructed a CGE model of the Illinois state economy, AMOIL, using the AMOS framework calibrated on a 2007 Social Accounting Matrix (SAM).[2] AMOS is a well-crafted modeling framework that allows the modeler to adopt a variety of perspectives concerning the operation of markets in small open economies, with particular attention to labor markets. It also offers a high degree of flexibility for the choice of key parameter values, model closures and even aggregate structure that allows the modeler to choose appropriate conditions for particular applications. Thus, it can be applied to a small open regional economy such as the Illinois region (which, in the context of the US as a whole, accounts for about 3% of national GNP). Detailed descriptions of the single region AMOS modeling framework can be found in Harrigan et al. (1991) and Ferguson et al. (2007). We give an overview of the model in Table 4. A condensed listing of the model variables and most important equations can be found at the journal's web-site with supporting material.

<<Insert Table 4 here>>

The key point for the testing of our estimated import elasticities is the specification of the production function and determination of the price of output. We employ a nested CES function for each of the 24 production sectors, where output is a combination of value-added (capital and labor) and a composite intermediate input. Here, we assume that an

[2] AMOS is an acronym for a macro-micro model of Scotland, the regional economy on which the CGE modeling software was initially calibrated (Harrigan et al., 1991).

elasticity of substitution of 0.3 applies at each of these nests throughout (this is the default AMOS value, previously applied for UK regions). While these production parameters should be the focus on region-specific estimation in future research, it is worth noting there that the lower the substitutability between the composite intermediate input and value added, the greater will be the impact on the sectoral output price of restricting substitutability between domestic and imported goods as local prices change, and vice versa.

The intermediate composite involves a combination of goods and services produced in the US and the rest of the world (ROW) in a CES function. At the bottom level of the nest, the US composite also involves a CES combination but of goods and services produced in Illinois and the rest of the US (RUS). We assume cost minimization so that if Illinois prices rise, there will be a substitution effect in favor of RUS goods. The degree of substitutability is governed by the value attached to the elasticity of substitution in this CES function. The default AMOS value is 2.0 and the results reported in this section involve testing the impact of introducing the (generally lower) estimated values reported in the previous section.

However, the current specification of the AMOS production and consumption functions involved composite goods rather than commodity level substitution possibilities between Illinois and RUS goods. Therefore, we need to adjust the estimates in Tables 1 and 2 to input them to the model. We adjust by first creating a weight matrix of commodity use for all Illinois sectors and final consumers. The numerator of each element is sector *j*'s (consuming sector/final consumption activity) use of Illinois commodity *i* plus RUS commodity *i*. The denominator is total intermediates from Illinois and RUS. We then take the vector of estimated commodity elasticities (for both Model 1 and 2) as a column and multiply each element by each row element of the weight matrix (i.e. for each production sector and final consumer in turn), before summing down the columns for each user. This results in a weighted Illinois-RUS substitution elasticity for each sector and final consumer that we can introduce to the CGE model for Estimation Models 1 and 2 in turn (see Table 5). Given that we have not been able to estimate elasticities for all commodities, we impose values for the non-estimated or missing commodities. In the simulations reported below, we focus on the better fitting Estimation

Model 1 and the cases where we take the elastic AMOS default values of 2.0 and inelastic values of 0.5 for the non-estimated commodities.[3] We also focus on results for the targeted sectors (where the greatest impact is felt) and on the variables impacting the adjustment of the economy.

<<Insert Table 5 here>>

For illustrative purposes, we introduce a simple demand shock: A 5% permanent step increase in ROW export demand for the outputs of the seven Illinois manufacturing sectors (9-15 in Appendix 1). Such a stimulus would be expected to increase long-run GDP, employment, consumption and investment in Illinois (we assume no other changes in economic conditions so that all deviations from the base year data can be attributed solely to the export demand shock). However, we assume that there are short-run supply constraints: it takes time for investment to occur to increase capital stocks and also for labor stocks to increase through in-migration. In the first period after the demand stimulus occurs, the only excess capacity in primary inputs is unemployed labor. Thus, initially there is upward pressure on wages, capital rental rates and the price of output in all sectors, but particularly the targeted manufacturing sectors.

This is where the impact of varying the value of import elasticities is most important. In the simulations below, we focus our attention on the short-run and specifically on how the value assigned to the substitutability between Illinois and RUS intermediates impacts on input choices and output prices in the targeted sectors, and how these impact the returns to capital and labor driving the adjustment of the economy. Generally, under the assumption of cost minimization (or utility maximization), as capital and labor prices rise in the short run, there is upward pressure in the price of commodities produced in Illinois. This is dampened to the extent that producers can substitute away from value-added in favor of intermediates. As the price of goods and services produced in Illinois is pushed up, producers (and final consumers) will substitute in favor of imports from other US states in choosing their intermediate (goods and services) composite (and, to the extent

[3] In a fuller set of simulations (not reported here) we find that there is not a great deal of difference in CGE model results if we use the parameter estimates from Estimation Model 1 or 2.

that the US composite price is affected, in favor of ROW imports, though the dominance of US commodities in the intermediate composite of all sectors, the substitutability at this level of the production function is less important).[4]

<<Insert Table 6 here>>

In the first numerical column of Table 6 we report the impact of the 5% increase in ROW export demand on the use of imported intermediates from RUS in the targeted manufacturing sectors. Reading down from the AMOS default case we first impose only the estimated parameters and then a lower value of 0.5 for all the missing commodities. Observe that in each sector the increase in the use of RUS imports becomes smaller as the substitution effect becomes weaker.

However, examining the results for the use of Illinois commodities, while the substitution effect is negative (for sectors not directly targeted with the shock, this generally dominates, leading to a short run net decrease in the use of Illinois commodities), positive income effects from the exogenous increase in export demand causes a greater increase the lower the substitution elasticity. This is because local production is effectively protected in so far as, the more limited the ability to substitute in in favor of imports means that local producers must draw on local intermediates to meet increased consumption demand. This, in turn, is what causes the price of output in the targeted sectors to increase more with lower the import elasticities.

While the larger increase in output prices with lower elasticities restricts the growth of exports in response to the shock (because of the endogenous export demand response acting to offset the exogenous shock) it acts to increase the return on capital in each sector. This triggers a faster investment response where substitutability is lower. Moreover, the greater short-run increase in labor demand pushes the real wage level up and the unemployment rate down more quickly, so that a faster migration response also occurs. Thus, despite the initial spike in local prices and reduced competitiveness in the short-run, supply constraints are relaxed faster under the more restricted import elasticity,

[4] Again, in simulations not reported here, this conclusion has been tested but not reported here due to the constraints of space.

so that the adjustment to a new long-run equilibrium is faster.

6. Conclusions

The econometric analysis conducted in this paper suggests that the interregional trade of transportation equipment, non-metallic mineral product, food and tobacco product and machinery and electric equipment are more sensitive to price differences than other commodities. Conversely, we find that more natural-resources based commodities have lower price elasticities. A possible explanation is that production of these commodities is regionally specialized and trade in them less dependent on price. These findings and interpretations seem to be consistent with the examination of Midwestern trade flows by Munroe et al. (2007). Using a Grubel-Lloyd Index, they show that Illinois appears to have high trade overlap in high-tech industries (e.g. food products, fabricated metal products, and machinery) and more specialized trade in low-tech industries (e.g. fish, coal, ordinance or accessories, petroleum or coal, and clay, concrete, class or stone).

Additionally, the interregional trade elasticities estimated here tend to be lower than those estimated with US data or international trade data elsewhere in the literature. Our results are consistent with the conclusions of Bilgic et al. (2002), who argue that trade elasticities for a regional CGE model should be considered less sensitive to differences in prices of intraregional trade goods versus interregional trade goods than in the country or international cases. This is in contrast with the more general expectation that regional trade elasticities should find their lower bound in international trade elasticities. A possible explanation as to why regional trade elasticities may be less price responsive than comparable commodity group elasticities for the US national case, or for international trade, may be that regional economies tend to specialize, with the amount of interregional trade driven by non-price barriers and lower transport costs. One option in investigating further would be to formally separate out transport costs in the production function to test the degree to which changes in these costs influence the spatial choice of inputs. Haddad and Hewings (2005, 2007) test this argument in the context of a multiregional CGE model for Brazil.

The tests of the impact of introducing the estimated import elasticities into the Illinois CGE model demonstrate that these primarily impact on the initial response of the economy when labor and capital stocks are constrained. However, while more limited responsiveness to changes in Illinois prices does have implications in terms of competitiveness in the short-run, it also stimulates faster returns to factors of production, triggering a faster adjustment to a new long-run equilibrium. However, the CGE results also suggest that, while there is clear value added from the limited econometric parameterization reported here, it is important to attempt to widen the focus of econometric analysis to all sectors and commodities, including service sectors that are traded interregionally in the US. However, data availability is a problem in this respect, with the Commodity Flow Survey data here limited in terms of its scope.

References

Armington, P.S. (1969) A Theory of Demand for Products Distinguished by Place of Production. *International Monetary Fund Staff Papers*, 16, 159-176.

Bilgic, A., King, S., Lusby, A. and Schreiner, D.F. (2002) Estimation of U.S. Regional Commodity Trade Elasticities of Substitution. *The Journal of Regional Analysis and Policy*, 32, 79-98.

Blanchflower, D.G. and Oswald, A.J. (1994) *The Wage Curve*, M.I.T. Press, Cambridge, Massachusetts.

Bureau of Economic Analysis () Regional Economic Information System. Retrieved from http://www.bea.gov/regional/index.htm

Bureau of Labor Statistics () Quarterly Census of Employment and Wages. Retrieved from http://www.bls.gov/cew/data.htm

Bureau of Transportation Statistics (2005) Commodity Flow Survey 2002. Publication Number: C1-E02-ECFS-00-US1. Washington, D.C., Research and Innovative Technology Administration (RITA), U.S. Department of Transportation.

Chung, J.W. (1994) *Utility and Production Functions*. Blackwell, Cambridge, Massachusetts,.

DeVuyst, E.A., and P.V. Preckle (1997) Sensitivity Analysis Revisited: A Quadrature-Based Approach. *Journal of Policy Modeling*, 19, 175-185.

Dixon, P.B., M.T. Rimmer and M.E. Tsigas (2007) Regionalising Results from a Detailed CGE Model: Macro, Industry and State Effects in the U.S. of Removing Major Tariffs and Quotas. *Papers in Regional Science*, 86, 31-55.

Erkel-Rousse, H., and D. Mirza (2002) Import Price Elasticities: Reconsidering the Evidence. *Canadian Journal of Economics*, 35, 282-306.

Ferguson, L., D. Learmonth, P. McGregor, J.K. Swales and K. Turner (2007) The Impact of the Barnett Formula on the Scottish Economy: Endogenous Population and Variable Formula Proportions. *Environment and Planning A*, 39, 3008-3027.

Haddad E. A. and G.J.D. Hewings (2005) Market Imperfections in a Spatial Economy: Some Experimental Results. *The Quarterly Review of Economics and Finance* 45, 476-496.

Haddad E.A. and G.J.D. Hewings (2007) Analytically Important Transportation Links: A Field of Influence Approach to CGE Models. *Revista Brasileira de Estudos Regionais e Urbanos*, 1, 63-84.

Harrigan, F., P.G. McGregor, J.K. Swale, and N. Dourmashkin (1991) The Sensitivity of Output Multipliers to Alternative Technology and Factor Market Assumptions: A Computable General Equilibrium Analysis. In: Dewhurst J.H.L., R.C. Jensen, and G.J.D. Hewings (Eds.) *Regional Input-Output Modeling: New Development and Interpretation*. Aldershot, Avebury Press.

Harris, J.D. and M.P. Todaro (1970) Migration, Unemployment and Development: A Two Sector Analysis. *American Economic Review*, 60, 126-142.

Harrison, G.W. and H.D. Vinod (1992) The Sensitivity Analysis of Applied General Equilibrium Models: Completely Randomized Factorial Sampling Designs. *Review of Economics and Statistics*, 74, 357-362.

Harrison, G.W., R. Jones, L.J. Kimbell, and R. Wigle (1993) How Robust is Applied General Equilibrium Analysis? *Journal of Policy Modeling*, 15, 99-115.

Head, K. and T. Mayer (2000) Non-Europe: The Magnitude and Causes of Market Fragmentation in Europe. *Weltwirtschaftliches Archiv*, 136, 285–314.

Hertel, T.W. (1985) Partial vs. General Equilibrium Analysis and Choice of Functional

Form: Implications for Policy Modeling. *Journal of Policy Modeling*, 7, 281-303.

Hewings, G.J.D. and J.B. Parr (2009) The Changing Structure of Trade and Interdependence in a Mature Economy: The US Midwest. In: P. McCann (Ed.) *Technological Change and Mature Industrial Regions: Firms, Knowledge, and Policy*. Cheltenham, UK, Edward Elgar, 64-84.

Hoffman, S., S. Robinson, and S. Subramanian (2006) The Role of Defense Cuts in the California Recession Computable General Equilibrium Models and Interstate Factor Mobility. *Journal of Regional Science*, 36, 571-595.

Holland, D. (2010) What Happens when Exports Expand: Some Ideas for Closure of Regional Computable General Equilibrium Models. *Annals of Regional Science*, 45, 439-451.

Jones, R.W. and H. Kierzkowski (2005) International Fragmentation and the New Economic Geography. *North American Journal of Economics and Finance*, 16, 1-10.

Lawson, T. (1980) A 'Rational Modeling Procedure' (and the Estimating of Input-Output Coefficients). *Economics of Planning*, 16, 105-117.

Munroe, D.K., G.J.D. Hewings and D. Guo (2007) The Role of Intraindustry Trade in Interregional Trade in the Midwest of the U.S. In: Cooper, R.J., K.P. Donaghy and G.J.D. Hewings. (Eds.) *Globalization and Regional Economic Modeling*. Berlin, Springer.

Partridge, M.D. and D.S. Rickman. (1998) Regional Computable General Equilibrium Modeling: A Survey and Critical Appraisal. *International Regional Science Review*, 21, 205–248.

Partridge, M.D. and D.S. Rickman. (2010) Computable General Equilibrium (CGE) Modeling for Regional Economic Development Analysis. *Regional Studies*, 44, 1311-1328.

Reinert, K.A. and D.W. Roland-Holst (1992) Armington Elasticities for United States Manufacturing Sectors. *Journal of Policy Modeling*, 14, 531-639.

Romero, I., H.W.A. Dietzenbacher and G.J.D. Hewings. (2009) Fragmentation and Complexity: Analyzing Structural Change in the Chicago Regional Economy. *Revista de Economía Mundial*, 23, 263-282.

Seung, C.K., and E.C. Waters (2010) Evaluating Supply-Side and Demand-Side Shocks for Fisheries: A Computable General Equilibrium (CGE) model for Alaska. *Economics Systems Research*, 22, 87-109.

Shiells, C.R. and K.A. Reinert (1993) Armington Models and Terms-of-Trade Effects: Some Econometric Evidence for North America. *Canadian Journal of Economics*, 26, 299-316.

Shiells, C.R., R.M. Stern, and A.V. Deardorff. (1986) Estimates of the Elasticities of Substitution between Imports and Home Goods for the United States. *Review of World Economics*, 122, 497-519.

Stern, R.M., J. Francis and B. Schumacher (1976) *Price Elasticities in International Trade: An Annotated Bibliography*. London, Macmillan Press.

Appendix 1. Sectoral breakdown of the Illinois CGE Model (AMOIL)

Illinois CGE sector
01. Agriculture, Forestry, Fish & Hunting
02. Oil & Gas Extraction
03. Mining (except Oil and Gas)
04. Support Activities for Mining
05. Electricity
06. Natural Gas
07. Water, sewage and other systems
08. Construction
09. Food, Beverage, and Tobacco Product Manufacturing
10. Textile, Apparel, and Leather Product Manufacturing
11. Paper Manufacturing and Printing Related Activities
12. Chemical Products Manufacturing
13. Primary Metal and Metal Product Manufacturing
14. Machinery and Equipment Manufacturing
15. Wood, Furniture, and Miscellaneous Manufacturing
16. Wholesale trade
17. Retail trade
18. Transportation and warehousing
19. Finance, insurance, and Management of companies/enterprises
20. Educational services
21. Health care and social assistance
22. Accommodation and food services
23. All Other Services, including Information, Real Estate & Rental, Professional & Tech Services etc
24. Government Enterprises

APPENDIX 2. A CONDENSED VERSION OF AMOIL

Equations	Short run
(1) Gross Output Price	$pq_i = pq_i(pv_i, pm_i)$
(2) Value Added Price	$pv_i = pv_i(w_n, w_{k,i})$
(3) Intermediate Composite Price	$pm_i = pm_i(pq)$
(4) Wage setting	$w_n = w_n\left(\frac{N}{L}, cpi, t_n\right)$
(5) Labor force	$L = \bar{L}$
(6) Consumer price index	$cpi = \sum_i \theta_i \; pq_i + \sum_i \theta_i^{RUS} \bar{pq}_i^{RUS} + \sum_i \theta_i^{ROW} \bar{pq}_i^{ROW}$
(7) Capital supply	$K_i^s = \bar{K}_i^s$
(8) Capital price index	$kpi = \sum_i \gamma_i \; pq_i + \sum_i \gamma_i^{RUS} \bar{pq}_i^{RUS} + \sum_i \gamma_i^{ROW} \bar{pq}_i^{ROW}$
(9) Labor demand	$N_i^d = N_i^d(V_i, w_n, w_{k,i})$
(10) Capital demand	$K_i^d = K_i^d(V_i, w_n, w_{k,i})$
(11) Labor market clearing	$N^s = \sum_i N_i^d = N$
(12) Capital market clearing	$K_i^s = K_i^d$
(13) Household income	$Y = \Psi_n N w_n (1-t_n) + \Psi_k \sum_i \bar{w}_{k,i}(1-t_k) + \bar{T}$
(14) Commodity demand	$Q_i = C_i + I_i + G_i + X_i + R_i$
(15) Consumption Demand	$C_i = C_i\left(pq_i, \bar{pq}_i^{RUS}, \bar{pq}_i^{ROW}, Y, cpi\right)$

(16) Investment Demand	$I_i = I_i\left(pq_i, \bar{p}q_i^{RUS}, \bar{p}q_i^{ROW}, \sum_i b_{i,j} I_j^d\right)$ $I_j^d = h_j\left(K_j^d - K_j\right)$
(17) Government Demand	$G_i = \bar{G}_i$
(18) Export Demand	$X_i = X_i\left(p_i, \bar{p}_i^{RUS}, \bar{p}_i^{ROW}, \bar{D}^{RUS}, \bar{D}^{ROW}\right)$
(19) Intermediate Demand	$R_{i,j}^d = R_i^d\left(pq_i, pm_j, M_j\right)$ $R_i^d = \sum_j R_{i,j}^d$
(20) Intermediate Composite Demand	$M_i = M_i\left(pv_i, pm_i, Q_i\right)$
(21) Value Added Demand	$V_i = V_i\left(pv_i, pm_i, Q_i\right)$
Multi-period model	**Stock up-dating equations**
(22) Labor force	$L_t = L_{t-1} + nmg_{t-1}$
(23) Migration	$\frac{nmg}{L} = nmg\left(\frac{w_n(1-t_n)}{cpi}, \frac{w_n^{RUS}(1-t_n)}{cpi^{RUS}}, u, u^{RUS}\right)$
(24) Capital Stock	$K_{i,t} = (1-d_i)K_{i,t-1} + I_{i,t-1}^d$

NOTATION

Activity-Commodities

i, j are, respectively, the activity and commodity subscripts (There are twenty-four of each in AMOIL: see Appendix 1)

Transactors

RUS = Rest of the US, ROW = Rest of World

Functions

pm (.), pq(.), pv(.)	CES cost function
k^S(.), w(.)	Factor supply or wage-setting equations
K^d(.), N^d(.), R^d(.)	CES input demand functions
C(.), I(.), X(.)	Armington consumption, investment and export demand functions, homogenous of degree zero in prices and one in quantities

Variables and parameters

C	consumption
D	exogenous export demand
G	government demand for local goods
I	investment demand for local goods
I^d	investment demand by activity
K^d, K^S, K	capital demand, capital supply and capital employment
L	labor force
M	intermediate composite output
N^d, N^S, N	labor demand, labor supply and labor employment
Q	commodity/activity output
R	intermediate demand
T	nominal transfers from outwith the region
V	value added
X	exports
Y	household nominal income
b_{ij}	elements of capital matrix
cpi, kpi	consumer and capital price indices
d	physical depreciation
h	capital stock adjustment parameter

nmg	net migration
pm	price intermediate composite
pq	vector of commodity prices
pv	price of value added
$\mathbf{t_n, t_k}$	average direct tax on labor and capital income
u	unemployment rate
$\mathbf{W_n, W_k}$	price of labor to the firm, capital rental
Ψ	share of factor income retained in region
θ	consumption weights
γ	capital weights

Table 1 Import elasticity estimates using Estimation Model 1 (Equation 8)

	Commodity	Elasticity σ	Market Size δ_1	Distance Factor δ_2	R^2
1	Agriculture, Forestry, Fish & Hunting	0.919*** *0.156*	2.699*** *0.165*	2.282*** *0.111*	0.962
2, 3, 4	Oil & Gas Extraction, Mining, and Support Activities for Mining	0.814*** *0.082*	0.968*** *0.138*	3.401*** *0.092*	0.927
9	Food, Beverage and Tobacco Products Manufacturing	1.282*** *0.169*	0.513*** *0.100*	1.022*** *0.106*	0.880
10	Textile, Apparel, and Leather Product Manufacturing	0.068* *0.112*	9.909*** *0.050*	17.287 *0.048*	0.926
11	Paper Manufacturing and Printing Related Activities	0.850*** *0.076*	1.099*** *0.080*	1.327*** *0.070*	0.910
12	Chemical Products Manufacturing				
12a	Chemical and Petroleum Products	0.712*** *0.055*	1.336*** *0.064*	1.746*** *0.074*	0.956
12b	Non-Metallic Mineral Products	1.357*** *0.083*	0.489*** *0.094*	0.945*** *0.099*	0.985
13	Primary Metal and Metal Product Manufacturing	0.922*** *0.078*	1.057*** *0.078*	1.390*** *0.056*	0.977
14	Machinery and Equipment Manufacturing				
14a	Machinery and Electric Equipment	1.012*** *0.090*	0.986*** *0.072*	0.898*** *0.067*	0.932
14b	Transportation Equipment	1.517*** *0.231*	0.415*** *0.079*	0.922*** *0.063*	0.926
14c	Medical, Precision and Optical Instrument	0.286*** *0.102*	2.428*** *0.047*	2.722*** *0.023*	0.946
15	Wood, Furniture, and Miscellaneous Manufacturing				
15a	Wood Products and Furniture	0.941*** *0.079*	1.082*** *0.126*	1.343*** *0.088*	0.770
15b	Miscellaneous Manufacturing	0.619*** *0.121*	1.506** *0.058*	1.919*** *0.068*	0.973

1) Standard errors are in Italics

2) *** significant at 1%, ** at 5%, and * at 10%

Table 2 Import elasticity estimates using Model 2 (equation 10)

	Commodity	Elasticity σ	Market size δ_1	Distance factor δ_2	R^2
1	Agriculture, Forestry, Fish & Hunting	0.645** *0.302*	3.458*** *0.431*	1.403*** *0.283*	0.663
2, 3, 4	Oil & Gas Extraction, Mining, and Support Activities for Mining	0.963*** *0.147*	0.669*** *0.254*	0.974** *0.383*	0.723
9	Food, Beverage and Tobacco Products Manufacturing	1.093*** *0.229*	1.329*** *0.288*	0.900*** *0.278*	0.410
10	Textile, Apparel, and Leather Product Manufacturing	0.421* *0.251*	1.512*** *0.132*	0.062 *0.191*	0.561
11	Paper Manufacturing and Printing Related Activities	0.868*** *0.086*	1.611*** *0.118*	0.772*** *0.122*	0.809
12	Chemical Products Manufacturing				
12a	Chemical and Petroleum Products	0.675*** *0.076*	1.935*** *0.093*	0.682*** *0.113*	0.830
12b	Non-Metallic Mineral Products	2.169*** *0.125*	0.443*** *0.242*	0.047 *0.106*	0.953
13	Primary Metal and Metal Product Manufacturing	1.016** *0.169*	1.245*** *0.168*	0.349** *0.181*	0.812
14	Machinery and Equipment Manufacturing				
14a	Machinery and Electric Equipment	1.336*** *0.117*	0.753*** *0.158*	0.065 *0.159*	0.791
14b	Transportation Equipment	1.905*** *0.338*	0.491*** *0.129*	0.184** *0.149*	0.759
14c	Medical, Precision and Optical Instrument	0.186 *0.330*	2.884* *0.316*	0.535 *0.374*	0.567
15	Wood, Furniture, and Miscellaneous Manufacturing				
15a	Wood Products and Furniture	0.947*** *0.084*	1.416*** *0.170*	0.433*** *0.151*	0.778
15b	Miscellaneous Manufacturing	1.007*** *0.283*	1.098*** *0.200*	0.167 *0.234*	0.638

1) Standard errors are in Italics
2) *** significant at 1%, ** at 5%, and * at 10%

Table 3 Comparison of current study import elasticity estimates with others

Sector	Commodity	Eq. 8	Eq. 10	Bilgic et al. (2002)	Reinert and Roland-Holst (1992)	Shiells et al. (1983)	Erkel-Rousse and Mirza (2002)
1	Agriculture, Forestry, Fish & Hunting	0.919	0.645	1.477	N/A	N/A	N/A
2, 3, 4	Oil & Gas Extraction, Mining, and Support Activities for Mining	0.814	0.963	1.837	1.012	N/A	N/A
9	Food, Beverage, and Tobacco Product Manufacturing	1.282	1.093	0.516	1.049	0.338	0.75~ 3.898
10	Textile, Apparel, and Leather Product Manufacturing	0.068	0.421	0.290~ 0.625	0.815~ 0.858	1.620~ 2.580	0.625~ 6.258
11	Paper Manufacturing and Printing Related Activities	0.850	0.868	1.184	1.351	1.800	1.023~ 5.687
12	Chemical Products Manufacturing						
	(Chemical and Petroleum Products)	0.712	0.675	0.891~ 2.872	0.400~ 1.097	6.740~ 6.979	1.021~ 5.881
	(Non-Metallic Mineral Products)	1.357	2.169	0.843~ 1.106	0.661~ 0.706	1.540~ 2.696	0.758~ 12.695
13	Primary Metal and Metal Product Manufacturing	0.922	1.016	1.745	0.915	2.598	0.927~ 5.146
14	Machinery and Equipment Manufacturing						
	(Machinery and Electric Equipment)	1.012	1.336	0.596~ 0.848	0.347~ 0.834	3.340~ 7.460	0.781~ 2.511
	(Transportation Equip)	1.517	1.905	0.600	0.969	3.010	0.793~ 7.547
	(Medical, Precision and Optical Instrument)	0.286	0.186	0.396	0.788	0.450	0.986~ 2.176
15	Wood, Furniture, and Miscellaneous Manufacturing						
	(Wood Products and Furniture)	0.941	0.947	0.931~ 1.429	0.050~ 1.838	0.260~ 12.130	0.898~ 9.583
	(Miscellaneous Manufacturing)	0.619	1.007	0.654	0.140	3.550	0.861~ 1.607
Country/region estimates apply to		IL		US (all states)	US national	US national	OECD countries

Table 4. Overview of assumptions in the Illinois CGE model

Variable	Assumption
Domestic transactors	Three groups: the household sector; firms; and government
Commodities/activities	24 in total (see Appendix 1)
Final demand	Four components: household consumption (a linear homogeneous function of real disposable income); investment (see under 'capital stock' below); government expenditure (exogenous in this application); and export demand
External transactors	Two exogenous external transactors: the Rest of the US (RUS) and the Rest of the World (ROW), with demand for exports and imports sensitive to changes in relative prices between (endogenous) domestic/regional and (exogenous) external prices.
Production costs	Cost-minimization in production regardless of the choice of other values
Production structure	A multi-level nested function in each production sector, where output is a combination of value-added (capital and labor) and intermediate inputs. The intermediates composite is a combination of (composite) imports from ROW and US intermediates, with the latter a combination of composite imports from RUS and domestic production. The functional form at each nest is generally CES, with Leontief and Cobb Douglas available as special cases.
Capital stock	Updated between time periods to ensure that investment equals depreciation plus some fraction of the gap between the desired and actual capital stock
Labor market	A single Illinois labor market with perfect sectoral mobility and real wages determination via a regional bargaining closure, with a negative relationship between the unemployment and real wage rate (Blanchflower and Oswald, 1994)
Migration	Endogenous, with the population update between time periods related to the real wage differential and the unemployment rate differential between Illinois and RUS (Harris and Todaro, 1970)

Table 5. Weighted import elasticity estimates

		Model 1 results			Model 2 results		
		Elasticity values imposed for missing commodities			Elasticity values imposed for missing commodities		
Sector	Amos	0.5	1	2	0.5	1	2
1	2	0.817	1.002	1.370	0.786	0.971	1.339
2	2	0.622	0.967	1.657	0.684	1.029	1.718
3	2	0.667	0.947	1.508	0.748	1.028	1.589
4	2	0.698	0.981	1.545	0.796	1.079	1.643
5	2	0.667	0.927	1.446	0.754	1.013	1.533
6	2	0.716	0.880	1.208	0.819	0.983	1.312
7	2	0.532	0.998	1.929	0.551	1.016	1.948
8	2	0.722	0.970	1.466	0.849	1.097	1.593
9	2	0.896	1.049	1.354	0.805	0.957	1.262
10	2	0.586	0.785	1.183	0.784	0.983	1.381
11	2	0.723	0.935	1.360	0.782	0.994	1.419
12	2	0.804	0.964	1.282	0.995	1.154	1.473
13	2	0.754	0.957	1.362	0.832	1.035	1.441
14	2	0.781	0.959	1.313	0.906	1.083	1.438
15	2	0.716	0.924	1.339	0.802	1.009	1.424
16	2	0.549	0.991	1.876	0.576	1.019	1.904
17	2	0.532	0.989	1.902	0.551	1.008	1.921
18	2	0.653	0.998	1.689	0.751	1.096	1.786
19	2	0.508	0.998	1.979	0.511	1.001	1.982
20	2	0.585	1.014	1.871	0.587	1.015	1.873
21	2	0.616	0.998	1.761	0.668	1.050	1.813
22	2	0.725	1.053	1.709	0.704	1.032	1.688
23	2	0.545	0.993	1.888	0.568	1.015	1.911
24	2	0.668	0.987	1.624	0.769	1.087	1.724
HH	2	0.592	1.010	1.816	0.616	1.024	1.839
GOVT	2	0.558	0.995	1.869	0.583	1.020	1.894
CAPITAL	2	0.636	0.976	1.654	0.701	1.040	1.719

Table 6. Impacts of a 5% increase in ROW export demand for Illinois manufacturing sectors on key adjustment variables

	AMOS default model					
	Use of intermediates			Investment	Migration function	
	RUS	Illinois	Price output	Return on Capital	Real TH wage	Unemployment rate
Targetted sectors						
Food, Beverage, and Tobacco Product	0.501	0.278	0.111	1.377		
Textile, Apparel, and Leather Product	0.865	0.532	0.166	2.414		
Paper Manufacturing and Printing Related	0.252	0.017	0.118	0.526		
Chemical Products	1.422	0.023	0.697	2.278		
Primary Metal and Metal Product	0.379	0.007	0.186	0.863		
Machinery and Equipment	2.054	0.517	0.762	4.541		
Wood, Furniture, and Miscellaneous	1.323	0.054	0.632	2.475		
Labour migration function					0.050	-0.441

	Estimation Model 1 (missing commomodities 2.0)					
	Use of intermediates			Investment	Migration function	
	RUS	Illinois	Price output	Return on Capital	Real TH wage	Unemployment rate
Targetted sectors						
Food, Beverage, and Tobacco Product	0.472	0.315	0.116	1.392		
Textile, Apparel, and Leather Product	0.786	0.580	0.173	2.415		
Paper Manufacturing and Printing Related	0.209	0.040	0.124	0.495		
Chemical Products	1.139	0.181	0.745	2.426		
Primary Metal and Metal Product	0.328	0.070	0.190	0.850		
Machinery and Equipment	1.791	0.748	0.787	4.654		
Wood, Furniture, and Miscellaneous	1.103	0.227	0.652	2.520		
Labour migration function					0.056	-0.494

	Estimation Model 1 (missing commomodities 0.5)					
	Use of intermediates			Investment	Migration function	
	RUS	Illinois	Price output	Return on Capital	Real TH wage	Unemployment rate
Targetted sectors						
Food, Beverage, and Tobacco Product	0.462	0.342	0.133	1.432		
Textile, Apparel, and Leather Product	0.715	0.598	0.200	2.386		
Paper Manufacturing and Printing Related	0.139	0.030	0.150	0.376		
Chemical Products	0.960	0.300	0.819	2.616		
Primary Metal and Metal Product	0.265	0.112	0.203	0.789		
Machinery and Equipment	1.599	0.937	0.841	4.808		
Wood, Furniture, and Miscellaneous	0.910	0.398	0.712	2.629		
Labour migration function					0.082	-0.719