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MEASURING THE ECONOMIC IMPACT OF AGRICULTURAL POLICIES IN METRO AND NON-METRO REGIONS IN WASHINGTON: A REGIONAL GENERAL EQUILIBRIUM APPROACH

By

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ABSTRACT

A regional CGE model for the state of Washington was used to examine the economic impacts from increasing export demand in different agricultural industries and manufacturing. We developed a procedure to modify a state level IMPLAN based CGE model to include 4 household groups designated by geographic location (metro or non-metro) and type of household (farm or non-farm). We also disaggregated the single labor category from IMPLAN into 6 distinct labor groups comprised of like-skill occupations.

Our grouping of households by geography and type verifies that economic impacts from agricultural export shocks, are not evenly distributed. Our results demonstrate that wages paid by the agriculture industry tend to benefit farm households more, and non-metro farm households the most. Welfare effects are also greatest for farm households in terms of equivalent variation. However, even metro non-farm households also receive positive welfare change through spillover effects in the form of increased returns to labor and capital captured by these households.

Keywords: agricultural exports, equivalent variation, welfare changes on metro and non-metro households

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INTRODUCTION

Computable General Equilibrium models (CGE) combine the theoretical structure of Walrasian equilibrium formalized by Arrow and Debreu with real-world data to simulate how various perturbations impact an economy (Wing 2004). CGE models that categorize households according to income level offer no information about the type or location of the household. We modify a Washington state regional CGE model (Holland et al) to include two distinct types of households (farm or non-farm) grouped by their geographic location (metro or non-metro). Instead of a single labor market, we identify six labor groups according to common skill sets. We examine how the economic impact of an assumed increased export demand for specific agricultural commodities affects capital and labor income and how that income is distributed across our household and geographic groups. Our results suggest that increases in agricultural export demand primarily benefits farm households and agricultural labor. Conversely, we find a similar increase in manufacturing export demand has a larger total impact that is distributed more evenly to all households and all regions.

THE WASHINGTON MODEL

CGE Models are multi-sector models that, as suggested by their title, solve for general equilibrium conditions of a specified economy. CGE models begin with a similar framework but are open to adjustments and modifications, making them robust. Generally speaking, producers are treated as profit-maximizers, selling a differentiated product domestically or as exports. The model we use employs a Leontief-cum-constant elasticity of substitution (CES) type production function: fixed proportions of intermediate inputs and CES technology and capital/labor substitution for primary factors for a given industry. The Leontief part of the production function ensures weak separability between primary (labor and capital) and intermediate factors. Representative households are assumed to be utility-maximizers able to consume both domestic goods and imports.

Walrasian equilibrium is achieved by a vector of prices that clear both product and factor markets. The equilibrium prices (commodity prices, factor prices and the exchange rate) that clear product, factor and foreign exchange markers are determined endogenously. Specific functional forms are used to capture the behavior of economic agents. The parameters of these functional forms are obtained by calibration to a dataset, in the case of our model, a Social

Accounting Matrix (SAM). The benchmark year is considered to be in equilibrium for calibration purposes.

Additional assumptions about the structure of the economy are necessary to parameterize the CGE model. Specific to this study, labor and capital are both assumed to be mobile and their endowment variable, implying that capital and labor are assumed mobile across state borders. Mobility allows for the movement of factors across industries as well as in and out of the state; a long-run phenomenon. Mobility and variable endowment assumptions lead to factor market adjustment through changes in factor supply as well as changes in wage and rental rates.

The supply elasticity of all labor groups was set at 2 and the supply elasticity of capital was set at .5. A supply elasticity of 2 suggests that larger increases in wages are necessary to recruit labor than a higher elasticity, say 20. As such, when equilibrium is solved after an imposed shock, there is a lower increase in the labor supply than if a higher elasticity were imposed. Generally speaking, the relatively low supply elasticity of labor should lead to increases in the use of capital through factor substitution. However, since the elasticity of capital is fairly inelastic, increases in both the quantity and return to capital are limited. The elasticity of world export demand was set at 10, implying a very elastic response to changing international export prices.

We use the General Algebraic Modeling System (GAMS) to construct the CGE model and to solve the system of linear and non-linear equations using the PATH solver. Further model details are available upon request from the authors.

We parameterized the Washington state CGE model using a SAM created using 2002 IMPLAN data (MIG 2002). The initial SAM was constructed using IMPLAN and has 23 industries based on NAICS (North American Industry Classification System) (**Table 1**), one labor factor and one capital factor. For the purposes of the study, we disaggregated labor into six distinct labor groups. Typically, CGE models (and input-output models) parameterized using SAMs categorize households according to income level categories. However, it can be instructive to examine the distribution of impacts from changes in agricultural production across functional household types. Bautista (1997) examines the impact of agricultural production on 5 household groups in the Philippines: Metro Manila, other urban, large and small farmers and other rural households. Similarly, Pradhan and Amarendra (2006) examine the impact of trade reform on 4 rural and 5 urban household types. We designated four household groups according to region (metro or non-metro) and type (farm or non-farm).

Table 1: NAICS industries specified in Washington CGE[1]

	Industry Description	NAICS Code	IMPLAN Sectors
1	Crop Production	111	1-10
2	Animal Production	112	11-13
3	Forestry and Logging	113	14-15
4	Fishing, Hunting and Trapping	114	16-17
5	Mining	21	19-29
6	Utilities	22	30-32, 495, 498
7	Construction	23	33-45
8	Manufacturing	31-33	46-389
9	Wholesale and Retail Trade	42, 44-45	390, 401-412
10	Transportation and Warehousing	48-49	391-400
11	Information	51	413-424
12	Finance and Insurance	52	425-430
13	Real Estate and Rental and Leasing	53	431-436
14	Professional, Scientific, and Technical Services	54	437-450
15	Management of Companies and Enterprises	55	451
16	Administrative and Support and Waste Management and Remediation Services	56	452-460
17	Educational Services	61	461-463
18	Health Care and Social Assistance	62	464-470
19	Arts, Entertainment, and Recreation	71	471-478
20	Accommodation and Food Services	72	479-481
21	Other Services (except Public Administration)	81	18, 482-494
22	Public Administration	92	503-506
23	Miscellaneous	NA	496, 497, 499-502, 507-509

Source: Minnesota IMPLAN Group (MIG)

To make changes to the Washington SAM, we rely on US Census Bureau's Public Use Microdata Sample (PUMS) files, which list characteristics of persons and their associated

[1] The 3-digit NAICS industry *agricultural and forestry support activities* is aggregated with the 2-digit *service* industry. The 2002 IMPLAN detail on this industry shows negative capital factor payments. Rather than allow for a CES production function with capital as a negative return we decided to aggregate the service oriented agricultural support activities with Other Service industries.

household[2]. The PUMS files are available for each state as 1 percent and 5 percent samples of the population, the 5 percent data offering finer geographic detail than the 1 percent data[3]. Using weights provided in the PUMS files, characteristics of entire state populations can be derived. For this project, we use the 2000 Census, state of Washington 5 percent PUMS file.

The PUMS files for the state of Washington contain detail on over 129 thousand households and roughly 296 thousands persons living in those households. We match the persons with their respective households and apply a weight to these files to compile an estimate of all persons and households in the state of Washington. From this data set we compile estimates about the characteristics of the Washington state labor force and households.

ESTIMATION OF INDUSTRY PAYMENTS TO LABOR (OCCUPATIONAL) GROUPS

As previously stated, our model provides detail on six Labor groups which were based on the 23 occupational categories defined by the standard occupation classification (SOC) system used by the Department of Labor (**Table 2**). The labor groups aggregate like-skilled occupations. The group *PRO* aggregates occupations requiring specialized professional skills. *UNSKILLED* aggregates SOC occupations that are generally labor-intensive. *SERVICE* aggregates service and support type occupations. *AG, CONSTRUCTION* and *MILITARY* all contain only one SOC group. The group *AG* contains only SOC group 45, *Farming, Fishing and Forestry Occupations* so as to provide more detailed results on the employment of agricultural labor by industry.

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[2] The data was taken from: http://www.census.gov/main/www/pums.html and compiled using Microsoft Access, 2003.

[3] To maintain confidentiality of the PUMS data, the Census sets minimum population thresholds for the size of the geographic units reported. The 5 percent state files report household location using PUMAs (Public Use Microdata Area) which have a minimum population of 100,000. The 1 percent state files use Super-PUMAs which have a minimum population of 400,000. The 5 percent PUMS data also reports location using Super-PUMAs, which are comprised of several smaller PUMAs.

Table 2: Labor groups specified in Washington CGE

CGE Labor Group	SOC Occupations
PRO	11-0000 Management Occupations
	13-0000 Business and Financial Operations Occupations
	15-0000 Computer and Mathematical Occupations
	17-0000 Architecture and Engineering Occupations
	19-0000 Life, Physical, and Social Science Occupations
	23-0000 Legal Occupations
	27-0000 Arts, Design, Entertainment, Sports, and Media Occupations
	41-0000 Sales and Related Occupations
SERVICE	21-0000 Community and Social Services Occupations
	25-0000 Education, Training, and Library Occupations
	29-0000 Healthcare Practitioners and Technical Occupations
	31-0000 Healthcare Support Occupations
	33-0000 Protective Service Occupations
	35-0000 Food Preparation and Serving Related Occupations
	37-0000 Building and Grounds Cleaning and Maintenance Occupations
	39-0000 Personal Care and Service Occupations
	43-0000 Office and Administrative Support Occupations
AG	45-0000 Farming, Fishing, and Forestry Occupations
CONSTRUCTION	47-0000 Construction and Extraction Occupations
UNSKILLED	49-0000 Installation, Maintenance, and Repair Occupations
	51-0000 Production Occupations
	53-0000 Transportation and Material Moving Occupations
MILITARY	55-0000 Military Specific Occupations

Source: SOC Occupations are taken from the Department of Labor. Aggregation procedures are the authors' procedure

PUMS identifies the industry in which each wage earner is employed using the North American Industry Classification System (NAICS). PUMS provides at least 2-digit NAICS detail, which corresponds well with IMPLANs sectoring scheme. Fortunately, PUMS also has 3-digit detail of persons employed in the agricultural industries, offering more detail in those industries. We aggregate the wage and salary earnings for all persons within the same NAICS and Labor groups to arrive at an estimate of industry payments to each of the 6 labor groups. The end result is an estimate of the percentage distribution of industry payments to labor groups by industry (**Table 3**).

As can be seen, the four *Agricultural, Forestry and Fishing* industries pay the majority of their wages to *AG* labor (50, 47, 50 and 57 percent) as would be expected. Few other industries employ significant *AG* labor, and none to the extent of the *Ag* industries. *Manufacturing* employs a large amount of both *PRO* (skilled) and *LABOR* (unskilled). The only industry to employ *MILITARY* is *Public Administration*, which is a result of NAICS convention.

Table 3: NAICS industry payments to labor groups as a percentage of total wages

NAICS Industries	Labor Groups						
	PRO	SOCIAL	AG	CONSTRUCTION	LABOR	MILITARY	TOTAL
Crop Prod	33%	4%	50%	0.4%	12%	0.0%	100%
Animal Prod	43%	2%	47%	0.9%	7%	0.0%	100%
Forestry, Logging	16%	6%	50%	4.5%	24%	0.0%	100%
Fish, Hunt, Trap	23%	5%	57%	0.0%	15%	0.0%	100%
Mining	29%	9%	0.0%	28.7%	33%	0.0%	100%
Utilities	36%	15%	0.1%	8.5%	40%	0.0%	100%
Construction	27%	3%	0.0%	59.5%	10%	0.0%	100%
Manufacturing	48%	8%	0.2%	3.5%	41%	0.0%	100%
Trade	69%	13%	0.6%	1.0%	17%	0.0%	100%
Trans, Warehousing	22%	23%	0.2%	1.2%	54%	0.0%	100%
Information	78%	11%	0.1%	0.3%	11%	0.0%	100%
Finance, Insurance	81%	18%	0.0%	0.2%	1%	0.0%	100%
Real Estate	80%	11%	0.0%	2.2%	6%	0.0%	100%
Pro, Sci, Tech Svcs	88%	9%	0.0%	0.4%	2%	0.0%	100%
Mgmt	89%	11%	0.0%	0.0%	0%	0.0%	100%
Admin, Waste Mgmt	42%	40%	0.3%	2.4%	16%	0.0%	100%
Ed Svcs	25%	71%	0.1%	1.0%	4%	0.0%	100%
Health Care	15%	82%	0.0%	0.6%	2%	0.0%	100%
Arts, Ent, Rec	48%	44%	0.2%	1.6%	6%	0.0%	100%
Acc, Food Svcs	36%	58%	0.0%	0.6%	5%	0.0%	100%
Svcs	29%	33%	0.5%	1.2%	37%	0.0%	100%
Public Admin	37%	43%	0.4%	2.5%	10%	6.7%	100%

Source: Derived using US Census Bureau PUMS data

ESTIMATION OF THE DISTRIBUTION OF FACTOR INCOME TO HOUSEHOLDS

The PUMS data provides detail on 8 types of household income (**Table 4**). Using methods developed by Yusuf (2000), we calculated household income by summing the income of all persons in a household. Households were then classified according to the most important source of income. For example, households who received most of their income from interest dividends and rent are classified as *capital* households.

Table 4: Household income types defined by Census of Population

Income Type	Definition
Wage or salary	Total money earnings received for work performed as an employee during the calendar year 1999.
Self-employment	Both farm and nonfarm self-employment income.
Interest, dividends, or net rental	Interest on savings or bonds, dividends from stockholdings or membership in associations, net income from rental of property to others and receipts from boarders or lodgers, net royalties, and periodic payments from an estate or trust fund.
Social security	Social security pensions and survivors benefits, permanent disability insurance payments made by the Social Security Administration prior to deductions for medical insurance, and railroad retirement insurance checks from the U.S. government. Medicare reimbursements are not included.
Supplemental Security Income (SSI)	(SSI) is a nationwide U.S. assistance program administered by the Social Security Administration that guarantees a minimum level of income for needy aged, blind, or disabled individuals.
Public assistance	Includes general assistance and Temporary Assistance to Needy Families (TANF). Separate payments received for hospital or other medical care (vendor payments) are excluded. This does not include Supplemental Security Income (SSI).
Retirement	Includes: (1) retirement pensions and survivor benefits from a former employer; labor union; or federal, state, or local government; and the U.S. military; (2) income from workers' compensation; disability income from companies or unions; federal, state, or local government; and the U.S. military; (3) periodic receipts from annuities and insurance; and (4) regular income from IRA and KEOGH plans. This does not include social security income.
Other	Includes: Unemployment compensation, Veterans' Administration (VA) payments, alimony and child support, contributions received periodically from people not living in the household, military family allotments, and other kinds of periodic income other than earnings.

Source: US Census Bureau

The source of income for each of the eight household types is shown in **Table 5**[4]. Of course, each household receives the majority of their income from the source by which they are identified. *Labor* households received over $96 billion from wages and salaries and $1.7 and $2.7 billion from self employment and interest respectively. *Public assistance* (PA) households received by far the lowest amount of total income ($199 million). *Supplemental security income* (SS) households total income was also very low ($324 million). **Table 6** shows that PA and SS households also comprise the smallest number of households in the state of Washington (roughly 16 and 27 thousand respectively), and the lowest total income per household (both around $12 thousand per household). Not terribly surprising is that *Labor* households are the largest group (1.6 million) and *Capital*, *Self-employed* and *Labor* households have the three largest incomes

[4] For accounting purposes, two other *households* are included in Table 4: Mixed and Rest. The Mixed household represents households who have 2 or more sources of income of the same magnitude responsible for the largest contributions to household income. For example, a household with total income of $70k that reports $30k from retirement income and $30k from other income is classified as a Mixed household. The likelihood that a large number of households actually have 2 or more sources of income of identical amounts is small. However, because the Census reports income after rounding to the nearest hundred, identical levels of income become more likely. *Rest* households account for those households reporting negative levels of income.

per household. Capital households receive the highest mean income per household, but the mean income per household is only 48 percent greater than the mean income of labor households.

Table 5: Household types and their sources of income (millions of $'s)

Household Type	Source of Income (millions of $'s)								
	Wages	Self-emp	Interest	S.S.	Supp	PA	Retire	Other	Total
Labor	$ 96,776	$ 1,779	$ 2,742	$ 1,026	$ 186	$ 157	$ 1,486	$ 1,161	$ 105,314
Self-emp	$ 1,066	$ 5,935	$ 271	$ 99	$ 11	$ 9	$ 95	$ 53	$ 7,538
Capital	$ 1,015	$ 161	$ 6,304	$ 795	$ 16	$ 3	$ 571	$ 119	$ 8,984
SS	$ 218	$ 37	$ 448	$ 3,077	$ 61	$ 17	$ 704	$ 132	$ 4,693
Supp	$ 19	$ 2	$ 4	$ 26	$ 240	$ 13	$ 11	$ 9	$ 324
PA	$ 21	$ 1	$ 2	$ 12	$ 9	$ 143	$ 3	$ 8	$ 199
Retired	$ 498	$ 72	$ 508	$ 1,129	$ 34	$ 8	$ 4,124	$ 140	$ 6,513
Other	$ 192	$ 16	$ 110	$ 247	$ 24	$ 11	$ 134	$ 1,237	$ 1,971
Mixed	$ 54	$ 32	$ 32	$ 41	$ 5	$ 2	$ 45	$ 18	$ 229
Rest	$ -	$ (5)	$ (1)	$ -	$ -	$ -	$ -	$ -	$ (6)
Total	$ 99,859	$ 8,030	$ 10,420	$ 6,452	$ 586	$ 364	$ 7,172	$ 2,877	$ 135,759

Source: Derived from US Census Bureau PUMS data

Table 6: Number of households and total income per household by type

Household Type	Number of Households	Total Income per Household
Labor	1,612,305	$ 65,319
Self-emp	96,365	$ 78,220
Capital	93,410	$ 96,183
SS	218,522	$ 21,477
Supp	26,905	$ 12,043
PA	16,441	$ 12,083
Retired	127,007	$ 51,277
Other	51,443	$ 38,310

Source: Derived from US Census Bureau PUMS data

We were interested in characterizing households by sub-regions in Washington (metro and non-metro) with two distinct household types for each geographic region (farm or non-farm). PUMS identifies the geographic location of each household according to the Public Use Microsample Areas (PUMAs) in which they live. A PUMA may encompass more than one county or there may be multiple PUMAs within a county.

There are 21 different area types identifying the geographic location of each PUMA. For our study we designated households as being non-metro who live in PUMA area type 90 and all others as metro[5]. PUMS also designates each household as being farm or non-farm. To qualify as a farm household the housing unit must be located on 1 or more acre and have at least $1,000 worth of agricultural products sold from the property (US Census Bureau 2003). As expected, the majority of the population in Washington lived in a Metro region and was classified as a non-farm household (**Table 7**). Roughly an equal number of the 44 thousand farm households are found in metro and non-metro areas.

Table 7: Population distribution by geography and household type[6]

Houshold		PUMS		Census	NIIP
		Total	**Percentage**		
Metro	**Farm**	22,373	0.4%		
	Non-farm	4,931,814	84.8%		
	Total	**4,954,187**	**85.2%**	**4,899,154**	**5,168,460**
Non-Metro	**Farm**	21,987	0.4%		
	Non-farm	840,240	14.4%		
	Total	**862,227**	**14.8%**	**994,967**	**742,722**
Metro and Non-Metro	**Total**	**5,816,414**	**100%**	**5,894,121**	**5,911,182**

Source: Derived from US Census Bureau PUMS data

Our methods of estimating metro and non-metro households using the PUMA classification compares reasonably well with Census estimates and Northwest Income Indicators Project estimates (NIIP)[7] of metro and non-metro populations.

For every labor group, it was necessary to estimate how that occupation's labor payments were distributed to each type of household in each region. Using the wage bill for each labor group, we calculate labor payments to each household category as estimated from PUMS (**Table 8**).

The vast majority of labor payments go to metro non-farm households, which is due to the large share of population and undoubtedly, the more developed economy in metro areas. A bit surprising is the large share of *AG* labor payments going to non-farm households. This is

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[5] All but 2 of the area types (70 and 90) in PUMS identify the area as being metropolitan and incorporate some description of its relation to a central city, MSA, or some other designation. Because there is no way to determine if households in area type 70 are metro or non-metro, we assume that they are all part of the metropolitan area.

[6] Population estimates are calculated excluding households identified previously as *Mixed* or *Rest.* Only those household where a labor industry can be identified are included. Total PUMS population including all individuals totals 5,894,780, between Census and NIIP estimates.

[7] The Census estimate is taken from: http://factfinder.census.gov, Table SF-1. The NIIP estimate is found at: http://niip.wsu.edu/ and is based on figures from the Bureau of Economic Analysis.

largely due to the large share Ag labor being provided by non-farm households. Considering that metro and non-metro farm households comprise .4 and .4 percent of the state population (**Table 7**), the 1.5 and 2.0 percent share of *AG* labor payments is relatively large.

Table 8: Labor payments to household groups as a percentage

Houshold		Labor Group					
		Pro	**Social**	**Ag**	**Const**	**Labor**	**Military**
Metro	**Farm**	0.4%	0.3%	1.5%	0.3%	0.3%	1.0%
	Non-farm	93.2%	88.2%	53.2%	86.8%	85.9%	97.4%
	Total	**93.6%**	**88.4%**	**54.7%**	**87.1%**	**86.2%**	**98.3%**
Non-Metro	**Farm**	0.3%	0.2%	2.0%	0.2%	0.2%	0.0%
	Non-farm	6.1%	11.3%	43.3%	12.7%	13.7%	1.7%
	Total	**6.4%**	**11.6%**	**45.3%**	**12.9%**	**13.8%**	**1.7%**
Metro and Non-Metro	**Total**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Derived from US Census Bureau PUMS data

PUMS also provides estimates of household income received from non-wage sources. We aggregated self-employment and interest income to derive an estimate of the distribution of household payments from capital. We also aggregate transfer payments to households (social security income, public assistance income, retirement income and other income) to estimate how government transfers are distributed to households in Washington. The result is an estimate of the percentage distribution of capital and other (transfer) income to households (**Table 9**). Again, a large share of total capital and other income flows to metro non-farm households. However, farm household's share of capital income relative to their share of total population is large.

Table 9: Capital and other income to households as a percentage

Houshold		Other Income	
		Capital	**Other**
Metro	**Farm**	1.0%	0.4%
	Non-farm	85.6%	82.0%
	Total	**86.6%**	**82.4%**
Non-Metro	**Farm**	0.9%	0.4%
	Non-farm	12.5%	17.1%
	Total	**13.4%**	**17.6%**
Metro and Non-Metro	**Total**	**100%**	**100%**

Source: Derived from US Census Bureau PUMS data

Briefly summarized, the problem was to distribute estimates of labor income, capital income and transfer income from the IMPLAN SAM to farm and non-farm households in metro and non-metro regions in Washington. For labor, we identified six labor categories and used the information in **Table 8** to distribute the wage bill to households. For capital and transfer income we used the information in **Table 9** to distribute capital type income and transfers to households.

ESTIMATES OF HOUSEHOLD CONSUMPTION BY HOUSEHOLD BY REGION

Estimates of the bundle of household consumption for each household are calculated by first establishing average household income for each of our 4 household groups using PUMS data (**Table 10**). Metro farm households had the highest average household income and they were the smallest group (approximately 7,930 households). Non-metro non-farm households had the lowest average household income, representative of rural income levels, with an average income nearly $30 thousand less than metro farm average household income.

Table 10: Total and average household income

Houshold		Income Figures		
		Total Income	Number of Households	Average Household Income
Metro	**Farm**	$ 587,663,170	7,930	$ 74,110
	Non-farm	$ 119,574,894,016	1,901,659	$ 62,879
	Total	**$ 120,162,557,186**	**1,909,589**	**$ 62,926**
Non-Metro	**Farm**	$ 515,654,328	8,485	$ 60,769
	Non-farm	$ 14,857,372,246	324,324	$ 45,810
	Total	**$ 15,373,026,574**	**332,809**	**$ 46,192**
Metro and Non-Metro	**Total**	**$ 135,535,583,760**	**2,242,398**	**$ 60,442**

Source: Derived from US Census Bureau PUMS data

We assumed that each of our 4 household groups share similar consumption bundles as households in IMPLAN with similar household incomes. We created two separate IMPLAN SAMs, one based on Washington metro counties and one based on Washington non-metro counties. Then we took the consumption bundle of the household in the metro or non-metro SAM with similar household income to our households. The result is four consumption functions for each of our 4 households. We then normalized these 4 consumption vectors according to total household income levels in IMPLAN[8].

[8] **Table A.1** provides a comparison of two of the consumption bundles taken from IMPLAN.

We apply our estimates for the distribution of labor payments, household income and household consumption to our base SAM. The modified SAM is then used to calibrate a new Washington CGE model. In the end, the modified CGE solves for 23 industries, 2 regions, 2 household types, and 6 labor groups (treated as 6 labor markets in the model).

THE ECONOMIC IMPACT OF EXPORT DEMAND SHOCKS ON HOUSEHOLD INCOME

The primary aim of this research was to examine how a hypothetical increase in agricultural export demand would impact household income and welfare in metro and non-metro regions in the state of Washington. Specifically, we simulate an increase in export demand in 2 different 3-digit NAICS industries: *crop production* and *animal production*[9]. Additionally, we examine the impact of increased export demand in manufacturing, which includes the production of food manufactured from agricultural commodities.

We run one scenario involving a 20 percent increase in export demand (the intercept term in the foreign export demand function was increased by twenty percent) in each of the agricultural industries and in the manufacturing industry, for a total of 3 scenarios. We also run one scenario in which export demand increases in both *crop* and *animal production* (**Table 11**).

Again, the regional labor supply elasticity of all labor groups is set to 2; a relatively long-run phenomenon. The endowment of labor is variable in the model implying that labor is mobile between Washington, and rest of the U.S. Capital is also mobile and variable in endowment, but the regional supply elasticity is set at .5; less elastic than labor.

Table 11: Scenarios: changes in industry export demand

Scenario	Description
1	20 percent increase in foreign export demand for agricultural crops
2	20 percent increase in foreign export demand for animal products
3	Scenarios 1 and 2 combined
4	20 percent increase in foreign export demand for maufacturing products

[9] Initially we estimated the impacts resulting from increased export demand in *Forestry and Logging* and *Fishing, Hunting and Trapping*. However, the impacts from a 20 percent increase were infinitesimal and therefore the results are not included.

RESULTS

State Economic Impacts

As export demand for a given commodity increases, so does commodity supply in that industry (**Table 12**). Increased export demand in *animal production* (scenario 2) generates relatively small increases in supply (.011 percent), whereas increases in *manufacturing* export demand (scenario 4) generate much larger increases in domestic supply (.82 percent). This reflects the relative importance of export demand for each given commodity. In manufacturing, foreign exports are an important part to total commodity demand, while in animal production that is not true.

Scenario 2 also reveals that production in the indirectly affected *crops* commodity has a slightly larger increase (.012 percent) than *animal production (*.011 percent). This result seems unusual, that increased export demand in *animal production* would have a larger impact on *crop production.* However, the SAM used to parameterize this model reveals that the *animal production* industry purchases more inputs from *crop production* than any other industry; as required by the large inputs of feed required to maintain livestock.

Increased export demand simulated in scenarios 1-4 also generates decreases in production in other industries (indicated by the parenthesis in Table 12). For example an increase in c*rop production* export demand (scenario 1) results in a small reduction in supply in *forestry and logging, fishing and hunting, construction, mining* and others. Increased export demand in the *crop production* industry drives up the demand for labor in that industry. Although labor is mobile and the endowment variable, given an elastic supply of labor, wages must increase to satisfy production requirements. Increased wages leads to increased costs in other industries and possible reduction in their commodity supply.

An increase in export demand in *manufacturing* (scenario 4) generates a relatively large increase in supply in selected other industries. For example, a*nimal production*, *mining*, and *forestry and logging* increase by 2.05, 1.78 and 1.72 percent respectively, due largely to manufacturing's strong backward linkage with those industries. An increase in *manufacturing* export demand does not lead to a decrease in supply in any other industry. Again, this is partially a function of the high level of aggregation in our manufacturing industry. However, it is also a result of strong interindustry linkages. Increasing *manufacturing* production requires support from a large number of primary industries, such as agricultural production. Even though *manufacturing* production leads to higher wage payments for all industries, manufacturing's production requirements still lead to increases in domestic supply for supporting industries.

Table 12: Percentage change in commodity supply

Commodity	**Scenario**			
	1	**2**	**3**	**4**
CROPS	0.201	0.012	0.213	0.958
ANIMAL	0.014	0.011	0.025	2.059
FOREST	(0.066)	0.000	(0.066)	1.722
FISHUNT	(0.004)	0.001	(0.004)	1.569
CONST	(0.001)	0.000	(0.001)	0.028
UTIL	0.010	0.001	0.011	0.406
TRAD	0.007	0.000	0.007	0.401
MIN	(0.007)	0.001	(0.006)	1.784
FOOD	0.005	0.000	0.006	0.269
MANUF	0.010	0.001	0.011	0.817
SERVICE	0.062	0.001	0.063	0.300
MISC	(0.004)	0.000	(0.004)	0.224
TRANSP	0.004	0.000	0.005	0.481
INFO	(0.005)	(0.000)	(0.005)	0.021
FINANCE	0.002	0.000	0.002	0.195
RESTATE	0.022	0.001	0.023	0.186
PROF	(0.005)	0.000	(0.005)	0.235
MGMT	(0.005)	0.001	(0.004)	1.133
ADMIN	(0.006)	0.000	(0.006)	0.049
EDUC	0.006	0.000	0.006	0.264
HLTH	0.006	0.000	0.006	0.236
ARTS	0.000	0.000	0.000	0.194
PUBLIC	0.004	0.000	0.005	0.078

Source: Washington State CGE Model

The competition for labor resulting from increased export demand in a given industry also affects the quantity of foreign and domestic exports in other industries (**Table 13**). For example, an increase in export demand in *crop production* (scenario 1) generates a 2.05 percent increase in *crop production* exports as well as a .17 and .39 percent increase in *forestry* and *fishing* exports respectively. However, in general increased export demand in one industry leads to decreases in exports in most other industries. In scenario 4, increased export demand in *manufacturing* generates decreased exports in all industries except: *animal prod*, *forestry*, *management* and of course *manufacturing*. With the increase in regional wages (leading to increased prices of commodities) and bidding away of labor by manufacturing the net result is a decrease the international competitiveness of many Washington produced commodities in international markets.

Table 13: Percentage change in commodity exports

Commodity	**Scenario**			
	1	**2**	**3**	**4**
CROPS	2.052	0.003	2.055	(0.459)
ANIMAL	0.172	0.164	0.337	1.199
FOREST	(0.173)	(0.001)	(0.174)	0.304
FISHUNT	(0.394)	(0.004)	(0.398)	(1.516)
CONST	(0.012)	(0.000)	(0.012)	(0.166)
UTIL	(0.039)	(0.000)	(0.039)	(0.304)
TRAD	(0.014)	(0.000)	(0.014)	(0.062)
MIN	(0.066)	(0.001)	(0.067)	(0.066)
FOOD	(0.006)	0.000	(0.006)	(0.017)
MANUF	(0.013)	0.001	(0.012)	3.149
SERVICE	0.034	0.000	0.034	(0.105)
MISC	(0.040)	(0.000)	(0.040)	(0.256)
TRANSP	(0.021)	(0.000)	(0.021)	(0.227)
INFO	(0.053)	(0.001)	(0.054)	(0.873)
FINANCE	(0.031)	(0.000)	(0.031)	(0.405)
RESTATE	(0.030)	(0.000)	(0.030)	(0.482)
PROF	(0.028)	(0.000)	(0.029)	(0.356)
MGMT	(0.036)	(0.000)	(0.036)	0.116
ADMIN	(0.026)	(0.001)	(0.027)	(0.553)
EDUC	(0.017)	(0.000)	(0.017)	(0.208)
HLTH	(0.010)	(0.000)	(0.010)	(0.078)
ARTS	(0.021)	(0.000)	(0.022)	(0.252)
PUBLIC	-	-	-	-

Source: Washington State CGE Model

Impacts On Labor Markets

All of the scenarios simulated in this study impact agriculture industries either directly or indirectly (via manufacturing in scenario 4). Increased export demand generates an increase in production and therefore a need for factors of production, i.e., labor and capital. In this study, labor was disaggregated into 6 distinct groups. As such, the impact of increases in production can be examined in more detail across labor groups.

Increased export demand for Ag commodities primarily benefits *AG* labor. In scenarios 1-3, the largest increase in the counterfactual market clearing wage rate occurs with the *AG* labor group as expected since they are the primary labor factor employed (**Table 14**). In scenario 1 the increase in *AG* wages is .22 percent with only minimal wage increases for other labor groups. The impact on *AG* labor in scenario 2 is .002 percent and the impact on *non-AG* labor is infinitesimal.

Table 14: Percentage increase in wages

Labor Group	Scenario			
	1	**2**	**3**	**4**
PRO	0.002	0.000	0.002	0.168
SERVICE	0.003	0.000	0.003	0.120
AG	0.218	0.002	0.219	0.094
CONSTRUCTION	0.002	0.000	0.002	0.143
UNSKILLED	0.005	0.000	0.005	0.365
MILITARY	0.003	0.000	0.003	0.079
CAPITAL	0.022	0.000	0.022	0.251

Source: Washington State CGE Model

Compared to the other scenarios, scenario 4 (increased export demand in manufacturing) has more of an impact on all labor groups. The *UNSKILLED* group has the largest wage increase (.365), and *PRO*, *CONSTRUCTION* and *SEVICE* also experience similar increases (.168, .143, and .12). Increased manufacturing production impacts far more industries than agricultural production, thereby generating larger increases in wages for a broader range of labor groups.

The use of *CAPITAL* is also very different between scenarios. Increased export demand in *crop production* (scenario 1) increases the market clearing capital rental rate (.02 percent) whereas as *animal production* (scenario 2) creates no increase in rental rate (**Table 14**).

Alternatively, increased *manufacturing* export demand generates a .25 of one percent increase in the capital rental rate. The inelasticity of capital in this model (.5) means that when manufacturing increases, commodity supply, it bids up the market clearing capital rental rate.

The change in the number of jobs is presented in actual as well as percentage terms in **Table 15**. As can be seen, *AG* labor is by far the smallest group (30,123) and *PRO* is the largest (1,762,000).

Table 15: Change in jobs in actual amounts and as a percentage

Labor Group	**No. of Jobs**	**Scenario**			
		1	**2**	**3**	**4**
PRO	1,762,000	83	4	87	5,928
	49.8%	0.005%	0.000%	0.005%	0.336%
SERVICES	940,910	55	2	56	2,262
	26.6%	0.006%	0.000%	0.006%	0.240%
AG	30,123	131	1	132	57
	0.9%	0.436%	0.004%	0.439%	0.189%
CONSTRUCTION	191,114	7	0	7	548
	5.4%	0.004%	0.000%	0.004%	0.287%
UNSKILLED	569,265	52	2	54	4,167
	16.1%	0.009%	0.000%	0.010%	0.732%
MILITARY	42,152	2	0	2	67
	1.2%	0.005%	0.000%	0.006%	0.158%
TOTAL	**3,535,565**	**329**	**10**	**340**	**13,028**

Source: Washington State CGE Model

Of all the scenarios, scenario 4 generates the largest increase in total jobs (13,028) with the majority of jobs in *PRO* (5,928) and *UNSKILLED* (4,167). The response in the labor supply to an increase in export demand in *animal production* is smallest (10). This is representative of the low increases in supply (**Table 12**) and exports (**Table 13**) resulting from increased export demand in *animal production*. Even with the small increase in export demand in *animal production*, the corresponding increases in wages and prices negate any increases that might be realized in supply, exports, wages or labor supply.

Impact On Household Income

Metro farm households have the largest average gross income of all our household groups ($105,927); and non-metro, non-farm households have the lowest ($65,475). It may be noted that these mean incomes are higher than the mean household incomes reported in Table 10 based on PUMS data. The difference is explained by different years and different income measures in IMPLAN versus PUMS. The IMPLAN data represent household income in 2002 while the data presented in Table 10 represent income in 1999. Also, the IMPLAN estimate of gross household income includes estimates of household borrowing and estimates of inter-household transfers which results in an increase in estimated mean household income in the IMPLAN based data compared to PUMS.

For each scenario, we estimate the increase in average gross household income in actual amounts and as a percentage (**Table 16**). In scenarios 1-3 farm households experience a larger income increase than non-farm households (actual and as a percentage); non-metro farm households experience the largest income increase (as a percentage) and metro non-farm the smallest (actual and as a percentage). These results are expected, non-metro farm households are most involved in agricultural production, thereby receiving the majority of the economic benefits from the assumed export shock in the form of increased household income. However there is some income increase captured by non-farm households as well. This comes from the a positive ripple effect stemming from non-agricultural industries and the fact that non-metro, non-farm households provide a large share of agricultural labor and benefit from the increased wage bill in that labor market.

The other item of interest is the magnitude of the income changes associated with the assumed export shock. The twenty percent rest of world export demand increase for crops increased farm household income by an average of only $27 per farm household. Returning to the previous tables the export shock increased crops exports by two percent and crop supply by only 0.2 percent. This provides some perspective on how difficult it is to translate increases in agricultural export demand into increases in household income. The increase in crop supply comes at the expense of supply in much of the rest of the economy. Capital and labor must be bid away from other industries and the crop supply response is limited by wage and capital cost increases.

Table 16: Increase in average gross and net household income in actual amounts and as a percentage

Houshold		Average Gross Household Income	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Metro	**Farm**	$ 105,927	$ 27.3	$ 0.4	$ 27.7	$ 384.1
			0.026%	0.000%	0.026%	0.363%
	Non-Farm	$ 89,871	$ 10.4	$ 0.3	$ 10.7	$ 332.4
			0.012%	0.000%	0.012%	0.370%
Non Metro	**Farm**	$ 86,851	$ 26.8	$ 0.4	$ 27.2	$ 298.1
			0.031%	0.000%	0.031%	0.343%
	Non-Farm	$ 65,475	$ 14.4	$ 0.2	$ 14.6	$ 224.5
			0.022%	0.000%	0.022%	0.343%

Source: Washington State CGE Model

An assumed increase in rest of world demand for manufacturing exports (scenario 4) generates a much larger increase in income for all households than the Ag exports scenarios; a consequence of our high level of aggregation of the manufacturing industry, and also the large amount of labor and capital utilized by manufacturing. Increases in manufacturing export demand clearly benefits all households more than Ag export demand, with scenario 2 (*the animal export scenario*) generating virtually no income for any of the household groups.

Impact on Household Welfare

The welfare of households for each scenario is estimated in terms of equivalent variation (EV) in dollar amounts (**Table 17**). Scenarios 1-3 all show that farm households are better off, in EV terms, relative to non-farm households, but all household groups experience positive welfare change. The skewed EV value for farm households is representative of their relatively large increase in household income and their increased consumption of commodities. For example, the demand shock in scenario 1 translates into a $15 increase in EV for both metro and non-metro farm households, whereas the EV increase to non-metro non-farm and metro non-farm households is $8 and $3 respectively. The $8 EV to non-metro non-farm households is driven by that group's increase in income (**Table 16**) -- consistently the third largest. Even metro non-farm households are shown to receive some welfare gains from the crops and animal scenarios. This suggests that the rising tide generated by increased crop agricultural exports does lift all boats, even non-farm households in metro areas.

The impact from the assumed animal rest of the world demand shock (Scenario 2) is notable on several counts. The scenario illustrates the minor role that foreign demand plays in the demand structure for Washington livestock. This is understandable because most livestock are processed in Washington into meat before the meat commodity is exported. This commodity is included in our Manufacturing sector and meat exports are a part of Manufacturing exports. The distribution of household income and welfare under the animal scenario is somewhat different from the crops scenario. In Scenario 2, Metro farm households are shown to be the main welfare gainer, with metro non-farm households gaining just as much as non-metro non-farm households. Livestock production requires different mix of labor requirement than crop production and this mix favors metro household more that non-metro households.

Table 17: Change in Household Welfare (EV)

Household		**Scenario**			
		1	**2**	**3**	**4**
Metro	**Farm**	$ 15	$ 0.22	$ 15	$ 196
	Non-Farm	$ 3	$ 0.13	$ 3	$ 171
Non Metro	**Farm**	$ 15	$ 0.20	$ 16	$ 151
	Non-Farm	$ 8	$ 0.13	$ 8	$ 120

Source: Washington State CGE Model

Scenario 4 has the largest welfare effect on metro farm and non-farm households, equivalent to a $196 and $171 increase in household income. It is interesting that metro farm households have a larger EV increase than non-farm households in response to an increase in manufacturing production. It should be pointed out that Metro farm households receive a larger amount of capital rents (on average roughly $37 thousand) than metro non-farm households (on average roughly $13 thousand). Since manufacturing is capital intensive, increased production in manufacturing leads to increased rents and a higher EV change for metro farm households. This estimate may be skewed however. This model does not distinguish different types of capital. Intuitively, farm households own a large share of land capital, whereas manufacturing production employs more physical capital. As a result, the model may be biased upward in its estimate of the share of non-land capital returns accruing to farm households.

Non-metro households also benefit significantly from the impact generated by scenario 4. Again, manufacturing employs a large amount of labor, which generates increased income for households. Although the price of commodities also increases with the increased export demand, the increase in household income more than offsets that price effect.

CONCLUSIONS

We used a modified regional CGE model for the state of Washington to examine the economic impacts from increasing export demand in different agricultural industries and manufacturing. We developed procedures to modify a generic state level IMPLAN based CGE model to include 4 household groups designated by geographic location (metro or non-metro) and type of household (farm or non-farm). We also disaggregated the single labor category from IMPLAN into 6 distinct labor groups comprised of like-skill occupations. Finally, we represented the agriculture industry using 4, 2-digit NAICS industries, which offers more detail than the traditional 1-digit aggregation scheme.

Our 6 labor categories provide detail about the labor requirements of the 23 industries in our model. As we expected, it is apparent that increases in agricultural export demand have the largest beneficial impact on agricultural labor. The 2-digit NAICS detail for the agriculture industries illuminates the competition for labor by those industries and the large disparity in the impacts generated by different agriculture industries compared to manufacturing industries.

Our grouping of households by geography and type verifies that economic impacts from increased output, specifically in the agriculture industries, are not evenly distributed across regions and types of households. Our results for the crops sector demonstrate that wages paid by the agriculture industry tend to benefit farm households more, and non-metro farm households the most. Further, welfare effects are also greatest for farm households in terms of equivalent variation. However, even metro non-farm households also receive positive net benefit through spillover effects in the form of increased returns to labor and capital. The story for livestock is a bit different with greater impact on metro households.

The results of our efforts are fairly intuitive: returns to agricultural labor increase and farm households are the primary beneficiaries of increased agricultural export demand. However, this paper does offer for the first time some insight into the relative magnitudes of economic impact of agricultural sector shocks for households in metro and non-metro areas in Washington.

Furthermore, we show to use available data, specifically Census data, to examine the geographic distribution of economic impacts in a general equilibrium context. PUMS data are available for every state in the US and there are also similar data sets for foreign countries. Adding rural-urban detail to economic impact analysis can only benefit the already popular use of state level CGE models. In retrospect it would have be better if we had disaggregated the food processing industry from manufacturing so that we could examine the impact of a food export shock. Also, in future models the problem of disaggregate capital payments into land and other capital should be addressed to understand how rents to various kinds of capital are paid and distributed across types of households.

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APPENDIX A

Our assumption about the consumption patterns of our 4 household types is based on data found in IMPLAN. Shown below (**Table A.1**) is a comparison of two consumption bundles we used for metro non-farm and non-metro farm households. These two household groups have similar average income levels but differ by their geographic location. As such, noticeable differences in consumption between metro and non-metro regions may be found by comparing these two households.

According to the IMPLAN vectors for household consumption, the average non-metro farm households consistently allocate more of their total spending to the consumption of goods; i.e. agricultural products, transportation, etc. However, the difference is relatively small. Intuitively, the amount spent on transportation for non-metro households should be much larger, but this is not firmly represented by the numbers below. There are two significant differences in the percent of spending by the two household groups: payments to other households and savings. Metro households dedicate more than 5 percent more of their income to savings. This could be representative of the higher wages received by metro residents which translate into higher levels of savings/investment. Non-metro households send more than 3 percent more of their income to other households. Household to household payments could be representative of the environment in which non-metro residents live, i.e. contracting neighbors for services, and a stronger sense of family; or could be some other phenomenon.

Overall, there appears to be little about these consumption bundles that make them appear distinctively metro or non-metro. Specification of geographic consumption patterns by household could provide additional insight into a model such as the one used for this paper.

Table A.1: Consumption bundles taken from IMPLAN for metro and non-metro households in the same income class

Sector	Metro Non Farm	Non-Metro Farm
agriculture	0.39%	0.39%
construction	0.00%	0.00%
utilities	1.39%	1.41%
trade (retail and wholesale)	10.02%	10.20%
mining	0.00%	0.00%
food (processed)	4.04%	4.11%
manufacturing	11.14%	11.33%
services	3.95%	4.02%
miscellaneous	10.08%	10.26%
transportation	1.73%	1.76%
information	2.46%	2.51%
fire	5.53%	5.63%
real estate	1.70%	1.73%
professional	0.94%	0.96%
management	0.00%	0.00%
administrative	0.34%	0.35%
education	2.35%	2.39%
health	11.91%	12.12%
arts	1.46%	1.48%
public admin	0.00%	0.00%

Sector	Metro Non Farm	Non-Metro Farm
other households	**2.59%**	**5.74%**
fed-defense	9.05%	9.95%
fed-non defense	0.00%	0.00%
fed-investment	0.00%	0.00%
state govt-non ed	0.98%	1.15%
state govt-ed	0.00%	0.00%
state govt-inv	0.00%	0.00%
investment	**17.65%**	**12.15%**
foreign trade	0.29%	0.36%
domestic trade	0.00%	0.00%
TOTAL	100.00%	100.00%