School of Economic Sciences

Working Paper Series

WP 2010-12

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July 2010

Washington State University

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ABSTRACT

Because of more restrictive assumptions on regional input-output (IO) models compared to computable general equilibrium (CGE) models, the literature agrees IO results are intuitively consistent with long run equilibrium but otherwise overestimated. We compare the results of IO and CGE models from an exogenous export shock under various labor market constraints and capital closures. Consistent with the literature, we find the IO model's results do not match those of the CGE models. But contrary to conventional wisdom, the positive secondary impacts are larger with the CGE models than with the IO model. Furthermore, we find the closest match between direct effects is when the CGE model has short run restrictions. Our finding means that the common view of CGE model results being both lower in estimate and more accurate in the short run than IO models does not universally hold. Thus researchers' choice of models and interpretation of results need to be more nuanced and cautious than previously thought.

Keywords: input-output, computable general equilibrium, economic impacts, exports

JEL Classification: C67, C68, R13, R15

· Andrew J. Cassey (contact author) is Assistant Professor, David W. Holland is Professor Emeritus, and Abdul Razack was a research assistant in the School of Economic Sciences, Washington State University. This work was partially supported by a grant from the IMPACT Center, Washington State University.

Correspondence: 101 Hulbert Hall, Pullman WA, 99163; cassey@wsu.edu; 509.335.8334. Fax: 509.335.1173

I. Introduction

Though fixed-price models such as economic base and input-output (IO) are widely used for regional policy analysis, they have restrictive assumptions that do not match well with the behavior of regional economies, particularly in the short run. Regional neo-classical Computable General Equilibrium (CGE) models do not require as restrictive assumptions as fixed-price models and thus are thought by the literature to better model the real-world economy. But they are harder to use for analysis because of their more flexible and complicated relationships.

There has been a lot of progress in regional economic modeling. And the literature agrees that because IO models have restrictive assumptions such as fixed prices, fixed coefficients, and no capacity constraint on production, their results are at best consistent with the long run equilibrium of the economy. For this reason, the literature views fixed-price model results as simplified overestimates of the regional supply response to an exogenous shock or policy.

We continue this literature by showing the qualitative and quantitative differences in economic impact estimates from an IO model and multiple variants of a CGE model. We do this comparison by constructing an IO model and CGE models for the Washington State economy. We then shock each model by exogenously increasing crop exports by three percent and simulate the results under various labor and capital market closure assumptions. Finally we compare the models' predicted response in output, employment, and labor income. We examine exports to the rest of the world and the rest of the United States and welfare in appendices.

Consistent with the literature, we find that the models' results differ, often greatly. The mismatch is most profound for employment regardless of the factor constraints applied

in our CGE models. Therefore, we agree with the literature that the size of these differences should make any careful researcher contemplating an IO model for the sake of simplicity pause.

But, importantly, we find that IO model's results are *less* than the CGE models' results for the positive secondary impacts. Furthermore, we find the closest match between direct effects is when the CGE model has short run restrictions. Our finding means that the common view of CGE model results being both lower in estimate and more accurate than IO models does not universally hold. Thus, researchers' choice of models and interpretation of results need to be more nuanced and cautious than previously thought.

II. What is Known and What is Not Known

Because fixed-price and CGE models are the two predominant techniques for modeling regional economies, there exists a literature comparing them. Patridge and Rickman (1998) give a summary of CGE models in analyzing regional economic issues and compare their contributions to fixed-price models. Thus we already know some of the differences between their results.

Result 1: Merrifield (1987, 1990) shows the numerical difference in multipliers predicted by an economic base and a CGE model in the case of mobile capital and partially mobile labor.

Result 2: Similar in methodology and results to Despotakis and Fisher (1988) and Harrigan and McGregor (1989), Harrigan, McGregor, Swales, and Dourmashkinet (1991) construct a CGE model that embeds an IO model when the supply side of the economy is made passive. Under different labor closure assumptions, the model is shocked with increased manufactured exports. The CGE model calculates smaller multipliers in

manufacturing goods compared to the embedded IO model because the CGE multipliers are sensitive to factor market conditions ignored in the IO model. Harrigan et al. emphasize the role of price endogenity and limited factor supplies for their result whereas Despotkis and Fisher attribute it to substitutability between factors of production and absorption of factors of production released by affected industries by the other industries.

Result 3: McGregor, Swales, and Yin (1996) compare the short and long run properties of a CGE model by period simulation. They argue that the long run CGE results are similar to an IO model. They attribute the similar behavior of their long run CGE model and their IO model to the assumptions of perfect factor mobility and that the rate of return for capital is determined in the national market.

Result 4: Kraybill, Johnson, and Orden (1992) and Gazel (1996) study how results from single-region national models compare to multi-region national models. They demonstrate that macroeconomic and international trade shocks or policies have different effects across regions and sectors than when using a national model. Kraybill et. al also show the linear relationship between sectors typical of IO models does not hold in the data.

As these references show, the field knows a lot about the differences in results from fixed-price and CGE models. And the consensus is that IO model results are the upper bound for predicting long run outcomes. But what is not known is if and how these models differ in the secondary responses to a trade shock. This lack of knowledge is an important problem because the frequency of trade policy proposals means economic predictions are used to make welfare decisions for directly and indirectly effected sectors in the region whether these predictions are accurate or not. It is wise, then, to make the predictions as accurate as possible.

III. Methodology and Data

We contribute to the literature comparing fixed-price and CGE model estimates by constructing an IO model and multiple variants of a CGE model of the 2002 Washington State economy. We shock each model with a three percent increase in agricultural crop exports to foreign destinations and compare the models' response to the shock in terms of output, employment, and labor income.

We construct our regional economic models with a 2002 Washington social accounting matrix (SAM) from IMPLAN (2006). In 2002, there were 528 industries in the IMPLAN database that we reduce to 16 sectors. Sectors that we believe *a priori* to be affected by the export shock, directly or indirectly, have been kept at the most disaggregated level. These sectors are closely related to crops. The remaining sectors are aggregated into broader multi-sector composites. See appendix A for a list of sectors and their aggregation.

IV. Model Designs and Results

Before comparing IO and CGE model results, we describe the design and results of each model individually. In particular, we focus on the different results between the nine different CGE models to illustrate how they work. Then, in the robustness section, we can use these lessons to understand the CGE models' estimates in comparison to the IO model's estimates.

IV.1 Fixed-Price Model

IV.1.1 Design

We use the IMPLAN data directly for our IO model. We construct the 2002 Washington SAM using IMPLAN software. The SAM has regional industry sales to, and purchases

from, other industries and income and expenditures of regional households and government. The SAM can be used to capture the extent to which the state's total industry sales and jobs are dependent on crop sector exports. We use a standard IO model in that it assumes no supply constraint, no relative price effect, and the assumption of fixed proportion (Leontief) technology in production.

Changes in final demand drive the IO model. This occurs because the IO model has the inter-sector relationships built-in. If one sector gets bumped up, that bump pulls the other sectors up as well. The IO model uses the information on economic relationships between sectors to satisfy the increased crops demand by also increasing demand for related non-crop sectors. Type SAM multipliers show the direct, indirect, and induced effects. The direct effect is the change in the shocked sector. The indirect effect is the change in sectors that supply inputs to the crops sector. The induced effect is the change in household income and household consumption as a result of the change in payrolls.

IV.1.2 Results

Table 1 reports the IO model's estimate of the change to the Washington State economy from an exogenous three percent increase in crop exports to the world. The left section of table 1 is the direct, indirect, and induced effects on output in millions of 2002 dollars. The direct effect to output in the crops sector is $21.89 million. The indirect effect on the crops sector is $1.35 million and the induced effect as a result of change in household income is $0.05 million. The IO model predicts the total output change in the crops sector is $23.29 million.

Table 1. IO Model Response to 3% Increase in Crops Exports

SECTORS	OUTPUT (millions)				EMPLOYMENT (jobs)				LABOR INCOME (millions)			
	Direct	**Indirect**	**Induced**	**Total**	**Direct**	**Indirect**	**Induced**	**Total**	**Direct**	**Indirect**	**Induced**	**Total**
Crops	21.89	1.35	0.05	23.29	371.52	22.97	0.76	395.27	7.92	0.49	0.02	8.42
Animals		0.12	0.07	0.18		1.48	0.88	2.36		0.01	0.01	0.02
Fishing		0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00
Forest		0.03	0.01	0.03		0.09	0.03	0.15		0.01	0.00	0.01
Minerals		0.03	0.01	0.04		0.18	0.09	0.24		0.01	0.00	0.01
Utilities		0.13	0.08	0.22		0.24	0.15	0.39		0.03	0.02	0.05
Construction		0.10	0.05	0.15		0.85	0.42	1.27		0.04	0.02	0.06
Crop food		0.01	0.09	0.10		0.03	0.33	0.36		0.00	0.01	0.02
Animal food		0.01	0.17	0.18		0.03	0.61	0.64		0.00	0.03	0.03
Manufacturing		2.02	1.06	3.08		7.70	4.03	11.70		0.55	0.29	0.84
Services		2.36	3.35	5.70		22.24	31.55	53.79		0.99	1.40	2.39
Food service		0.03	0.41	0.44		0.64	9.97	10.61		0.01	0.16	0.17
Transportation		1.29	0.78	2.07		9.58	5.79	15.36		0.52	0.31	0.83
Wholesale		0.04	0.84	0.88		0.67	13.67	14.33		0.02	0.38	0.40
Retail		0.01	0.16	0.17		0.09	2.55	2.67		0.00	0.08	0.08
Government		0.32	1.40	1.72		3.12	13.58	16.70		0.15	0.64	0.79
Statewide	21.89	7.84	8.52	38.25	371.52	69.91	84.39	525.85	7.92	2.82	3.37	14.11
Multiplier				1.74				1.42				1.78

Notes: Sectors are commodities in the input-output table.

To meet the increase in output in the crops sector, the other sectors in the economy increase their output. The values are also reported in the first section of table 1. The total impact to the economy is the sum of the sector totals. The IO model estimates a $38.25 million increase to the statewide economy from the export shock. The output multiplier is 1.74, which is the state total effect divided by the direct effect on the crop sector (38.25 / 21.89). The multiplier means the IO model predicts that each $1 increase in crop export sales yields $1.74 statewide.

The middle section of table 1 shows the IO model's estimates for the change to employment for the sixteen sectors of the economy from the export shock. The direct number of jobs created in the crops sector is 372. The indirect effect increases jobs by 23 and the total increase in jobs is 395. The other sectors that see large increases in employment are manufacturing with 12, services with 53, and transportation with 15. The total predicted increase in employment in Washington is 526, making the jobs multiplier 1.42 (= 525.85 / 371.52).

The right section of table 1 shows the results for the third variable under study, labor income. The IO model predicts a $7.92 million dollar direct effect increase in the crops sector and a $14.11 total statewide increase in labor income. This is a labor income multiplier of 1.78.

IV.2 CGE Models

Like fixed-price models, CGE models are multi-sector models of a regional economy. But unlike fixed-price models, CGE models are based on Walrasian general equilibrium principles and neoclassical behavioral assumptions. There is endogenous determination of equilibrium prices to clear the output, factor, and foreign exchange markets.

We build CGE models with three different labor market restrictions and three capital closure assumptions. We do this to compare the results from the IO model, thought best by the literature at long run predictions, to CGE model results spanning conditions mimicking the short run through the long run. All nine CGE models share most of the same features.

In our CGE models, households are a representative agent having Stone-Geary preferences. Given prices, the households maximize utility by consuming a mix of domestic and imported goods. The composition of domestic supply depends on the relative prices of domestic products and imports.

Producers are profit maximizers taking the relative price of domestic products and imports and given. They have a Leontief-cum-constant elasticity of substitution (CES) production technology. This technology has fixed proportion of intermediate inputs but CES technology and capital and labor substitution for primary factors. The Leontief part of the production function ensures weak separability between primary labor and capital and intermediate factors. Producers may sell in both the domestic or foreign market depending on prices.

Federal government expenditure and investment are exogenous.

Our CGE models allow for imperfect substitution between regionally produced goods and foreign goods in the Washington market. We use an Armington (1969) aggregator to capture households' substitution possibilities between domestic and imported goods. The higher the value of the Armington elasticity, the easier is the substitution between Washington and imported goods. We nest the Armington function. First, we allow for substitution between domestic Washington goods and goods imported from anywhere outside of Washington. Second, we allow for substitution between Washington

imports from rest of the United States (henceforth called "domestic imports"; RoUS) and imports from rest of the world ("foreign imports;" RoW).

We assume that the US-RoW current account is fixed at the benchmark-year level, with the foreign exchange rate adjusting to maintain the current account balance. This assumption is without loss of generality since the current account balance can be modeled as changing around a fixed foreign exchange rate. The choice does not matter for our results.

The export supply function specifies the value of exports as a function of domestic and exports prices. We use a constant elasticity of transformation (CET) function, which defines the production possibilities available to a given industry assuming exported products are differentiated from products produced for the Washington market. Again, we nest the CET depicting the production possibilities. First, there are goods produced for the Washington market and the rest of the U.S. market and second, there is this aggregate and goods produced for the rest of the world.

Import price is a function of the world price, possible import tariffs, and the exchange rate. Import demand is the first-order condition obtained from the cost minimization problem of buying a given amount of the composite good. Composite supply is a function of the price of imports and the price of regionally produced goods. The regional export and import composites are a function of the price of exports and imports from RoUS and RoW. Household income is obtained from capital and labor payment, government transfers, and household borrowing.

Initially, consumer prices of domestic goods and imports, the world price of exports, factor prices, and the exchange rate are all set equal to one and the consumer price index is

the numeraire. The world price of imports is exogenous. We therefore make the "small country" assumption for Washington State and consider the terms of trade to be fixed.

We estimate the change in output, employment, and labor income from a three percent exogenous increase in crop exports. We do this by solving for a counterfactual equilibrium for the Washington economy where all prices, commodity markets, and factor markets have adjusted to the increase in crops export demand. We use GAMS software and PATH solver (n.d.) to construct, calibrate, and solve each CGE model, a simultaneous system of non-linear equations. The model is initially solved to replicate the base year SAM by appropriately calibrating the parameters of the model. However, we use values from the literature for the Armington elasticity, the CET elasticity, the elasticity of substitution in production, the household income elasticity, and the export demand elasticity. We set the Armington elasticity to range from 0.5–1.75 and the CET elasticity to 2 for traded sectors and 0.5 for non-traded sectors, though we increase the traded sector's elasticity to 4 in appendix B.

IV.2.1 CGE Model 1 Design: Labor mobile across sectors but fixed in region

In CGE model 1, labor is assumed mobile across sectors but fixed for the state. For capital, we compute results for three closures. In model 1A, capital is fixed across sectors and the total endowment in Washington is fixed. Model 1A represents economic adjustment in the very short run. In model 1B, we allow capital to be mobile across sectors with a fixed endowment for Washington so that there is an elastic supply of capital in the state. In model 1C, we let capital be mobile across sectors and for the total state endowment to vary so the supply of state capital has elasticity of 0.5. Think of model 1C as representing long run equilibrium with statewide labor endowment fixed.

IV.2.2 CGE Model 1 Results: Labor mobile across sectors but fixed in region

We begin by examining the results on output, employment, and labor income from the CGE model 1A. After these results are explained, we move to the results for models 1B and 1C.

In response to the demand increase, model 1A predicts both the foreign export crop price and quantity of foreign crop exports increase, but by less than three percent. As the left section of table 2 shows, the total output of crops in the Washington economy increases by $19.16 million. This is only slightly less than the $21.89 million estimated in the IO model, whose results are included in table 2 for comparison. Unlike the IO model, in CGE model 1A, manufacturing and services output decrease by $13.81 and $21.68 million. Other sectors with output decreases are transportation, government, utilities, and wholesale retail sectors. The reasons for the decrease in some non-crop sectors is that model 1A shifts labor from non-crop sectors to the crop sector to meet the increased croup output. The middle section of table 2 shows the crops sector increases employment by 652 whereas manufacturing and services lose 69 and 344 jobs. Other sectors react similarly. Because labor is pulled away, output in some non-crop sectors decreases. Model 1A has to reallocate labor across sectors to meet the increased crop demand because the fixed labor assumption means the total change in statewide jobs *must* be zero. This inter-sectoral transfer of factors drives the differences in results from this model and the IO model, which has no such labor supply constraint.

Because of the increased demand for labor in the crops sector caused by export shock and increased production, the total wage bill for crops in model 1A increases by $11.26 million as seen in the right section of table 2. Likewise, market-clearing wage increases for all others. In these sectors, labor income increases despite a decrease in

employment. This is because the increase in the wage rate in these sectors is more than the decrease in employment.

Compared to CGE model 1A where capital is fixed by sector, CGE model 1B has more than double the estimated increase in the output of crops, $49.75 million. Similar results hold for all sectors. The output response is larger in absolute value (either up or down) than CGE model 1A because capital is free to shift to the crops sector at the expense of other sectors. Capital shifts to crops because the export shock is exogenously increasing demand in that sector. The statewide result is, unlike model 1A, a *decrease* in output.

These expansionary effects are more pronounced in CGE model 1C than 1B because there is not the statewide capital constraint in 1C. In 1C, capital flows into the state to take advantage of the export shock to crops. But this easing of the capital constraint means some capital that shifted to crops from other Washington sectors in CGE model 1B remains in place in CGE model 1C.

Because CGE model 1 assumes a fixed supply of labor, employment gains in one sector must be offset by job losses in other sectors. Models 1A, 1B, and 1C agree qualitatively with job gains for most sectors, though they differ quantitatively. This is because the loosening of the capital constraint allows labor to follow capital as capital shifts sectors. Model 1A disagrees with the employment predictions of model 1B and 1C for the forest, crop food, and animal food sectors. Notice these are the same sectors that model 1A qualitatively disagrees with the others for output.

Table 2. CGE Model 1 Response to 3% Increase in Crops Exports

SECTORS	OUTPUT				EMPLOYMENT				LABOR INCOME			
Model	IO Total	1A	1B	1C	IO Total	1A	1B	1C	IO Total	1A	1B	1C
Crops	23.29	19.16	49.73	50.05	395.27	652.26	842.19	844.42	8.42	11.26	14.57	14.62
Animals	0.18	0.07	1.72	1.76	2.36	1.08	22.29	22.64	0.02	0.04	0.20	0.21
Fishing	0.00	-0.15	-1.01	-0.90	0.00	-3.51	-9.37	-8.76	0.00	-0.04	-0.18	-0.16
Forest	0.03	-0.22	2.10	2.27	0.15	-2.53	7.70	7.89	0.01	-0.01	0.37	0.39
Minerals	0.04	-0.14	-0.57	-0.51	0.24	-1.86	-3.68	-3.52	0.01	-0.03	-0.09	-0.08
Utilities	0.22	-1.21	-2.78	-2.13	0.39	-0.83	-1.72	-1.29	0.05	0.01	-0.03	0.00
Construction	0.15	-0.89	-1.51	-1.35	1.27	-10.28	-17.92	-20.92	0.06	1.51	1.91	1.91
Crop food	0.10	-0.92	1.46	1.79	0.36	-7.26	4.27	4.53	0.02	-0.06	0.49	0.51
Animal food	0.18	-0.34	0.95	1.03	0.64	-1.42	3.31	3.44	0.03	0.08	0.35	0.36
Manufacturing	3.08	13.81	-23.09	-21.72	11.70	-68.96	-93.33	-92.43	0.84	-1.01	-1.33	-1.05
Services	5.70	21.68	-45.96	-40.99	53.79	-344.08	-483.17	-480.76	2.39	-1.01	-1.89	-1.08
Food service	0.44	-0.80	-1.03	-0.90	10.61	-21.37	-26.26	-24.81	0.17	0.38	0.57	0.63
Transportation	2.07	-4.44	-6.45	-5.62	15.36	-44.84	-52.33	-51.17	0.83	0.31	0.87	1.08
Wholesale	0.88	-1.83	-3.31	-2.92	14.33	-43.36	-61.62	-62.85	0.40	0.60	0.75	0.83
Retail	0.17	-0.49	-0.90	-0.81	2.67	-10.91	-15.76	-15.90	0.08	0.09	0.09	0.11
Government	1.72	-3.97	-7.20	-6.20	16.70	-92.15	-114.62	-120.52	0.79	1.50	2.57	2.64
Statewide	38.25	31.67	-37.85	-27.16	525.85	0.00	0.00	0.00	14.11	13.60	19.22	20.94

Notes: CGE Model 1 assumes labor is mobile across sectors, but that there is a fixed statewide endowment. IO total is repeated from table 1. Model 1A is the closure with capital fixed across sectors and in the region. Model 1B is the closure with capital mobile across sectors but fixed in the region. Model 1C is the closure with capital mobile across sectors and in the region. Sectors are commodities in the Social Accounting Matrix.

The predictions for labor income, unlike output, are in relative agreement across the variants of model 1. And these statewide values are similar to the fixed price result of $14.11 million. But labor income in specific sectors does not agree between CGE model 1 and the IO model. The results of the IO model show the secondary effects on manufacturing and services are positive, but in CGE Model 1, labor income decreases in both manufacturing and service industries in spite of a higher wage.

It might seem puzzling that in CGE model 1 labor income increases for some sectors though there is employment loss. This is due to a decrease in equilibrium wage. This is an example of price flexibility in the CGE model that is absent from the IO model making a large difference.

IV.2.3 CGE Model 2 Design: Wages fixed across sectors

In CGE model 2, we assume wages are fixed across the sectors. The labor market adjusts to the export shock in crops by changing employment rather than wage as in CGE model 1. Labor is perfectly mobile across industries and the region, with the total supply of labor being the market-clearing variable. Thus, the labor supply curve is infinitely elastic.

As we did with CGE model 1, we simulate CGE model 2 with three capital closure assumptions. In CGE model 2B, capital is mobile across sectors with a perfectly inelastic state supply whereas in CGE model 2C, the elasticity of regional capital supply is 0.5.

IV.2.4 CGE Model 2 Results: Wages fixed across sectors

All three variants of CGE model 2 are in agreement that statewide output increases from an export shock to crops. Because of the assumption of fixed wage on labor markets, the magnitude of the increases in output is greater than in CGE model 1. Despite this, the left section of table 3 shows that output gains are uneven across sectors, with the fishing and

Table 3. CGE Model 2 Response to 3% Increase in Crops Exports

SECTORS	OUTPUT				EMPLOYMENT				LABOR INCOME			
Model	IO Total	2A	2B	2C	IO Total	2A	2B	2C	IO Total	2A	2B	2C
Crops	23.29	20.10	51.51	52.14	395.27	684.13	890.32	897.14	8.42	11.47	14.93	15.05
Animals	0.18	0.41	2.21	2.31	2.36	6.15	29.76	30.82	0.02	0.04	0.21	0.22
Fishing	0.00	0.00	-0.64	-0.43	0.00	-0.11	-3.77	-2.43	0.00	0.00	-0.10	-0.06
Forest	0.03	0.14	2.95	3.27	0.15	1.57	13.72	14.43	0.01	0.05	0.48	0.50
Minerals	0.04	0.00	-0.28	-0.17	0.24	-0.02	-0.92	-0.48	0.01	0.00	-0.04	-0.02
Utilities	0.22	0.70	-0.18	1.00	0.39	0.37	0.22	1.03	0.05	0.03	0.02	0.07
Construction	0.15	0.29	0.00	0.35	1.27	3.36	18.57	16.44	0.06	0.13	0.72	0.63
Crop food	0.10	0.29	3.56	4.23	0.36	2.28	17.66	18.99	0.02	0.09	0.71	0.77
Animal food	0.18	0.42	2.03	2.22	0.64	1.76	7.95	8.46	0.03	0.08	0.37	0.40
Manufacturing	3.08	1.71	-1.00	2.66	11.70	8.55	14.50	23.40	0.84	0.58	0.99	1.60
Services	5.70	6.71	-4.83	5.75	53.79	105.00	140.62	187.72	2.39	3.88	5.20	6.94
Food service	0.44	0.83	1.25	1.61	10.61	22.23	37.09	43.76	0.17	0.35	0.59	0.69
Transportation	2.07	2.42	3.33	5.31	15.36	24.41	45.30	53.89	0.83	1.23	2.28	2.72
Wholesale	0.88	1.31	0.82	1.71	14.33	31.07	45.02	50.50	0.40	0.77	1.12	1.26
Retail	0.17	0.26	0.11	0.31	2.67	5.91	7.93	9.36	0.08	0.16	0.21	0.25
Government	1.72	2.35	0.90	3.01	16.70	54.77	91.56	96.72	0.79	2.58	4.31	4.55
Statewide	38.25	37.95	61.75	85.29	525.85	951.44	1355.53	1449.73	14.11	21.46	32.02	35.57

Notes: CGE Model 2 assumes wage is fixed and statewide employment adjusts. IO total is repeated from table 1. Model 2A is the closure with capital fixed across sectors and in the region. Model 2B is the closure with capital mobile across sectors but fixed in the region. Model 2C is the closure with capital mobile across sectors and in the region. Sectors are commodities in the Social Accounting Matrix.

minerals sectors the least affected. The difference in output by sector is more pronounced as the capital closure changes from model 2A to 2B to 2C.

Nearly all sectors in the economy gain jobs as opposed to CGE model 1. For model 2, statewide labor can increase. Thus the differences in results from model 2A to 1A are because the increase to exports does not pull labor away from other sectors. Instead non-crop sectors more-or-less keep their employment and additional labor, at the fixed wage, is added to sectors with increased output. Statewide employment increases by 952 jobs in CGE model 2A because of the export shock compared to the 526 jobs with the IO model. And statewide labor income increases by $21.46 million compared to $14.11 million.

Models 2B and 2C have larger gains to the economy than 2A. The decrease in output in some non-crop sectors is because capital is free to move to sectors with greater demand, thus removing capital from their original sectors. But in CGE model 2, the relaxation of the labor constraint means that the loss of capital in non-crop sectors such as manufacturing are somewhat replaced by a large increase in new *outside* employment. Thus we see in table 3 that manufacturing output decreases by 1 in model 2B, though employment increases by 14.5. This effect is most pronounced in CGE model 2C because the statewide level of both labor and capital is free. Therefore capital can be reallocated to crops without as drastic a shift away from most non-crop sectors *and* employment can increase in most of these sectors. Fishing, though, is an example of a sector that still loses.

IV.2.5 CGE Model 3 Design: Labor mobile within region and wages flexible

For CGE model 3, labor is mobile across sectors and wages are flexible as in model 1. But the state labor supply function has an elasticity of 4.0. So the regional labor supply function is elastic but not perfectly elastic as in model 2. We make the same three capital closure assumptions.

IV.2.6 CGE Model 3 Results: Labor mobile across sectors and wages flexible

Table 4 shows the results. The output in crops sector increases by $19.87 million. This is slightly higher than CGE model 1A and slightly less than model 2A. Similarly, crops employment at 676 is more than model 1A but less than model 2A. This is because the equilibrium wage in model 3 increases, thus making production costs higher than in model 2, in which the wage is fixed to the pre-shock level.

The difference in results from model 3 and model 2 is that the output and employment response is smaller for model 3 for non-crop sectors, but very similar for crops. The upward sloping regional labor supply curve of model 3 exerts it influence on the regional supply and job response to the export shock, but does not change the response of the directly affected crops sector much.

IV.3 Robustness

Our results report the change to output, employment, and labor income for the state and the sixteen sectors for three CGE models and for each model, three capital closures. We support our findings by 1) separating Washington exports into exports to RoW and RoUS and 2) reporting the change to welfare based on nine representative households that differ in income.

IV.3.1 Separating Exports to the Rest of the World & the Rest of the US

In CGE model 1, exports of crops to RoW increase but exports to RoUS decrease because of market substitution. For a robustness check, we build CGE model 4 identical to model 1 (labor is mobile across sectors but fixed statewide) except that we increase the constant elasticity of transformation CET function from 2 to 4 for crops. This means the Washington crops sector exports will be more responsive to price changes in both RoUS and RoW.

Table 4. CGE Model 3 Response to 3% Increase in Crops Exports

SECTORS	OUTPUT				EMPLOYMENT				LABOR INCOME			
Model	IO Total	3A	3B	3C	IO Total	3A	3B	3C	IO Total	3A	3B	3C
Crops	23.29	19.88	51.07	51.62	395.27	676.54	878.47	883.93	8.42	11.42	14.84	14.94
Animals	0.18	0.33	2.09	2.17	2.36	4.94	27.92	28.77	0.02	0.04	0.21	0.21
Fishing	0.00	-0.04	-0.73	-0.54	0.00	-0.92	-5.15	-4.02	0.00	-0.01	-0.12	-0.09
Forest	0.03	0.05	2.74	3.02	0.15	0.60	12.24	12.79	0.01	0.04	0.45	0.47
Minerals	0.04	-0.03	-0.35	-0.25	0.24	-0.46	-1.60	-1.25	0.01	-0.01	-0.05	-0.04
Utilities	0.22	0.25	-0.82	0.21	0.39	0.09	-0.26	0.45	0.05	0.02	0.00	0.06
Construction	0.15	0.01	-0.37	-0.07	1.27	0.11	9.59	7.08	0.06	0.46	1.01	0.95
Crop food	0.10	0.00	3.04	3.62	0.36	0.01	14.36	15.37	0.02	0.06	0.66	0.70
Animal food	0.18	0.24	1.77	1.92	0.64	1.00	6.81	7.20	0.03	0.08	0.37	0.39
Manufacturing	3.08	-1.98	-6.43	-3.45	11.70	-9.91	-12.04	-5.62	0.84	0.20	0.42	0.94
Services	5.70	-0.05	-14.95	-5.96	53.79	-1.97	-12.92	20.25	2.39	2.72	3.46	4.93
Food service	0.44	0.44	0.69	0.98	10.61	11.84	21.50	26.58	0.17	0.36	0.58	0.68
Transportation	2.07	0.79	0.92	2.57	15.36	7.91	21.27	27.57	0.83	1.01	1.93	2.31
Wholesale	0.88	0.56	-0.20	0.55	14.33	13.34	18.77	22.11	0.40	0.73	1.03	1.15
Retail	0.17	0.09	-0.14	0.03	2.67	1.91	2.10	3.03	0.08	0.14	0.18	0.22
Government	1.72	0.85	-1.09	0.70	16.70	19.78	40.81	42.29	0.79	2.32	3.88	4.08
Statewide	38.25	21.37	37.24	57.12	525.85	724.82	1021.87	1086.54	14.11	19.59	28.87	31.91

Notes: CGE Model 3 assumes labor is mobile across sectors and elastically supplied statewide. IO total is repeated from table 1. Model 3A is the closure with capital fixed across sectors and in the region. Model 3B is the closure with capital mobile across sectors but fixed in the region. Model 3C is the closure with capital mobile across sectors and in the region. Sectors are commodities in the Social Accounting Matrix.

The results indicate the increased elasticity amplifies the findings from model 1 and thus the results are left to appendix B. The lessons learned from CGE model 1 are robust to elasticity change. But we also separate Washington exports to RoW and RoUS to learn about export substitution as a result of the shock. This separation does not change results.

IV.3.2 Welfare

In appendix C, we report CGE results on welfare for nine different households in our three CGE models and three capital closures. The nine households have income of less than 10K, 10–15K, 15–25K, 25–35K, 35–50K, 50–75K, 75–100K, 100–150K, and 150K+.

The finding show that the exogenous increase to crops demand creates an increase in demand for factors of production. These factors may or may not be available without reallocation within non-crop sectors depending on the labor and capital closure assumptions. The change to factor demand begets increased production cost that begets increased output cost. Households, regardless of income level, respond by decreasing consumption. Thus welfare depends on the relative size of the increase in labor income versus the increase in consumption cost.

In our short run models in which labor is fixed statewide (models 1A, 1B, and 1C), the welfare change is negative. In long run models the welfare change is positive except for low-income households.

V. Comparison of Models and Conclusions

The computational simplicity of IO modeling is due to its strong assumptions such as price inflexibility, fixed proportions production technology, and no supply constraints. These assumptions are intuitively those of the economic long run. But because of their simplicity, fixed prices models are often used to assess the short run economic impacts from an

exogenous shock or policy. The literature agrees that CGE model estimates are more accurate for short run prediction.

We estimate an IO model and three CGE models (with three different capital closures) that are each subject to a three percent export shock to the crops sector of a 2002 Washington State regional economy. Table 5 compares the results, highlighting the crops sector and statewide economy.

Table 5. Comparison of Flexible Price Models & Fixed Price Models

		CROPS			
	VARIABLES	**A**	**B**	**C**	**IO**
Model 1	Output	**19.16**	49.73	50.05	21.89
	Employment	**652.26**	842.19	844.42	371.00
	Labor Income	**11.26**	14.57	14.62	7.92
Model 2	Output	20.10	51.51	52.14	21.89
	Employment	684.13	890.32	897.14	371.00
	Labor Income	11.47	14.93	15.05	7.92
Model 3	Output	19.88	51.07	51.62	21.89
	Employment	676.54	878.47	883.93	371.00
	Labor Income	11.42	14.84	14.94	7.92
		STATEWIDE			
	VARIABLES	**A**	**B**	**C**	**IO**
Model 1	Output	-31.67	-37.85	-27.16	38.25
	Employment	0.00	0.00	0.00	525.85
	Labor Income	**13.60**	19.22	20.94	14.11
Model 2	Output	**37.95**	61.75	85.29	38.25
	Employment	951.44	1355.53	1449.73	525.85
	Labor Income	21.46	32.02	35.57	14.11
Model 3	Output	21.37	37.24	57.12	38.25
	Employment	**724.82**	1021.87	1086.54	525.85
	Labor Income	19.59	28.87	31.91	14.11

Notes: Model 1 is mobile labor across sectors, but fixed statewide. Model 2 is flexible labor across sectors, but fixed wage. Model 3 is flexible labor across sectors and inelastic statewide labor supply. For all CGE models, A is capital fixed across sectors, B is capital is fixed statewide, and C is capital is inelastically supplied statewide. **Bold** indicates the best CGE to IO match.

V.1 Crops Sector

From table 5, we see that except for the short-run where capital is assumed fixed by sector (version A for all models), the output change for crops is *greater* in the CGE models than the IO model. In fact, the *short-run* CGE model provides a good approximation of the output change predicted by the IO model. This is because the fixed coefficient technology of the IO model depicts a crops sector much less responsive to the export shock than the CES production function in the CGE model.

The estimated impact to crops' employment and labor income is much *larger* in every CGE model, including the *short run* capital fixed versions. This is due to the presence of relative price effect in the CGE models. Our conjecture is that the predicted job response in the directly effected sector using fixed-price modeling is likely to be dramatically underestimated since the CGE model better captures labor and capital market behavior in regional CGE models.

Model 1A, which has the most severe supply restrictions and thought to be short run, best matches the IO results for output, employment, and labor income. This finding is against the conventional wisdom that the IO model provides an upper bound estimate best suited for the long run.

V.2 Statewide

The bottom half of table 5 compares the statewide effects. From table 5, we see that in all versions of model 1, regional output decreases. We attribute this to the mobility of labor shifting towards crops at the expense of other sectors. On balance, the decrease in output from non-crop sectors outweighs the increase in output from the crop sector. Contrast this with the statewide output in the IO model. There *must* be positive ripple effect in the IO model because of the assumption of no supply constraint.

The fixed wage assumption drives the results from model 2. Output increases statewide because labor is elastically supplied at the fixed wage rate. Gains in crops employment does not have as large a negative impact on other sectors as in model 1. This effect is moderated in model 3 in which the assumption of no labor constraint is replaced with labor supplied with elasticity of 4. Model 3's wage flexibility reduces results compared to model 2 because the increase in wages also increases production costs. But none of these models provides the best match to the IO model for output, employment, and labor income.

V.3 Last Thoughts

If we use the model with the best match for the sector most affected by the shock, it would be the short run model, 1A. But the statewide results show this model is not the best match to the IO model for output and employment. Rather the best statewide match depends on the variable.

The direct effect on crop *output* is roughly the same for IO and CGE models when there is the short run assumption of capital fixed across sectors regardless of a labor constraint. But the same is not true for labor income, and in particular, employment. For these variables, the CGE model estimates are larger, and sometimes dramatically larger, than the IO estimates for all variants. The *indirect* effect on output matters in the short run assumption of restricted labor (model 1) regardless of capital constraint.

Our findings contribute to the literature comparing fixed-price input-output models and computable general equilibrium models. Consistent with the literature, we find that the models' results differ, often greatly. The mismatch is most profound in employment regardless of the factor constraints applied in our CGE models. Therefore, we agree with the literature that the size of these differences should make any careful researcher

contemplating an IO model for the sake of simplicity pause. But, importantly, we find that IO models results are *less* than CGE model results for the positive secondary impacts. Furthermore, we find the closest match between direct effects is when the CGE model has short run restrictions. Our finding means that the common view of CGE model results being both lower in estimate and more accurate than IO models does not universally hold.

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Appendix A: Aggregation Scheme

Table A1. Aggregation Scheme for the Washington State Economy

Sectors	IMPLAN Sector Codes
Crops	1-10, 18
Animals	11-13
Fishing	16, 17
Forest	14, 15
Mining	19,29
Utility	30-32
Construction	33-45
Crop Food	46-61&72-91
Animal Food	62-71
Manufacturing	92-389
Services	413-494
Food Services	481
Transportation	390-400
Wholesale Retail Trade	401-412
Food Retail	405
Government Enterprise	495-509

Appendix B: Results for CGE Model 4

In CGE model 1, the export price of crops increases by 1.63% in the world market, whereas it increases by 0.03% in the RoUS. Due to this price increase, crops exports to RoW increase by 3.04%. But Washington exports to RoUS decline because of the product-product transformation embodied in the CET function. Since we assume no change in RoUS crop demand, the decrease in the supply of crops to RoUS increases the export price of crops by 0.03%. As output is diverted to RoW, the quantity of exports from Washington to RoUS decreases by 0.17%.

In CGE model 1B and 1C, the export price of crops in RoW increases by the same proportion as export price declines in RoUS. Table B1 shows that the increase in crop exports from Washington to RoW is roughly the same in model 1B and 1C (3.74%). In mode1 4 on the right side of table B1, the export price of crops increases by 1.35% in RoW

and quantity of exports increases by 4.47%. The percentage increase in exports for models 4B and 4C are about 5.19%.

Table B1. Percentage Change Price and Quantity of Crops Exports

Price of Exports (Crops)	**1A**	**1B**	**1C**	**4A**	**4B**	**4C**
Rest of World	1.63	1.49	1.49	1.35	1.21	1.21
Rest of US	0.03	-0.10	-0.10	0.11	-0.03	-0.03
Qty. of Exports (Crops)						
Rest of World	3.04	3.74	3.75	4.47	5.18	5.19
Rest of US	-0.17	0.51	0.52	-0.54	0.14	0.14

Since model 4's CET function for crops is more elastic, the response to price changes in external markets is higher. Table B2 compares model 1 and 4 export changes for all sectors separated by RoW and RoUS. The aggregate increase in exports to ROW in model 4 is $26.05 million compared to $15.75 million in model 1 due to the increased elasticity in model 4. All the other sectors respond to the external markets in the same way as in model 1. But the export shock to the crops sector results in decreased exports to RoW by other sectors as a function of labor moving away from those sectors towards crops. This shift decreases the competiveness of those sectors in the rest of the world and rest of the U.S. markets. The implication is that a policy that succeeds in increasing crop exports comes at the cost of decreased exports to the rest of the United States by other industries.

In model 4, the direction of change in the policy variables is same as model 1, but the magnitude of the RoW response is larger. This is because it is easier to substitute crops produced for the RoUS than for crops produced for RoW as a result of the higher elasticity of the CET function for crops in model 4.

Table B3 shows how employment and labor income respond to the increased elasticity of the CET function. The results are similar to model 1 qualitatively, though there are some quantitative differences in the crops sector.

Table B2. Change in Regional Exports under Model 1 & 4 ($millions)

SECTORS	1A		1B		1C		4A		4B		4C	
	RoW	RoUS	RoW	RoUS	RoW	RoUS	RoW	RoUS	RoW	RoUS	RoW	RoUS
Crops	21.95	-4.61	27.01	13.99	27.06	14.17	32.29	-14.89	37.45	3.75	37.50	3.93
Animals	0.00	0.03	0.03	0.70	0.03	0.71	0.00	0.03	0.03	0.70	0.03	0.71
Fishing	-0.15	0.00	-1.00	0.00	-0.88	0.00	-0.15	0.00	-1.01	0.00	-0.89	0.00
Forest	0.00	-0.05	0.14	1.35	0.15	1.44	0.00	-0.05	0.14	1.36	0.15	1.45
Minerals	-0.01	-0.08	-0.04	-0.36	-0.04	-0.32	-0.01	-0.08	-0.04	-0.36	-0.04	-0.32
Utilities	0.00	-0.76	0.00	-1.85	0.00	-1.50	0.00	-0.76	0.00	-1.86	0.00	-1.51
Construction	0.00	-0.35	0.00	-0.53	0.00	-0.50	0.00	-0.35	0.00	-0.53	0.00	-0.50
Crop food	-0.05	-0.74	0.07	1.04	0.09	1.29	-0.05	-0.74	0.07	1.05	0.09	1.30
Animal food	-0.03	-0.17	0.08	0.41	0.09	0.44	-0.03	-0.17	0.08	0.41	0.09	0.44
Manufacturing	-4.50	-5.08	-7.64	-8.62	-7.25	-8.18	-4.52	-5.11	-7.68	-8.67	-7.29	-8.23
Services	-0.70	-10.12	-1.47	-21.40	-1.34	-19.50	-0.70	-10.17	-1.48	-21.52	-1.35	-19.61
Food service	0.00	-0.17	0.00	-0.21	0.00	-0.20	0.00	-0.17	0.00	-0.21	0.00	-0.20
Transportation	-0.69	-1.17	-1.10	-1.87	-1.02	-1.72	-0.69	-1.18	-1.11	-1.88	-1.02	-1.73
Wholesale	0.00	-0.42	0.00	-0.73	0.00	-0.67	0.00	-0.43	0.00	-0.73	0.00	-0.67
Retail	0.00	-0.19	0.00	-0.34	0.00	-0.32	0.00	-0.19	0.00	-0.34	0.00	-0.32
Government	-0.07	-0.41	-0.12	-0.71	-0.11	-0.65	-0.07	-0.41	-0.12	-0.72	-0.11	-0.65
Statewide	15.74	-24.27	15.95	-19.12	16.77	-15.51	26.05	-34.66	26.33	-29.54	27.15	-25.91

Notes: CGE Model 4 assumes a more elastic CET than CGE model 1, but they are the same that labor is mobile across sectors but fixed statewide. RoW is exports to the rest of the world and RoUS is exports to the rest of the United States excluding Washington. Sectors are commodities in the Social Accounting Matrix.

Table B3. CGE Model 4 Response to 3% Increase in Crops Exports

SECTORS	OUTPUT				EMPLOYMENT				LABOR INCOME			
Model	IO Total	4A	4B	4C	IO Total	4A	4B	4C	IO Total	4A	4B	4C
Crops	23.29	19.27	50.00	50.33	395.27	655.91	846.92	849.17	8.42	11.33	14.65	14.71
Animals	0.18	0.07	1.73	1.77	2.36	1.09	22.42	22.77	0.02	0.04	0.20	0.21
Fishing	0.00	-0.15	-1.02	-0.90	0.00	-3.53	-9.42	-8.81	0.00	-0.04	-0.18	-0.16
Forest	0.03	-0.23	2.11	2.28	0.15	-2.54	7.74	7.94	0.01	-0.01	0.38	0.39
Minerals	0.04	-0.14	-0.57	-0.51	0.24	-1.87	-3.70	-3.54	0.01	-0.03	-0.09	-0.08
Utilities	0.22	-1.22	-2.79	-2.15	0.39	-0.84	-1.73	-1.29	0.05	0.01	-0.03	0.00
Construction	0.15	-0.90	-1.51	-1.35	1.27	-10.34	-18.02	-21.04	0.06	1.52	1.92	1.92
Crop food	0.10	-0.93	1.46	1.80	0.36	-7.30	4.29	4.55	0.02	-0.06	0.49	0.52
Animal food	0.18	-0.34	0.96	1.03	0.64	-1.43	3.33	3.46	0.03	0.08	0.35	0.37
Manufacturing	3.08	-13.89	-23.22	-21.85	11.70	-69.34	-93.85	-92.95	0.84	-1.02	-1.34	-1.05
Services	5.70	-21.80	-46.22	-41.22	53.79	-346.00	-485.88	-483.46	2.39	-1.01	-1.90	-1.09
Food service	0.44	-0.81	-1.04	-0.91	10.61	-21.49	-26.41	-24.95	0.17	0.38	0.57	0.64
Transportation	2.07	-4.46	-6.49	-5.65	15.36	-45.09	-52.62	-51.45	0.83	0.31	0.87	1.09
Wholesale	0.88	-1.84	-3.33	-2.94	14.33	-43.60	-61.96	-63.21	0.40	0.60	0.76	0.83
Retail	0.17	-0.49	-0.90	-0.82	2.67	-10.97	-15.84	-15.98	0.08	0.09	0.09	0.11
Government	1.72	-3.99	-7.24	-6.24	16.70	-92.66	-115.26	-121.19	0.79	1.51	2.58	2.66
Statewide	38.25	-31.84	-38.07	-27.31	525.85	0.00	0.00	0.00	14.11	13.67	19.33	21.05

Notes: CGE Model 4 assumes a more elastic CET with labor is mobile across sectors but fixed statewide. IO total is repeated from table 1. Model 4A is the closure with capital fixed across sectors and in the region. Model 4B is the closure with capital mobile across sectors but fixed in the region. Model 4C is the closure with capital mobile across sectors and in the region. Sectors are commodities in the Social Accounting Matrix.

Appendix C: **Household Income and Welfare Impacts**

Table C1 displays the household income and welfare impacts due to the export shock under CGE model 1. There are nine categories of households based on the household's income range and they are: less than 10K, 10-15K, 15-25K, 25-35K, 35-50K, 50-75K, 75-100K, 100-150K, and 150K+. These are denoted in tables by their last number.

CGE Model 1: Labor mobile across sectors but fixed in region

The results in table C1 show average household income increases, though moderately, but welfare measured in terms of equivalent variation decreases for all households. This is because the effect of increased commodity prices more than offsets the increased household income. As labor shifts to the crop sector, the wage of increases slightly and this increases labor costs for all industries. The price level increases slightly, but even so is enough to overcome increases to household labor income. GDP increases by $26.63 million or 0.013%.

Table C1 also reports results when alternative capital closures are used. Recall the A version is the closure with capital fixed across sectors and in the region, B is the closure with capital mobile across sectors but fixed in the region, and C is the closure with capital mobile across sectors and in the region.

The results show CGE model 1B has higher net household incomes for all categories of households over model 1A. This is a direct results of the loosening of the capital constraint. Nevertheless, welfare measured in terms of equivalent variation decreases for all the categories of the household and this decrease is more than in model 1A. This is again due to price effect more than offsetting the income effect as in price level increases to 1.00169. GDP is $37.61 millions larger or 0.016%. As before, the increased use of labor and capital in the crops sector implies a loss of welfare because of the

Table C1. Welfare Impacts of Exogenous Crop Exports in CGE Model 1

MODEL	AVERAGE HOUSEHOLD INCOME			
1A	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31596.59	0.59	-2.48
15K	36779	36780.46	1.46	-2.09
25K	35999	36001.08	2.08	-1.39
35K	42901	42903.58	2.58	-1.58
50K	57871	57875.12	4.12	-1.66
75K	65886	65891.70	5.70	-0.96
100K	91167	91174.80	7.80	-1.46
150K	110494	110504.08	10.08	-1.14
150+K	134633	134645.71	12.71	-0.96
GDP	234929.71	234956.34	26.63	
Price level	1.000000	1.000100	0.000100	
1B	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31596.84	0.84	-4.34
15K	36779	36781.07	2.07	-3.89
25K	35999	36001.93	2.93	-2.87
35K	42901	42904.64	3.64	-3.30
50K	57871	57876.81	5.81	-3.82
75K	65886	65894.04	8.04	-3.12
100K	91167	91178.00	11.00	-4.78
150K	110494	110508.22	14.22	-4.91
150+K	134633	134650.92	17.92	-5.38
GDP	234929.71	234967.32	37.61	
Price level	1.000000	1.000169	0.000169	
1C	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31596.91	0.91	-3.94
15K	36779	36781.23	2.23	-3.34
25K	35999	36002.16	3.16	-2.25
35K	42901	42904.93	3.93	-2.57
50K	57871	57877.27	6.27	-2.76
75K	65886	65894.69	8.69	-1.78
100K	91167	91178.89	11.89	-2.93
150K	110494	110509.36	15.36	-2.60
150+K	134633	134652.36	19.36	-2.52
GDP	234929.71	234970.31	40.60	
Price level	1.000000	1.000158	0.000158	

Notes: CGE Model 1 assumes labor is mobile across sectors, but that there is a fixed statewide endowment. IO total is repeated from table 1. Model 1A is the closure with capital fixed across sectors and in the region. Model 1B is the closure with capital mobile across sectors but fixed in the region. Model 1C is the closure with capital mobile across sectors and in the region.

opportunity costs of crop production greater than the increased income from crop production. The same welfare result holds for model 1C. Thus as long as the regional supply of labor is fixed, the reallocation of labor and capita to the crops sector is not welfare increasing.

CGE Model 2: Wages fixed across sectors

The welfare impacts due to export shock under model 2 are displayed in table C2. Recall in model 2, employment increases because of the assumption of fixed wages across the sectors. It is then not surprising average net household income increases for all the categories of the households, welfare measured in terms of equivalent variation increases, the GDP increases by $41.39 million or 0.0177%. Welfare increases in spite of the inflation in the economy because the income effect overcomes the price effect.

When we allow capital to be mobile across sectors, the increase in average net household income, welfare (except for household category HHD1), and GDP ($61.8 million) is more than the increase in Model 2A. When there is no constraint for capital availability, average net household income, welfare, and GDP ($67.47 million) increases for all household categories. Thus when the labor endowment is not fixed as in model 2, the expansion of the crops sector does not generate major opportunity costs in the form of reduced output in the rest of the economy. Welfare change is positive in all three variants.

CGE Model 3: Labor mobile across sectors and wages flexible

Table C3 has the welfare results for CGE model 3, in labor is mobile across sectors but there is an upward sloping supply curve with elasticity of 4. As in model 2, the crops export shock increases the average net household income and welfare of all the categories increases except the lowest income group. When we allow the capital to be mobile with a fixed statewide level, the same qualitative results hold. The values increase however, from

version A. In model 2C, we see a larger increase in net household income and welfare (except for 10K), but the increases are less than model 2B.

Table C2. Welfare Impacts of Exogenous Crop Exports in CGE Model 2

MODEL	AVERAGE HOUSEHOLD INCOME			
2A	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31596.89	0.89	0.08
15K	36779	36781.24	2.24	1.30
25K	35999	36002.19	3.19	2.28
35K	42901	42904.97	3.97	2.88
50K	57871	57877.34	6.34	4.85
75K	65886	65894.79	8.79	7.08
100K	91167	91179.03	12.03	9.63
150K	110494	110509.55	15.55	12.64
150+K	134633	134652.60	19.60	16.06
GDP	234929.71	234971.10	41.39	
Price level	1.000000	1.000026	0.000026	
2B	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31597.33	1.33	-0.82
15K	36779	36782.32	3.32	0.87
25K	35999	36003.73	4.73	2.36
35K	42901	42906.89	5.89	3.07
50K	57871	57880.39	9.39	5.46
75K	65886	65899.03	13.03	8.42
100K	91167	91184.82	17.82	11.14
150K	110494	110517.05	23.05	14.94
150+K	134633	134662.05	29.05	19.17
GDP	234929.71	234990.89	61.18	
Price level	1.000000	1.000070	0.000070	
2C	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31597.47	1.47	0.04
15K	36779	36782.67	3.67	2.06
25K	35999	36004.22	5.22	3.67
35K	42901	42907.50	6.50	4.66
50K	57871	57881.36	10.36	7.76
75K	65886	65900.39	14.39	11.29
100K	91167	91186.68	19.68	15.11
150K	110494	110519.44	25.44	19.91
150+K	134633	134665.07	32.07	25.32
GDP	234929.71	234997.17	67.47	
Price level	1.000000	1.000047	0.000047	

Notes: CGE Model 2 assumes wage is fixed and statewide employment adjusts. IO total is repeated from table 1. Model 2A is the closure with capital fixed across sectors and in the region. Model 2B is the closure with capital mobile across sectors but fixed in the region. Model 2C is the closure with capital mobile across sectors and in the region.

Table C3. Welfare Impacts of Exogenous Crop Exports in CGE Model 3

MODEL	AVERAGE HOUSEHOLD INCOME			
3A	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31596.82	0.82	-0.53
15K	36779	36781.05	2.05	0.50
25K	35999	36001.93	2.93	1.40
35K	42901	42904.64	3.64	1.82
50K	57871	57876.81	5.81	3.30
75K	65886	65894.05	8.05	5.16
100K	91167	91178.02	11.02	6.99
150K	110494	110508.25	14.25	9.36
150+K	134633	134650.96	17.96	12.01
GDP	234929.71	234967.58	37.88	
Price level	1.000000	1.000044	0.000044	
3B	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31597.21	1.21	-1.69
15K	36779	36782.01	3.01	-0.30
25K	35999	36003.29	4.29	1.07
35K	42901	42906.33	5.33	1.50
50K	57871	57879.51	8.51	3.18
75K	65886	65897.80	11.80	5.58
100K	91167	91183.14	16.14	7.22
150K	110494	110514.87	20.87	10.05
150+K	134633	134659.31	26.31	13.12
GDP	234929.71	234985.09	55.38	
Price level	1.000000	1.000095	0.000095	
3C	**Base**	**Calculated**	**Difference**	**EV** (dollars/household)
10K	31596	31597.33	1.33	-0.96
15K	36779	36782.31	3.31	0.71
25K	35999	36003.70	4.70	2.19
35K	42901	42906.85	5.85	2.85
50K	57871	57880.34	9.34	5.12
75K	65886	65898.96	12.96	8.02
100K	91167	91184.73	17.73	10.59
150K	110494	110516.92	22.92	14.27
150+K	134633	134661.88	28.88	18.35
GDP	234929.71	234990.44	60.74	
Price level	1.000000	1.000075	0.000075	

Notes: CGE Model 3 assumes labor is mobile across sectors and elastically supplied statewide. IO total is repeated from table 1. Model 3A is the closure with capital fixed across sectors and in the region. Model 3B is the closure with capital mobile across sectors but fixed in the region. Model 3C is the closure with capital mobile across sectors and in the region.