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Abstract

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; parameter estimates; regional modeling; Armington import elasticities

JEL classification: C51, C68, D58, R13, F10

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1. Introduction

One of the main issues in any economic model is the problem that uncertainty and errors exist in data, assumptions and estimations. Input-output models, commonly used to analyze the regional economic impact of policy changes, are linear and impose significant rigidities, including fixed prices, zero-substitution elasticities in consumption and production and multipliers estimated by taking the Leontief inverse of the estimated input-output coefficients. These rigidities are usually viewed as the trade-off necessary to achieve a more complete depiction of sectoral linkages. Therefore, since the beginning of its application, many studies pointed out several sources of the uncertainty and errors and developed the methodologies to solve bias and sensitivity of multipliers in input-output analysis, for example, addictive and multiplicative method (Lawson, 1980), over-and under-estimation of the Leontief inverse (Lahiri and Satchell, 1985), and field of influence analysis (Sonis and Hewings, 1992).

On the other hand, computable general equilibrium (CGE) models allow analysts to relax some of the rigidities of input-output model while retaining depiction of sectoral linkages, by introducing nonlinear functions in production and consumption and allowing endogenously determined prices. In addition to the problems associated with the input-output framework (which is embedded as the core database of a CGE model), the uncertainty in CGE models is further compounded by a variety of estimated or imposed features of the model. Harrison *et al*. (1993) categorized them into: (1) the equilibrium structure imposed on the model; (2) the functional forms used to represent tastes and technology; and (3) the empirical magnitudes inherent in the models (elasticity and share parameters).

Acknowledging these inherent problems, many variations of CGE models of the U.S. national economy have demonstrated the value of these systems for 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.[1] At the regional level, the analyses of those effects within countries have been more limited and problematic (Holland, 2009; Partridge and Rickman, 1998, 2008). Part of the reason for the lack of regional CGE studies (examples include Dixon *et al*, 2007; Witter *et al*, 2010; Vargas *et al*, 1999; Hoffmann *et al*, 2006; Seung *et al*, 2010) can be attributed to the fact that the necessary regional data are either not available or not available in a suitable form, and 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 researches have tested the uncertainty and errors

[1] See Shoven and Walley (1972) and more recent works such as De Melo and Tarr (1992), Goulder (1995) Jorgenson and Wilcoxen, (1993), and Rose and Oladosu, (2002).

surrounding these parameters in terms of their impact on the model (Hertel, 1985; Harrison and Vinod, 1992; Harrison *et al*., 1993; Wigle, 1991; Arndt, 1996; DeVuyst and Preckel, 1997; Domingues *et al*., 2004). 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. Thus, sensitivity analysis should always be included to improve the understanding of the relationships between input and output in the structure of CGE model (for example, see Turner, 2009), even where parameter estimation is not possible.

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 variables such as the trade balance, levels of income, employment etc will depend on the magnitude of key price elasticities and other parameters adopted in the model. In this paper, the focus is on the estimation of regional trade (import) substitution parameters for the Illinois economy. We focus on import substitution parameters because these are generally important in analysis for regional economies, which tend to be more open than national economies. Specifically, we direct our attention to the estimation of 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. In section 2, the theoretical background for the regional import elasticity estimates is provided. The analytical model and data used in our econometric estimation in are described in section 3, with results of the parameter estimation in section 4. In Section 5, we introduce the Illinois CGE model and test the impact of introducing the estimated parameter values. Some conclusions in section 6 complete the paper.

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 firm 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. This is commonly identified as an 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 technology 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, consumers 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*:

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

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:

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

that 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 U.S. have appeared over the last few decades. One of well-known studies for U.S. imports-demand elasticities was carried out by Stern *et al*. (1976). They offer estimates of U.S. 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) used quarterly data over the period 1980-1988 and obtained estimates for 128 mining and manufacturing sector outputs according to three different specification: 1) generalized-least-squares using a Cobb-Douglas price aggregator; 2) maximum-likelihood estimation, using a CES price aggregator; and 3) simultaneous equation estimation using a Cobb-Douglas price aggregator and a distributed lag model. As one of the most widely cited studies in the literature, Reinert and Roland-Holst (1992) estimated 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, they 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, or, alternatively, a Cobb-Douglas production function has been adopted in which the elasticity of substitution equals one.

3. Econometric model and data

To estimate regional import elasticities using the regional data for the Illinois CGE model (outlined below), data are selected from published information on 2002 commodity flows data (Commodity Flow Survey 2002 CD, Bureau of Transportation Statistics) 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 & Mirza (2002). For the first specification, a CES function is adopted to represent the direct commodity satisfaction (utility) index (applying to all consumers, intermediate or final: data are not available to estimate for different consumers individually):

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

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:

$$M_{ILk} = \sum_{j} P_{ILijk} X_{ILjk} \tag{4}$$

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

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

where $m = \left[\frac{\beta_{1k}}{\beta_{2k}} \right]$, $\sigma = [1/(1-\rho)]$ 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 j^{th} region and k^{th} commodity:

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

where m depends on states' characteristics defined as Q_{jk} and d_{ILj}, which represent market size and distance factor, respectively[2] and δ_s is the set of parameters associated with state j characteristics.

The market size factor is included as an explanatory variable to capture the share of the amount of intraregional demand to interregional demand. Presumably, 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

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

increases.[3] Distance is calculated as the centroid distance between Illinois and the other 49 states. Taking natural logs of both sides of equation (5) produces:

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

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 $\alpha_0 = \sigma\delta_0$, $\alpha_1 = \sigma\delta_1$, $\alpha_2 = \sigma\delta_2$,

$\ln\left[\frac{P_{jk}}{P_{ILk}}\right]$ is the natural log of the price ratio for interregional goods to intraregional goods.

$\delta_0 = \frac{\hat{\alpha}_0}{\hat{\sigma}}$, $\delta_1 = \frac{\hat{\alpha}_1}{\hat{\sigma}}$ *and* $\delta_2 = \frac{\hat{\alpha}_2}{\hat{\sigma}}$

The estimated parameters capture the effects of market size and distance as well as the constant term. The left hand side of equation (8) is the natural log of the ratio of the demand for

[3] Analysis of the 1993 and 1997 CFS data revealed that almost 40% of Illinois interregional imports and exports were with the other Midwest states of Wisconsin, Indiana, Ohio and Michigan (Munroe *et al*, 2007) and 2002 CFS data shows 31-39% of Illinois interregional imports and exports were with other Midwest states. In the 2007 Illinois SAM data used for the CGE model, interregional imports and exports with other Midwest states in the US are respectively 20% and 24% of total trade flows with other US states. These data reflect the greater sectoral coverage of the CGE model relative to the activities that our econometric estimates cover.

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 *j* state 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 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). Elastities 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 greater probability level in the results of estimating equation (8) and, for the equation (10), only the estimated elasticity for Textile, Apparel, and Leather Product Manufacturing is not statistically significant at the 10 percent level. The estimation from the equation (8) (Estimation Model 1) presents 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 the equation (10) – where Estimation Model 2 adds a weighted distance function (with the centroid distance function in Model 1 replaced with one also weighted by population and employment) – are higher than those resulting from the Estimation Model 1 (which takes the centroid distance). 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 the 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>>

The coefficient for market size is statistically significant at the 10 percent probability level and positive. The interpretation of this elasticity is that the 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 lower 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 (Estimation Model 1) shows that the result is statistically significant and positive for 8 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 not higher than the price elasticities in Food, Beverage, and Tobacco Product Manufacturing and Transportation Equipment. From this result, it could be inferred that these two commodity goods 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, 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. See Table 3. 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). Tobacco Products are 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.

<<insert table 3 here>>

<<insert table 4 here>>

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).[4] 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 (in the context of the US as a whole – about 3% of national GNP) open regional economy such as the Illinois region. Detailed descriptions of the single region AMOS modeling framework can be found in Harrigan *et. al*. (1991), Hanley *et al*. (2009) and Ferguson *et al*. (2007). Here an overview of the model is given in Table 4, with a condensed listing of the most important model equations in Appendix 2.

The key point for the testing of our estimated import elasticities is the specification of the production function and determination of the cost 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 elasticity of substitution of 0.3 applies at each of these nests throughout (this is the default AMOS value, previously applied for UK regions and based on Harris, 1989). [5]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

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[4] 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).

[5] These parameters should subject to region-specific estimation in future work.

where the default AMOS value is generally taken to be 2.0 (again, based on UK regional estimates – Gibson, 1990). 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 in favor of RUS goods (the price of which, as with ROW imports, is exogenous). The degree of substitution is governed by the value attached to the elasticity of substitution in this CES function, or the Armington import elasticity. 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. Similarly, in final consumption, a nested choice is made between Illinois, RUS and ROW commodities with a CES function at each level.

However, given that the current specification of the AMOS production and consumption functions involved composite goods rather than commodity level substitution possibilities between Illinois and RUS goods, we need to adjust the estimates reported in Tables 1 and 2 to input them to the model. We intend to make this specification more flexibile in future; however, the method reported here (although imperfect) allows us to examine the importance of our estimated results in an economy-wide modeling context.

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* (consuming sector/final consumption activity) use of IL commodity *i* plus RUS commodity *i*. The denominator is total intermediates from Illinois and RUS. We then take the vector of estimated commodity elasticites (for each 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. Given that we have not been able to estimate elasticities for all commodities, we impose values for the non-estimated or missing commodities. In order to gauge the impact of doing so, we assign three possible values for the import elasticities on the missing commodities: 0.5, 1, and 2. This is done for the results of both models in turn so that we have 6 versions of the import elasticity vector (2 sets of estimates and, within each, 3 cases for the missing commodities). The weighted elasticites are shown in Table 4. In the simulations, we also vary the import elasticity for the US-ROW combination.

For illustrative purposes, we introduce a simple demand shock. This takes the form of 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 to the Illinois economy would be expected to increase long-run GDP, employment, consumption and investment (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, in the short-run we assume that there are 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, in the early periods, after the demand stimulus, there is upward pressure on wages, capital rental rates and the price of output in all sectors, but particularly those manufacturing sectors directly impacted by the demand stimulus.

It is in this case that the impact of varying the value of import elasticities will be important. Under the assumption of cost minimization (or utility maximization), 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 that the US composite price is affected, in favor of ROW imports – a point we return to below). However, the lower the value attached to the import elasticity, the less able producers (and consumers) are able to do so, with the implication that there will be more upward pressure on the general price level in the Illinois economy. This is demonstrated in figure 1, where we take the consumer price index (CPI) as an indicator of the general price level in the Illinois economy. Here, we show the impact of introducing the Illinois-RUS import elasticity values reported in tables 1 and 2, under various assumptions about the values assigned for the 'missing' commodities for which we were unable to make estimates, and in comparison with the default parameters generally employed in the AMOS CGE modeling framework (see Turner, 2009). In a comparative scenario we impose the elasticity of 2.0 to the Illinois-RUS and US-ROW nests for all sectors and consumers; thereafter we relax this assumption for the Illinois-RUS nest for which we have estimated values.

Insert Figure 1 around here

The general result shown in figure 1 is that the lower the import elasticity value, the greater the short-run increase in the CPI (over time, given that we have assumed no long run constraints on the supply of labor and capital, and no other changes in economic conditions, all price return to their base year levels). However, what figure 1 also demonstrates is that it does not make a great deal of difference in a general equilibrium, or economy-wide, setting whether we use the results from Estimation Model 1 or 2 (where the latter has a more sophisticated treatment of distance). The most important factor is what we assume about the import elasticities for the commodities for which we were not able to generate estimate (generally services).

In terms of the wider macroeconomic impact, the sensitivity of the impact of the demand shock on Illinois GDP is shown in figure 2. The adjustment path of GDP will be directly affected by the change in prices, as will the long-run impact. In terms of the nature of the impact, the higher Illinois prices rise in the short-run, the greater is the negative competitiveness effect. Therefore, in the cases where we have imposed lower values to the Illinois-RUS import substitution elasticity (including the estimated parameters), there will be a greater reduction in RUS and ROW export demand for Illinois outputs. However, figure 2 shows that it is in these cases that GDP grows fastest. This is because the more limited substitution away from goods and services produced in Illinois protects local production in terms of local demands (intermediate, households, government and capital formation).

Insert Figure 2 around here

However, again the GDP impact of the demand shock has only very limited sensitivity to whether we use the results from Estimation Model 1 or 2, with the most important factor being what we assume about the non-econometrically estimated commodity import elastities.

Thus, the main conclusion of the CGE analysis is that estimation of import elasticities *is* important (though the results reported here suggest that treatment of distance therein is less important). The difference in the simulation results between the AMOS default case (all import elasticities set at 2.0) and the ones with Model 1 or 2 values for the commodities for which data allowed estimation, gives us a basic measure of value-added from the region-specific parameterization carried out here. However, it is also clearly important in such an economy-wide setting, that we need to be able to estimate a full range of import parameters (for all commodities and consumers). However, figure 3 suggests that it is less important, certainly in a regional setting such as Illinois to estimate elasticities for imports from ROW: here, we vary the ROW import elasticity between 0.5 and 2.0 across each of the 3 configurations for Model 1 (i.e. the different assumptions regarding the elasticity attached to the missing commodities). Of course, this result may be sensitive to the manner in which we have nested Illinois, RUS and ROW commodities (with combination of US and ROW composites, where changes in Illinois prices may not have a great impact on the price of the former). However, figure 4 shows that ROW imports account for a much smaller share of intermediates to production in Illinois.

Insert Figures 3 and 4 around here

6. Conclusions

Notwithstanding the fundamental difference in methodology and data between studies, the evidence from this analysis 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. Conversely, more natural-resources based industries are likely to have lower price elasticities, which implies that their trade is regionally specialized and less dependent on price. This interpretation that we obtain seems to match the exploration of Midwestern trade flows in Munroe *et al.* (2007). Using a Grubel-Lloyd Index, they shows 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, it should be noted that most of estimated interregional trade elasticities in each industry sector are positive but relatively lower than those estimated with US data or international trade data in other literature (see table 3). Compared to the US or international trade elasticities, this result suggests 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. A possible explanation is that regional trade elasticities are less elastic or less price responsive than comparable commodity group elasticities for US or international trade because the regional economy tends to specialize with the amount of interregional trade driven by non-price barriers and lower transport cost. One option 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; work by Haddad and Hewings (2005, 2007) has provided some testing in the context of a multiregional CGE model for Brazil. The role of lower transport costs, a prominent theme in new economic geography studies, has made possible sophisticated spatial organization of value chains; as noted earlier, much of the interregional trade in which Illinois participates is centered on exchange of intermediates. The sectors with the higher trade elasticities certainly conform to this characterization; that these elasticities are lower than those estimated at the national level may reflect some short-run frictions in the ability to substitute (as a result of plants specializing in subsets of the commodity space within any given sector to achieve scale economies). In essence, the Midwest economy of which Illinois is a part is one now characterized by both increasing complementarity between activities (through complex value chains) and increasing competition between states for the attraction and retention of components of these value chains.

The tests of the impact of introducing the estimated import elasticities into the Illinois CGE model demonstrate that these do impact the adjustment and magnitude of changes in key macroeconomic variables in response to an economic stimulus. However, the results also suggest that some elements of econometric specification that may be key in a micro setting may not be so important in a macro setting (here the difference in treatment of distance in the two estimation models). Moreover, the CGE results also suggest that, while there is clear value added from the limited econometric parameteriseation 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.

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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	$cpi = \sum_i \theta_i \; pq_i + \sum_i \theta_i^{RUS} \; \overline{pq}_i^{RUS} + \sum_i \theta_i^{ROW} \; \overline{pq}_i^{ROW}$
(7) Capital supply	$K_i^s = \bar{K}_i^s$
(8) Capital price index	$kpi = \sum_i \gamma_i \; pq_i + \sum_i \gamma_i^{RUS} \; \overline{pq}_i^{RUS} + \sum_i \gamma_i^{ROW} \; \overline{pq}_i^{ROW}$
(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	$Y = \Psi_n N w_n (1 - t_n) + \Psi_k \sum_i w_{k,i}(1 - t_k) + \bar{T}$
(14) Commodity demand	$Q_i = C_i + I_i + G_i + X_i + R_i$

(15) Consumption Demand	$C_i = C_i\left(pq_i, \bar{p}q_i^{RUS}, \bar{p}q_i^{ROW}, Y, cpi\right)$
(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

$\mathbf{b_{ij}}$	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
1	**Agriculture, Forestry, Fish & Hunting**	0.919***	2.699***	2.282***
		0.156	*0.165*	*0.111*
2, 3, 4	**Oil & Gas Extraction, Mining, and Support Activities for Mining**	0.814***	0.968***	3.401***
		0.082	*0.138*	*0.092*
9	**Food, Beverage and Tobacco Products Manufacturing**	1.282***	0.513***	1.022***
		0.169	*0.100*	*0.106*
10	**Textile, Apparel, and Leather Product Manufacturing**	0.068*	9.909***	17.287
		0.112	*0.050*	*0.048*
11	**Paper Manufacturing and Printing Related Activities**	0.850***	1.099***	1.327***
		0.076	*0.080*	*0.070*
12	**Chemical Products Manufacturing**			
	Chemical and Petroleum Products	0.712***	1.336***	1.746***
		0.055	*0.064*	*0.074*
	Non-Metallic Mineral Products	1.357***	0.489***	0.945***
		0.083	*0.094*	*0.099*
13	**Primary Metal and Metal Product Manufacturing**	0.922***	1.057***	1.390***
		0.078	*0.078*	*0.056*
14	**Machinery and Equipment Manufacturing**			
	Machinery and Electric Equipment	1.012***	0.986***	0.898***
		0.090	*0.072*	*0.067*
	Transportation Equipment	1.517***	0.415***	0.922***
		0.231	*0.079*	*0.063*
	Medical, Precision and Optical Instrument	0.286***	2.428***	2.722***
		0.102	*0.047*	*0.023*
15	**Wood, Furniture, and Miscellaneous Manufacturing**			
	Wood Products and Furniture	0.941***	1.082***	1.343***
		0.079	*0.126*	*0.088*
	Miscellaneous Manufacturing	0.619***	1.506**	1.919***
		0.121	*0.058*	*0.068*

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

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, Stern, and Deardorff (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	US	US	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)
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 (see below)
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
Migration	Endogenous, with the population update between time periods related to the real wage differential and the unemployment rate differential between Illinois and RUS

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

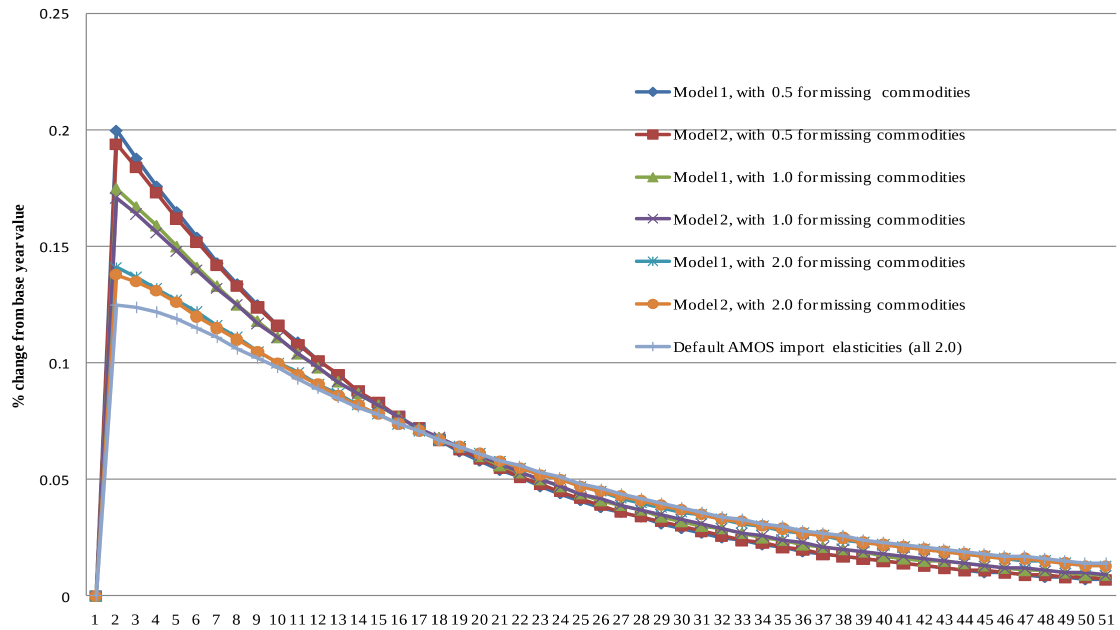

Figure 1. Sensitivity of CPI results for a 10% increase in ROW export demand for Illinois manufacturing to variations in the values of RUS import elasticity parameters

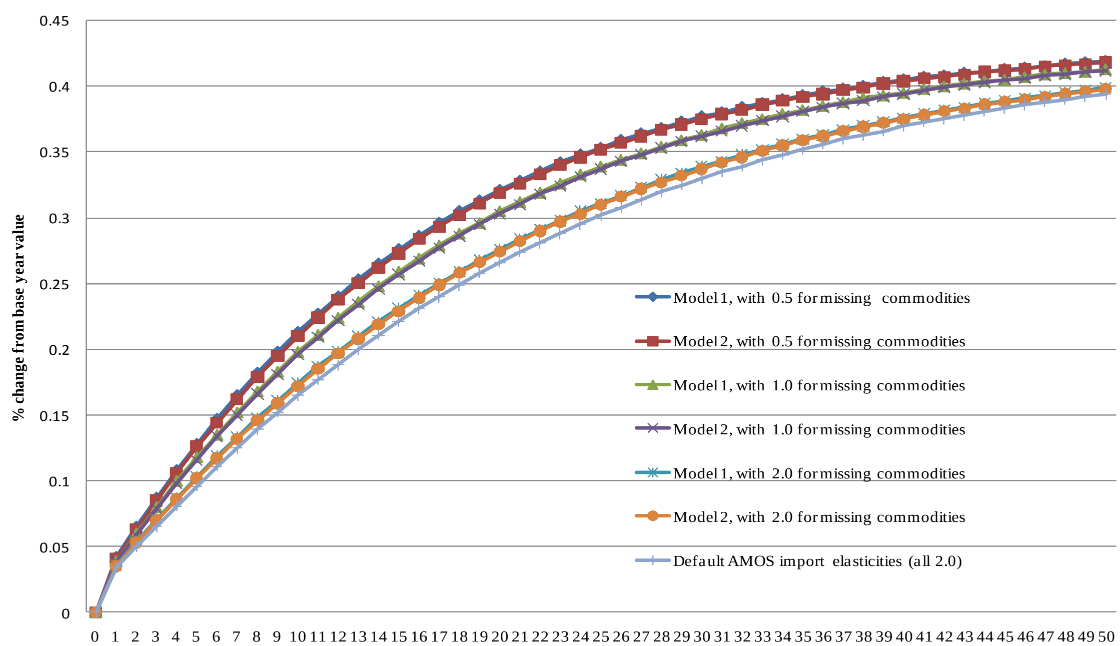

Figure 2. Sensitivity of GDP results for a 10% increase in ROW export demand for Illinois manufacturing to variations in the values of import elasticity parameters

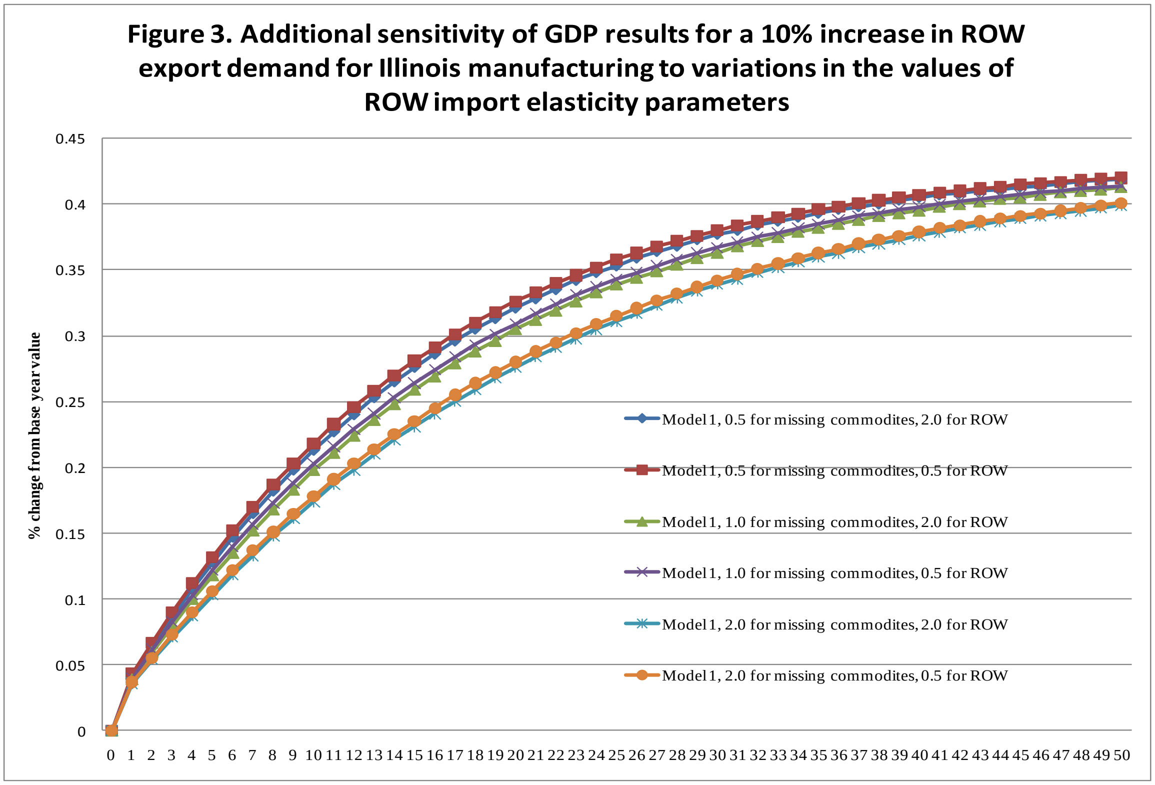

Figure 4. Share of Illinois, RUS and ROW goods and services in total intermediate demand of Illinois production sectors (2007)