Estimates of U.S. Regional Commodity Trade Elasticities of Substitution[*]

Abdulbaki Bilgic, Stephen King, Aaron Lusby and Dean F. Schreiner[1]

Abstract.   Countries and regions within countries frequently import and export from the same standard industrial classification (SIC) groupings. In describing international trade, the Armington assumption recognizes that imported goods may substitute imperfectly for domestically produced goods. Imports and domestically produced goods may differ in quality or composition. Elasticities of import substitution have been extensively estimated for international trade but limited information is available on elasticities of substitution for regional imports. One hypothesis in the literature is that international trade elasticities should be considered as lower bounds for regional trade elasticities presumably because of fewer non-price trade restrictions. This research estimates regional elasticities of import substitution for 20 two-digit groupings using commodity trade date in the U.S. The range in elasticities is from 0.45 to 2.80 depending on the characteristics of the SIC grouping. These results tend to refute the hypothesis that international trade elasticities are lower bounds for regional trade elasticities for comparable goods.

1. Introduction

Commodities produced at different locations are seldom perfect substitutes. Because of real or apparent differences, discriminating buyers evalu-

ate their willingness to substitute between imports and domestic goods within comparable product categories. This has led to the adoption of the Armington (1969) assumption, which recognizes that imports may substitute imperfectly for domestically produced products. Thus, there exists a potential for price differences between domestically produced and imported products from comparable product categories (Reinert and Roland – Holst, 1992). Consumers purchase quantities of domestic versus imported goods depending on their willingness to substitute and the ratio of the two prices.

Application of the Armington assumption has mainly been at the international level. Commodity trade among regions within the same country is a further level of application. Recent commodity flow data show that states export and import commodities from the same standard industrial classification (SIC) code (U.S. Department of Commerce, 1997). A primary reason for this substitution is quality differences among products. Differences in product mixes within the same category produced at each location may also account for imports and exports of the same category of goods.

Regional economic modeling, such as regional computable general equilibrium (RCGE), requires knowledge of the relationships describing regional commodity trade (Partridge and Rickman, 1998). The Armington assumption used in international trade is generally presented as a constant elasticity of substitution (CES), which empirically describes the willingness of consumers to substitute imports for domestic goods in the consumption of a fixed quantity of goods in a general category of products. These elasticities have been estimated for internationally traded commodities among countries. Unfortunately, elasticities have not been extensively estimated for trade among regions within the same country.

Practioners of RCGE modeling have generally assumed that the elasticities for international trade hold for regional trade. Berck et. al. (1996), in modeling California trade, use U.S. elasticities of import substitution and suggest that these elasticities are lower bounds for California because regions are probably more price sensitive than nations, perhaps because of fewer non-price trade restrictions. Results of regional elasticities of substitution are not available to test this hypothesis. An alternative hypothesis may be that regions are more specialized in the production of domestic commodities within a category of products (SIC) and thus less sensitive to differences in prices of domestically produced products versus regional imports.

The purpose of this research is to estimate elasticities of substitution for regionally produced versus imported products for U.S. regions (states) using recent commodity flow data. This data is based on the 1993 Commodity Flow Survey (CFS) published by the U.S. Department of Commerce (U.S. Department of Commerce, 1997).

The following section of this article reviews a selected number of CGE studies as to their source of elasticities of import substitution. The third section establishes the model of estimation for this study and describes the data

used for estimation. The fourth section presents the estimation results and compares the parameters with results from three national studies. The final section summarizes the results and suggests a central tendency and a range for the magnitude of elasticity parameters for six product categories.

2. Sources of Elasticities of Import Substitution

Regional studies frequently acquire estimates of elasticities of import substitution directly or indirectly from the literature on international trade (Table 1). Some of the common studies that serve as sources of elasticities of import substitution from international trade include: Reinert and Roland-Holst (1990); Roland-Holst, Reinert, and Shiells (1994); Shiells and Reinert (1993); Shiells, Stern and Deardorff (1983) and (1986); and Stern, Francis, and Schumacher (1976) and (1986). As shown in Table 1, regional CGE studies frequently cite directly international trade studies or indirectly through national CGE studies that use international trade elasticities of substitution.

The CGE model of de Melo and Tarr (1992) was used to analyze U.S. foreign trade policy. The basic model aggregates the U.S. economy into ten sectors: agriculture, food, mining, textiles and apparel, autos, iron and steel, other consumer goods, other manufactures, traded services, and construction and non-traded services. For analysis of efficient energy tax schemes, the model was further disaggregated by adding petroleum products and crude oil and natural gas. Three sets of elasticities were reported, central, low and high. Low and high elasticities were derived from a central elasticity estimate by subtracting or adding one standard deviation. The central elasticity estimates are the authors' preferred estimates.[2] The elasticities of substitution were interpolated from data in Shiells, Stern, and Deardorff (1986); Stern, Francis, and Schumacher (1976); and Dixon et al. (1982).

The CGE model by Dixon et al. (1982) on the Australian economy became operational in 1977 and has been used for many policy-oriented analyses. The model is not solely a national model, it also allows for a disaggregation of results to the regional (state) level. It is formally known as the ORANI model and grew out of the Johansen (1960) class of multi-sectoral models. ORANI allows for multi-product industries and multi-industry products. It incorporates detailed estimates of elasticities of substitution between domestically produced products and similar imported products. In standard applications, the ORANI model has 115 commodities and 113 industries and contains 113 parameters for the elasticity of substitution between domestic and foreign sources of supply.

---

[2] Tables of the elasticities for this study and the following studies are available from Stephen King.

[INSERT TABLES 1 & 2 HERE]

The following presents a review of seven regional CGE studies, giving the sources of elasticities of import substitution and their relative magnitudes. A summary of the CES trade parameters used in the regional studies is presented in Table 2. The elasticities for traded goods range from 1.5 to 3.5 and for services the elasticities range from 0.2 to 2.0.[3]

The first study comes from Berck et al. (1996). The California Dynamic Revenue Analysis Model (DRAM) is a CGE model for making dynamic revenue estimates. DRAM is a description of the relationships among California producers, households, government, and the rest of the world. For the DRAM model, the California economy was divided into 28 industrial sectors. In their review of the literature, import price elasticities estimated for the United States varied widely across sectors and no consistently observable sectoral patterns emerged. For DRAM, they chose the middle ground of published estimates obtained from recent studies on international trade. They make the assumption that California's trade patterns mimic U.S. trade and that true parameters for California resemble those of the U.S. At worst, they state that the U.S. estimates are lower bounds for California because there is good reason to believe that a region's goods are more price sensitive than those of a nation. Thus, for DRAM, they chose elasticities of substitution between domestic and import sources to be 1.5, except for less traded goods such as most services, which they set at 0.5. These parameter values are based on middle ground estimates from Reinert and Roland-Holst (1992), Shiells and Reinert (1993), and Roland-Holst, Reinert, and Shiells (1994).

The CGE model from Gazel (1996) was used to analyze the impact of free-trade-agreements (FTA) between Canada and U.S. subnational regions. The model included eight producing sectors: agriculture, construction, durables, nondurables, transportation, trade, finance, and services. Regional trade elasticity parameters were assumed to be equal to international elasticity parameters. The international trade elasticity parameters were based on estimates from Stern, Francis, and Schumacher (1986) but adjusted as needed. The actual CES estimates used were not reported.

Hoffman, Robinson and Subramanian (1996) created a 24-sector CGE model of California and used it to explore the impact of defense cuts on California's economy. The 24 producing sectors are agriculture, mining, construction, food manufacturing, textiles, wood, chemicals, metal, electric, machinery, cars, planes, ships, space, instruments, miscellaneous, transportation services, utilities, trade, housing, professional services, engineering services, other services, and public administration. No reference was made to the source or estimation of CES parameter estimates. A general reference to more specific detail about the model was made to Robinson, Hoffman, and Subramanian (1994).

---

[3] For some non-traded goods the elasticities are set to zero.

The multi-regional CGE model from Kraybill, Johnson, and Orden (1992) was used to evaluate consequences of federal budget and trade deficits on the state of Virginia. The model consists of five producing sectors: agriculture, forestry and wood products; mining and crude petroleum; apparel and textiles; other manufacturing; and services. Domestic regional trade elasticity parameters were initially set to international levels. The levels were set at 0.2 for services and 2.0 for the remaining sectors. These levels were obtained from the literature of Stern, Francis and Schumacher (1976), and Shiells, Stern, and Deardorff (1986). Kraybill, Johnson, and Orden then followed the procedure of Whalley and Trela (1986) to obtain the interregional estimates.

Morgan, Muti, and Partridge (1989) created a six-region CGE model of the United States to assess the potential long-run effects of state-local and federal tax policies on output and the allocation of factors across regions and sectors. The model consists of three "traded goods" sectors – agriculture, mining, and manufacturing; and four "non-traded goods" sectors – real estate, services, state-local public goods, and federal public goods. Following the Armington assumption, traded goods were assumed to be regionally differentiated and treated as highly substitutable but unique products. The reported elasticities of substitution between traded goods produced in different regions were 3.0.

The aggregate CGE model for Oklahoma by Schreiner, Marcouiller, Tembo, and Vargas (1999) serves as an educational tool in regional analysis. It has four sectors: agriculture, mining, manufacturing and services. A slightly expanded version by Vargas and Schreiner (1999) was used to evaluate imperfect markets in forest products. This version starts with the above four sectors but then disaggregates timber production from agriculture and wood processing from manufacturing. The CES trade parameters were based on de Melo and Tarr (1992).

Finally, the state-level CGE model by Waters, Holland, and Weber (1997) investigated economic adjustment to a property tax limitation in Oregon. The model consists of two sectors, one producing "goods" and the other producing "services". The CES estimates used in the study were obtained from de Melo and Tarr (1992) and set equal to 1.5 for the "goods" sector and 0.4 for the "services" sector.

3. Analytical Model and Data

Analytical Model

Trade theory and model estimation follow Reinert and Roland-Holst (1992) and Chung (1994). The direct commodity satisfaction (utility) index can be established as the quality-augmented CES function:

$$U_{jk} = \left(\sum_i \beta_{jk} X_{ijk}^{\rho_{jk}} \right)^{\frac{1}{\rho_k}} = \left(\beta_{1k} X^{\rho}_{jk} + \beta_{2k} X^{\rho}_{jk} \right)^{\frac{1}{\rho_k}} \tag{1}$$

where $j = 1,\ldots, r$ for region (state); $k = 1,\ldots n$ for commodity group; $\beta_{1k} + \beta_{2k} = 1$; ρ ? 1 is a substitution parameter; X_{1jk} refers to domestic commodity consumption of state j for commodity k; and X_{2jk} refers to import commodity consumption of state j for commodity k. The number of states for observed commodity consumption is limited to the 48 contiguous states.

The CES utility function, as a well-behaved function, embraces a set of demand equations, which are less restrictive than other linear logarithmic utility functions such as the Stone-Geary function, which is linear in terms of income, but may not be linear in terms of prices. The CES is linear in parameters, which is more easily estimated (Chung, 1994).

Maximizing equation (1) subject to the total expenditure constraint,

$$M_{jk} = \sum_i P_{ijk} X_{ijk} \tag{2}$$

produces a system of demands that predicts domestic and import consumption:

$$\left[\frac{X_{1jk}}{X_{2jk}}\right] = m^{\sigma}\left[\frac{P_{2jk}}{P_{1jk}}\right]^{\sigma} \tag{3}$$

where $m = \left[\dfrac{b_{1k}}{b_{2k}}\right]$, $s = [1/(1- r)]$ is the elasticity of substitution,

$P_{1jk} = \left[\dfrac{Domestic\ commodity\ k\ ton\ value}{Domestic\ commodity\ k\ weights}\right] * 1000$ is the unit price for j^{th} region

and k^{th} commodity domestic consumption, and

$P_{2jk} = \left[\dfrac{Import\ commodity\ k\ ton\ value}{Import\ commodity\ k\ weights}\right] * 1000$ is the unit price for import for j^{th}

region and k^{th} commodity. Let

$$m = \left[\frac{\beta_{1k}}{\beta_{2k}}\right] = \exp\left(\delta_0 + \delta_1 \ln Q_{1j} + \delta_2 \ln Q_{2j}\right) \tag{4}$$

where m depends on states' characteristics defined as Q_{1j} and Q_{2j}, which represent market size and isolation factor, respectively. The ds are sets of parameters associated with state j characteristics.

Market size is included as an explanatory variable of the amount of domestic consumption to import consumption. Presumably, larger markets are able to support production of a wider array of products within a grouping of products and thus consumption of domestic goods increases relative to im-

port goods. The market size variable is measured as the proportion of gross state product to national gross domestic product.

The isolation factor is included to indicate that the more sparsely populated (remote) the region, the more likely it will produce a larger array of its own (self- sufficient) consumption goods. Isolation is calculated as the number of square miles per person for each state. The greater the number of square miles per person, the higher is the expected ratio of domestic to imported quantities of the good. [4]

Estimation Procedure

Taking natural logs of both sides of equation (3) produces:

$$\ln\left[\frac{X_{1jk}}{X_{2jk}}\right] = \sigma\ln m + \sigma\ln\left[\frac{P_{2jk}}{P_{1jk}}\right] \quad . \tag{5}$$

Substituting for the term *m* defined by equation (4) into equation (5) produces:

$$\ln\left[\frac{X_{1jk}}{X_{2jk}}\right] = \sigma\left[\delta_0 + \delta_1\ln Q_{1j} + \delta_2\ln Q_{2j}\right] + \sigma\ln\left[\frac{P_{2jk}}{P_{1jk}}\right] \quad . \tag{6}$$

Equation (6) simplifies to the following form that is linear in the a parameters

$$\ln\left[\frac{X_{1jk}}{X_{2jk}}\right] = \left[a_0 + a_1\ln Q_{1j} + a_2\ln Q_{2j}\right] + s\ln\left[\frac{p_{2jk}}{p_{1jk}}\right] \tag{7}$$

where $a_0 = sd_0$, $a_1 = sd_1$, and $a_2 = sd_2$. The estimated parameters capture the effects of market size and isolation as well as the constant term. The left hand side of equation (7) is the natural log of the ratio of the demand for domestic consumption to the demand for import consumption. $Ln\left(\frac{P_{2jk}}{P_{1jk}}\right)$ is the natural log of the price ratio for import goods to domestic goods.

To obtain the ßs from the estimated equation (7) at the mean values of logarithm of market size and isolation factor, we need:

---

[4] To a certain extent, the isolation factor has the same effect as the market size factor. Both are expected to increase the ratio of domestic to import quantities of a good. But an isolated region (as defined here) is not generally expected to have a large market size. The correlation coefficient between these two variables is 0.23.

$$\frac{b_1}{b_2} = \frac{1 - b_2}{b_2} = \exp\left(d_0 + d_1 \ln Q_1 + d_2 \ln Q_2\right)$$

$$1 - b_2 = b_2 \exp\left(d_0 + d_1 \ln Q_1 + d_2 \ln Q_2\right)$$

$$b_2 = \frac{1}{\left(1 + \exp\left(d_0 + d_1 \ln Q_1 + d_2 \ln Q_2\right)\right)} \tag{8}$$

$$b_2 = \frac{1}{\left(1 + \exp\left(\dfrac{\hat{a}_0}{\hat{s}} + \dfrac{\hat{a}_1}{\hat{s}} \ln Q_1 + \dfrac{\hat{a}_2}{\hat{s}} \ln Q_2\right)\right)}$$

and $b_1 = 1 - b_2$

where j and k are suppressed , $b_1 + b_2 = 1$, $d_0 = \dfrac{\hat{a}_0}{\hat{s}}, d_1 = \dfrac{\hat{a}_1}{\hat{s}},$ and $d_2 = \dfrac{\hat{a}_2}{\hat{s}}$.

We use least squares regression model (OLS) to estimate parameter estimates. We test whether heteroskedasticity is present or not by regressing the squares of the least squares residual from the model against all independent variables for each commodity group. If t-value tests on each independent variable reveal that they are heteroskedastic, we then use only heteroskedastic variables to compute the weighted term used in the second step to obtain more efficient parameter estimates (Greene, 1997). Note that the number of observations (e.g., regions) may not be equal for all equations. This is mainly due to the fact that some regions may not import or domestically consume the commodity in question. Thus we simply delete these observations.

Data Sources

The domestic and import quantity and price variables were computed based on the 1993 Commodity Flow Survey (U.S. Department of Commerce, 1997). The Commodity Flow Survey (CFS) is a sample of covered establishments in areas of mining, manufacturing, wholesale trade and selected retail and service industries. The survey excluded farms, forestry, fisheries, oil and gas extraction, governments, construction, transportation, households, and foreign establishments.[5] The data captured in the CFS come from the fifty states and the District of Columbia, but do not include Puerto Rico or the other U.S. territories. Data for our study was limited to the 48 contiguous states. The CFS does not include shipments traveling through the U.S. but originating from and going to foreign locations. The CFS does include imports, with the importer's domestic location serving as the point of origination. Shipments from one point in the U.S. to another point in the U.S. that traveled through a foreign territory were included, with the mileage traveled in the foreign territory excluded. The CFS also included exports, using the port of exit from the U.S. as the domestic destination.

---

[5] Although the survey excluded farms, flows of some farm products were captured by other industries and thus are reported in the commodity flow survey. The data for agricultural commodities should be viewed as incomplete.

[INSERT TABLE 3 HERE]

Some industry categories that may have significant shipping activity but are not covered in the CFS include agriculture, government and retail. The CFS only covered agriculture shipments from initial processing centers and elevators to their destinations, not shipments from farm sites to processing centers or terminal elevators. Oil and gas extraction establishments were excluded from the survey because most had undeliverable mailing addresses.

The quantities of state-to-state shipments included domestic goods (shipments from the state to itself) and imports (shipments to the state from all other states). Similar data were available for value of shipments. The value data is in millions of dollars and the quantity data is in millions of tons. A value per ton shipped was calculated for the domestic and imported goods. However, these values are based on prices at point of origination. The price per ton at point of consumption needed to be computed.

A transport cost per ton-mile was calculated taking the total revenue for "general freight trucking" from the U.S. Census of Transportation[6] and dividing by the total trucking ton-miles for all commodities estimated from the CFS. The estimated ton-mile cost is $0.063 for 1993.[7]

The cost per ton-mile was multiplied by the total commodity weight-distance for each state's imports. This was then added to the total commodity ton value of shipments for each state. When divided by total commodity shipments, this resulted in a weighted commodity price at point of consumption. The procedure was completed to obtain both domestic and import prices.

The market size variable for each state was calculated by dividing the gross state product for that state by the total gross domestic product for the nation. This variable accounts for both population and income differences between states and is assumed to reflect attributes of market size. This data comes from the Regional Accounts data from the Bureau of Economic Analysis. Data on the gross domestic product for the nation can be obtained from the National Accounts Data section of the BEA web site[8] and data on gross state product can be obtained from the Regional Accounts Data section of the BEA web site.[9]

The isolation factor was calculated as the population per square mile for each state. Archived data on state population can obtained from the U.S. Census Bureau data archives[10] and land area for states can be obtained from

---

[6] http://www.census.gov/prod/1/trans/uc92-s-1.pdf

[7] This cost per ton-mile was used for all shipments. This does not account for differences in state and regional transport costs. More precise data are not readily available and should be considered as further research.

[8] http://www.bea.doc.gov/bea/dn1.htm

[9] http://www.bea.doc.gov/bea/regional/gsp/

[10] http://eire.census.gov/popest/archives/state/st-99-3.txt

the Statistical Abstract of the United States (1999).[11] Descriptive statistics of
the data are presented in Table 3.

4. Results

Results of estimating equation (7) are shown in Table 4. Results of the 21
estimations include 20 SIC groups plus an all commodities group. Eighteen
of the estimated elasticities of substitution are statistically significant at the
10 percent or greater probability level.

The coefficient for market size is statistically significant for nine of the 21
commodity groups and is positive for 18. The negative coefficient on the
three remaining commodities is not statistically significant from zero at the
10 percent probability. Interpretation of this elasticity shows the result of an
increase in the ratio of domestic to import demand for a one percent increase
in market size. This result suggests that as total gross state product in-
creases, domestic demand increases relative to import demand. Market size
is thus correlated with a region's ability to provide more domestic products
relative to imports within a commodity (SIC) group.

The coefficient for isolation factor is statistically significant for eight of
the 21 commodity groups and positive for 19. For the two commodity
groups with a negative sign, the coefficient is not statistically significant from
zero at the 10 percent probability level. These results suggest that the more
isolated a region, the more that region depends on its own domestically pro-
duced products. Market size and isolation factor are both highly significant
for the all commodities group.

The commodity groups are ranked by size of elasticity in Table 5. The
elasticities range from 2.87 for petroleum and coal products (SIC 29) to 0.29
for apparel and other finished textile products (SIC 23), although the latter is
not statistically different from zero. Results of this ranking tend to show that
the basic and primary processed commodity groups have larger elasticities
of import substitution relative to the more specialized commodity groups.
This would indicate that price differences between domestic goods and im-
ports are more important for primary and basic commodity groups com-
pared to the specialized commodity groups. This result supports the hy-
pothesis that regions tend to specialize within commodity group thus are
less sensitive to price differences between domestic and import goods.

In Table 6, our results for regionally estimated elasticities of import sub-
stitution are compared with three studies of international elasticities fre-
quently referenced as sources of elasticities for national and regional CGE
studies (see Table 1). The first column contains the regional elasticities of
import substitution estimated in this study. The second column shows the
standard error of the estimate. Columns three and four show lower and up-

---

[11] http://www.census.gov/prod/99pubs/99statab/sec06.pdf

per bounds of the parameter based on plus or minus two standard errors of the estimate. The remaining three columns are weighted averages of elasticity parameters from the three international studies. Parameters from each study were aggregated to correspond to the SIC groups of our study. Value added was used as weights to aggregate the elasticity parameters to an overall weighted parameter.[12]

A comparison of the elasticities of import substitution for our current regional study with the three studies on international parameters is shown in Table 7. The closest comparison of our study is with the Reinert and Roland-Holst (1992) study. It is also the most recent of the three studies. One-half of the Reinert and Roland-Holst elasticities are lower than our parameters and one-half are greater. Ten of the elasticities are within two standard errors of our results, six are below two standard errors and two are above two standard errors.

Our regional parameters compared with the international parameters of the other two studies diverge significantly. The functional form of the model used by Shiells, Stern and Deardorff (1983) differs from our model. Our model is derived from the utility-consistent Armington model to obtain elasticity of substitution from cross sectional data, whereas their model was based on two-stage log-linear expenditure functional form. The elasticity of substitution they obtained was an Allen-Uzawa indirect elasticity of substitution from time series data. Because our model is derived from an explicitly utility-consistent CES function, functional form has been determined on theoretical rather than empirical grounds.

Twenty-seven of the thirty-five parameters of the Shiells, Stern, and Deardorff (1983) and Dixon et al. (1982) studies are greater than our estimates. Comparing all three studies with our study, 47 percent of the elasticity parameters are above two standard errors, 36 percent are within the range of two standard errors, and 17 percent are below two standard errors.

Therefore, based upon the results of this study, there is little evidence to suggest that elasticities of import substitution from international trade are lower bounds for elasticities to be used in regional CGE modeling. Evidence from this study would suggest that, if anything, regional parameters are less elastic or less price responsive than comparable commodity group elasticities from international trade.

---

[12] SIC categories and value added weights are available from Stephen King.

[INSERT TABLE 4 HERE]

Table 5: Commodity Groups Ranked by Size of Elasticity of Import Substitution

SIC Commodity	Elasticity	Market Size	Isolation Factor
29:Petroleum and coal products	2.872**	0.739**	-0.411*
	(8.19)	(3.85)	(-1.90)
14:Nonmetallic minerals	1.837**	-0.061	0.077
	(7.38)	(-0.23)	(0.36)
33:Primary metal products	1.745**	0.331*	-0.414**
	(5.57)	(1.97)	(-3.03)
01:Farm products	1.477**	0.089	-0.147
	(6.45)	(0.38)	(0.77)
24:Lumber and wood product, excluding furniture	1.429**	0.135	-0.162
	(11.11)	(1.13)	(-1.53)
28:Chemicals and allied products	1.339**	0.328**	-0.151*
	(8.75)	(2.13)	(-1.65)
26:Pulp, paper, and allied products	1.184**	0.182	-0.154
	(3.93)	(1.58)	(-1.70)
32:Clay, concrete, glass, and stone products	1.106**	-0.010	-0.208**
	(5.48)	(-0.08)	(-2.23)
00:Clay, concrete, glass, and stone products	1.103**	0.29**	-0.14**
	(10.16)	(4.58)	(-2.56)
40:Waste and scrap materials	0.943	0.498	-0.086
	(0.90)	(1.26)	(-0.28_)
25:Furniture and fixtures	0.931**	0.374**	-0.129
	(2.86)	(2.68)	(-1.28)
35:Machinery, excluding electrical	0.848**	0.076	-0.171
	(3.35)	(0.50)	(-1.52)
30:Rubber and miscellaneous plastics products	0.891**	0.408**	-0.215**
	(2.77)	(4.22)	(-2.21)
34:Fabricated metal products	0.843**	0.316**	-0.088
	(3.67)	(3.35)	(-1.14)
39:Miscellaneous manufacturing products	0.654*	0.771**	-0.325*
	(1.73)	(3.28)	(-1.95)
22:Textile mill products	0.625	0.335	-0.160
	(1.63)	(1.31)	(-0.69)
37:Transportation equipment	0.600**	0.229	-0.088
	(2.28)	(1.18)	(-0.56)
36:Electrical machinery, equipment and supplies	0.596**	0.010	-0.096
	(2.57)	(0.06)	(-0.81)
20:Food or kindred products	0.516**	0.373**	-0.245**
	(2.28)	(5.61)	(-4.57)
38:Instruments, photographic goods, optical goods, watches, and clocks	0.396**	-0.037	-0.092
	(3.84)	(-0.47)	(-1.52)
23:Apparel and other finished textile products	0.290	0.108	0.029
	(0.58)	(0.33)	(0.11)

t - statistic is in parenthesis below the coefficient
* - indicates 10% probability
** - indicates 5% probability

[INSERT TABLE 6 HERE]

Table 7. Analysis of Comparison of Current Elasticity Estimates with International Estimates

Comparisons With current study	Reinert and Roland-Holst (1992)	Shiells, Stern And Deardorff (1983)	Dixon et al. (1982)
	Number of Elasticity Parameters		
Below	9	2	4
Above	9	15	12
Total	18	17	18
	Number of Elasticity Parameters		
Below two Standard errors	6	1	2
Within two Standard errors	10	2	7
Above two Standard errors	2	14	9
Total	18	17	18

Table 8. Suggested Magnitude of Elasticity of Import Substitution Parameters for U.S. Region CGE Models

Commodity Group	SIC Codes	Central Tendency	Lower-bound	Upper-bound
Petroleum and coal products	29	2.87	2.17	3.57
Primary products	01,14,24,33	1.60	1.14	2.06
Processed primary products	22,25,26,28,30,32	1.10	0.60	1.60
Machinery and metals	34,35	0.85	0.37	1.33
Transport equip, electrical machinery, and miscellaneous manufacturing	36,37,39	0.60	0.10	1.10
Food products	20	0.50	0.05	0.95
Apparel and specialty products	23,38	0.45	0.15	0.75

5. Summary and Conclusions

Elasticity of substitution parameters for regional imports for the U.S. are not available. Studies of regional computable general equilibrium (RCGE) analysis have used parameters from international trade. Literature has suggested that these international trade parameters should be considered as lower bounds when applied to regions. Regions should be more price sensitive perhaps due to fewer non-price trade barriers.

Results of the current study using commodity flow data do not support this hypothesis. Because RCGE studies are generally highly aggregated, regions tend to specialize within commodity groups thus increasing the amount of trade within that group and, consequently, are less price responsive. Because the commodity flow data of the U.S. are highly aggregated, it is not possible to completely test the above hypothesis by comparing regional and international parameters. However, the regional elasticity of import substitution parameters in the range of 2.0 to 3.5 used in a sample of regional studies appears to be too high (see Table 2).[13]

In Table 8 we suggest parameters from 0.45 to 2.80 depending on the commodity grouping. In general, the more primary the product grouping the higher the elasticity and the more specialized the product grouping the lower the elasticity. The suggested central tendency of the elasticity of import substitution parameters and lower and upper bounds given in Table 8 are based on the estimates obtained in this study.

References

Armington, P.A. 1969. A Theory of Demand for Products Distinguished by Place of Production. *International Monetary Fund Staff Papers,* 16:159-76.

Berck, P., E. Golan, B. Smith, J. Barnhart, and A. Dabalen. 1996. *Dynamic Revenue Analysis for California.* Sacramento, CA: California Department of Finance.

Chung, Jae Wan, 1994. *Utility and Production Functions.* Cambridge, Massachusetts: Blackwell Publishers.

de Melo, J. and D. Tarr. 1992. *A General Equilibrium Analysis of US Foreign Trade Policy.* Cambridge, MA: The MIT Press.

Dixon P., B. Parmenter, J. Sutton, and D. Vincent. 1982. *ORANI: A Multisectoral Model of the Australian Economy.* Amsterdam: North-Holland.

Gazel, R. 1996. Free Trade Agreements and Interregional Labor Migration: The Case of the U.S. and Canada. *Annals of Regional Science,* 30(4):373-90.

Greene, W. 1997. *Econometric Analysis.* Third Ed. New Jersey: Prentice-Hall, Inc.

---

[13] Other reasons why regional trade elasticities may differ from international trade elasticities need to be explored.

Hoffmann, S., S. Robinson, and S. Subramanian. 1996. The Role of Defense Cuts in the California Recession: Computable General Equilibrium Models and Interstate Factor Mobility. *Journal of Regional Science,* 36(4):571-95.

Johansen, L. 1960. *A Multi-Sectoral Study of Economic Growth.* Amsterdam: North-Holland Publishing Company.

Kraybill, D. S., T. G. Johnson, and D. Orden. 1992. Macroeconomic Imbalances: A Multiregional General Equilibrium Analysis. *American Journal of Agricultural Economics,* 74(3):726-36.

Morgan, W., J. Mutti, and M. Partridge. 1989. A Regional General Equilibrium Model of the United States: Tax Effects on Factor Movements and Regional Production. *The Review of Economics and Statistics,* 71(4):626-35.

Partridge, M. D. and D. S. Rickman. 1998. Regional Computable General Equilibrium Modeling: A Survey and Critical Appraisal. *International Regional Science Review,* 21(3):205-248.

Reinert, K. A., and D. W. Roland-Holst. 1990. Disaggregated Armington Elasticities for the Mining and Manufacturing Sectors of the United States. (Working Paper, May 15), Washington, D.C.: U.S. International Trade Commission.

Reinert, K. A., and D. W. Roland-Holst. 1992. Armington Elasticities for United States Manufacturing Sectors. *Journal of Policy Modeling,* 14(5):531-639.

Robinson, S., S. Hoffman, and S. Subramanian. 1994. Defense Spending Reductions and the California Economy: A Computable General Equilibrium Model. Working Paper No. 688. Department of Agricultural and Resource Economics, University of California, Berkeley.

Roland-Holst, D. W., K. A. Reinert, and C. R. Shiells. 1994. A General Equilibrium Analysis of North American Economics Integration. In *Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade,* J. F. Francois, and C. R. Shiells, eds., New York, NY: Cambridge University Press, pp. 47-82.

Schreiner, D. F., D. W. Marcouiller, G. Tembo, and E. E. Vargas. 1999. Computable General Equilibrium for Regional Analysis. In *Web-based Learning Material in Regional Science*, S. Loveridge, ed., Morgantown, WV: West Virginia University, Regional Research Institute. (http:/rrri.wvr.edu/regscweb.htm).

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(2):299-316.

Shiells, C. R., R. M. Stern, and A. V. Deardorff. 1983. Estimates of the Elasticities of Substitution Between Imports and Home Goods for the United States. Institute of Public Policy Studies Discussion Paper No. 183. Ann Arbor, MI: University of Michigan, Institute of Public Policy Studies. 36 pp.

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. *Weltwirtshaftliches Archiv,* 122:497-519.

Stern, R. M., J. Francis, and B. Schumacher. 1986. Price Elasticities in International Trade: An Annotated Bibliography. For the Trade Policy Research Center. London: Macmillan.

Stern, R. M., J. Francis, and B. Schumacher. 1976. Price Elasticities in International Trade: An Annotated Bibliography. Toronto: Macmillan of Canada.

U.S. Department of Commerce. 1997. 1993 Commodity Flow Survey. Compact Disc dBASE format, CD-CFS-93-3A, CD-CFS-93-3B. Washington, D.C.: U.S. Department of Commerce Administrative and Customer Service Division.

Vargas, E. E. and D. F. Schreiner. 1999. Modeling Monopsony Market with Regional CGE: The Oklahoma Forest Products Industry Case. *The Journal of Regional Analysis and Policy,* Vol. 29, No. 2:51-74.

Waters, E., D. W. Holland, and B. A. Weber. 1997. Economic Impacts of a Property Tax Limitation: A Computable General Equilibrium Analysis of Oregon's Measure 5. *Land Economics,* 73(1):72-89.

Whalley, J., and I. Trela. 1986. *Regional Aspects of Confederation.* Vol. 68, Royal Commission on the Economic Union and Development Prospects of Canada. Toronto: University of Toronto Press.