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ASSESSING THE ECONOMIC IMPACT OF ENERGY PRICE INCREASES ON WASHINGTON AGRICULTURE AND THE WASHINGTON ECONOMY: A GENERAL EQUILIBRIUM APPROACH

By

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David Holland, Leroy Stodick, and Kathleen Painter*

ABSTRACT

A general equilibrium, multi-sector economic model of the Washington economy was developed to examine the economic impact on the Washington economy, especially the agricultural industries, from increasing energy prices experienced in 2005 and 2006. The energy group includes such fossil fuel-based commodities as gasoline and diesel fuel (refined petroleum products), natural gas, nitrogenous fertilizer, and petrochemical products. The economic model shows how the Washington economy adjusts to the energy price changes in the short-run under the assumption of no technological change. Industries that are most dependent on fossil fuel-based energy inputs experience increased costs and a loss of economic competitiveness, resulting in economic damage (loss of profits and jobs) to the industry. However, all industries in Washington except for the energy sectors experience some damage, either directly or indirectly. The purposes of this study are to provide a benchmark of fossil fuel use in the Washington economy and to estimate the expected loss in gross state product from energy price shocks under the assumption of existing energy efficiency and technology. As such, the estimates in this paper provide an idea of the economic costs that may be mitigated by the adoption of more energy efficient technologies and the substitution of renewable energy for fossil fuel-based energy products.

Keywords: **The Washington Energy Model, Energy Price Shocks, Economic Impact, Welfare Change.**

JEL Classification: R13

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EXECUTIVE SUMMARY

Based on the results of a general equilibrium economic model measuring the impacts of energy price increases since 2003 on Washington State, gross state product (GSP) is predicted to decline by roughly $11 billion or about 4.9 percent of baseline GSP, despite the fact that returns to capital increase by over 200 percent in the oil and gas industries as well as many of the fossil fuel industries. The large and varying impacts of the energy shock on this state's industries show the widespread dependence of our economy on energy inputs. Energy price increases (based on U.S. producer price increases from 2003 to April 2006) included a 124 percent increase in crude oil and natural gas, a 112 percent increase in refined petroleum products, a 60 percent increase in petrochemicals, and a 44 percent increase in both nitrogen fertilizer manufacturing and natural gas.

Assumptions of the Economic Model:

1. Capital is assumed fixed, but labor is assumed to be perfectly mobile. This means there is no change in technology, such as buying more fuel efficient vehicles. All adjustments to the energy price increase are in the commodity and labor markets. Firms will purchase less expensive energy inputs and lay off workers.
2. World prices are assumed unchanged except for the fossil fuel commodities. In reality, prices for other commodities affected by energy prices will have changed outside this state. This model places Washington firms at a slight disadvantage in terms of their competition outside this state.

As expected, the transportation industries are dramatically affected by energy price increases. Air transportation experiences a 21 percent drop in supply, but this assumes that prices remain constant for air transportation companies outside this state, so these results are somewhat exaggerated. Other transportation services like truck and rail decline between 5 and 7 percent of baseline supply.

The net job loss in the Washington economy predicted by this model is 164,000 jobs, approximately 4.6 percent of all jobs. There is job loss in almost every industry in Washington, with the exception of the energy sectors and investor-owned utilities. Manufacturing loses over 19,000 jobs and over 62,000 jobs are lost in the services sector. Air transportation loses 4,100 jobs (32% of its workforce) while trucking loses 3,800 jobs, or about 12 percent of its workforce. Agriculture loses about 8,400 jobs over all of the agricultural industries represented. Most of the lost jobs are in the grain, fruit, and animal industries.

In terms of Washington State's agricultural industries, fruit production and animal agriculture are the hardest hit, with supply reductions of 7 percent for fruit production and 10 percent for animal agriculture. Fruit production is a relatively high user of gasoline and diesel, natural gas, and petrochemicals, especially pesticides, relative to other crop production. Animal agriculture, which includes dairy and poultry, is the most adversely affected by the energy price shocks of any other major agricultural commodity. This industry is a major consumer of agricultural products such as grains and also consumes a relatively high amount of electricity, gasoline, and diesel. The food manufacturing industry is also damaged by the energy price increases in this model, with a 4 percent drop, but not as severely as the rest of manufacturing, which has a 6 percent decline relative to baseline. In response to the energy price shock, most of the rest of Washington's industries experience a decline in commodity supply of between one and three percent relative to baseline.

This study also analyzes the impact of these energy price increases on Washington households stratified into nine income levels, ranging from approximately $32,912 annual net income per household to $141,916 annual net income per household. As a result of energy price increases, the lowest income households experienced a reduction in annual net household income of $261 (about 1%) while the reduction for the highest income households was $5938 (about 4%). In addition, the economic model examines the utility or welfare loss by households, which includes both their loss in household income and the reduction in buying power due to increased commodity prices. For the lower income households, the loss in welfare averages $739 per household, nearly three times greater than the average loss in net income. For the wealthiest group, welfare losses averaged $7271 per household, about 20 percent higher than the loss in household income alone. The loss of consumption due to price effects of the energy price shock is much more damaging to low income households than the loss of household income.

This simulation shows how vulnerable the Washington economy is to energy price shocks given existing production technology and markets. An important message of this analysis is that much of this economic damage can be avoided by the adoption of more energy efficient technology and by expanding the usage of renewable fuel sources. In fact, the transition to a more energy efficient economy and one more dependent upon renewable energy will offer business opportunities and potential for job creation in Washington.

Regarding Washington agriculture, one of the opportunities for economic growth as well as for a reduction in emissions is the expansion of the biofuels industry, especially biodiesel. From an economic development perspective, the substitution of Washington produced biodiesel for petrodiesel, much of which is imported, allows fuel dollars to produce multiplier effects within the state. This flow would otherwise be exported from the state in the form of payments for imported fuel or payments to state refineries that are totally dependent on non-Washington crude oil feedstocks. The real questions here are whether the in-state oilseed producing industry can be competitive with other sources of imported feedstocks for biodiesel and whether the production of oilseeds in Washington can be an attractive alternative crop across many production regions in Washington. These are questions that are beyond the scope of this paper and will require more detailed micro cost and returns studies for a definitive answer.

INTRODUCTION

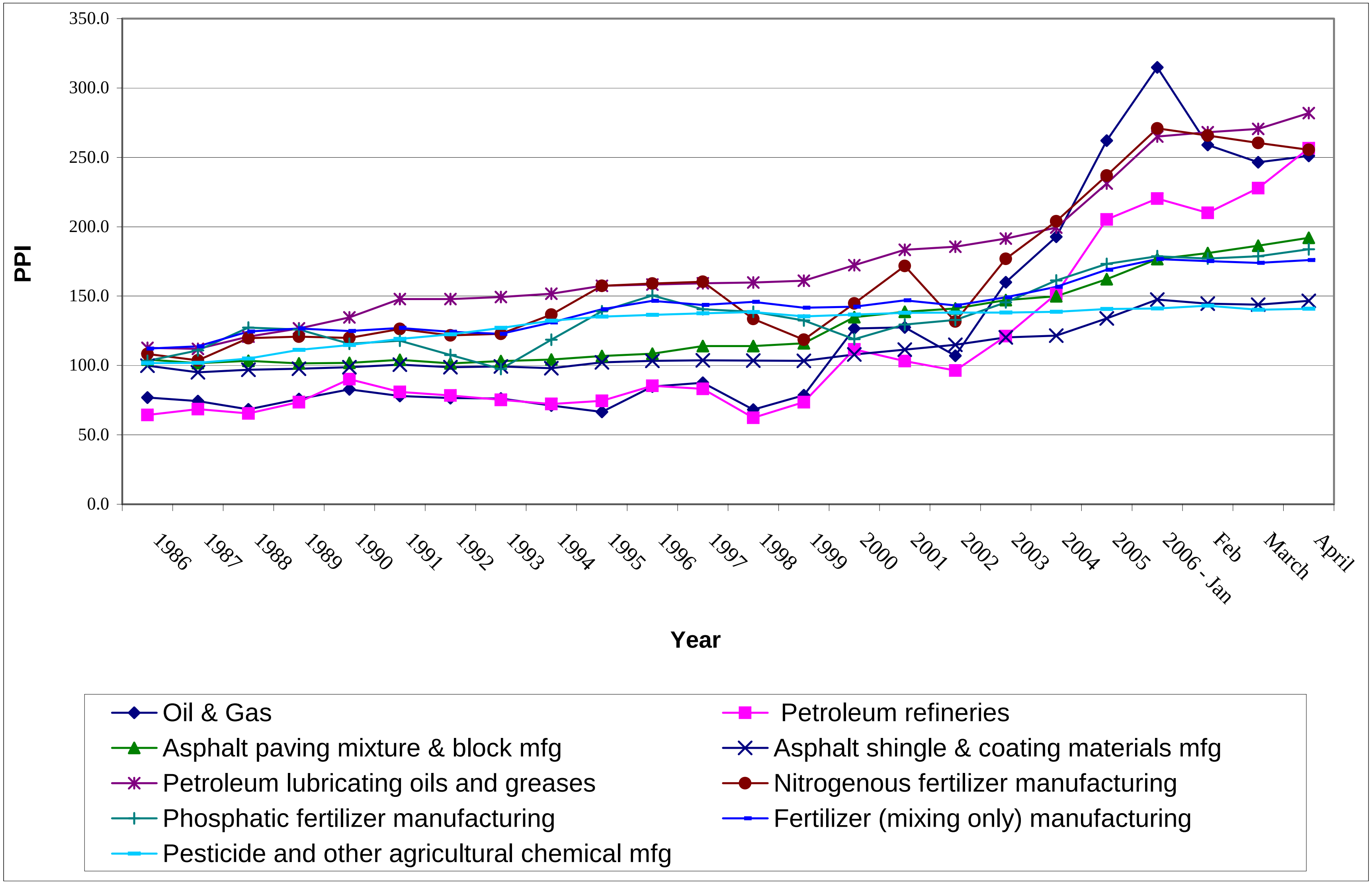
Recent increases in prices of natural gas and fossil fuel-based energy sources have had a large negative impact on the financial condition of many households and industries across the nation and in Washington State. As of mid-2006, the producer price (factory gate price) of crude oil had increased by roughly 124 percent from 2003. Prices for refined petroleum products were not far behind, with a 112 percent increase since 2003 (Figure 1). The cost of many commodities such as nitrogen fertilizer are closely linked to the price of fossil fuels and have also increased significantly. Nitrogen fertilizer prices rose 44 percent from 2003 to 2006.

In December of 2005, the U.S. Department of Energy forecast that oil prices will persist near or above $50 a barrel for years, discarding earlier predictions that costs would drop to around $30 a barrel (Hebert, 2005). This forecast reflected a significant change from the department's projections in 2004, when it predicted that oil prices would retreat in the long term and settle at about $31 a barrel by 2025. The December 2005 report said oil prices would remain in the mid-$40 range or higher in coming years and average $54 a barrel by 2025, increasing to an average of $57 a barrel by 2030, when adjusted for inflation.

Since crude oil prices have been hovering around $60 a barrel in the second half of 2006, after briefly soaring as high as $78 earlier this year, the prospect of higher than predicted fossil fuel prices into the future seems more certain. This paper will address the current fossil fuel energy situation in Washington and the likely short-run economic impact of higher energy prices for the Washington economy.

In the next sections, we describe the role of the fossil fuel energy sectors in the Washington economy and how the Washington economy reacts to energy price shocks in the short run. The short run assumes that capital is fixed by sector (industry) but labor is mobile across industries and the state border with a perfectly elastic labor supply curve. This means that the labor market adjusts by changes in job numbers rather than by wage changes, which is an appropriate short-run assumption. We assume, basically, that there is no technical change in response to the energy shock. In other words, the economy is endowed with a given production function and must adjust to the energy price shock within that production constraint. Thus, we are generating estimates of the sort of economic losses that could be mitigated, to some degree, by conservation as well as by appropriate technical and public policy changes.

Figure 1. Producer price indices of energy based commodities.



Source: Producer Price Index, U.S Dept. of Labor, Bureau of Labor Statistics.

A DESCRIPTION OF ENERGY, AGRICULTURE, AND FOOD SUPPLY IN THE WASHINGTON ECONOMY

The supply situation of commodities produced and consumed in Washington is summarized in Table 1. A given commodity may be produced by one or more industries and, in the case of manufactured commodities, this is usually the case. Commodities may be goods or services. Industries use commodities along with capital and labor to make other commodities. Column 1 shows the production of goods and services (commodities) by Washington industries in millions of dollars. Column 2 shows estimated exports of goods and services from Washington. Column 3, which is the difference between column 1 and column 2, shows Washington production of goods and services that are consumed in Washington. Column 4 shows imports of goods and services (commodities) into Washington. Column 5 shows the absorption of goods and services in Washington, which is the sum of column 3 and column 4.

Washington produced over $7.3 billion of refined petroleum products in 2003 (REFINED-C, row 25 in Table 1), yet it has a relatively nonexistent oil and gas industry, consisting mainly of oil and gas exploration and support activities. This mystery is explained by the presence of North Slope oil in Alaska, much of which is shipped south and refined in Washington. Washington imported $6.5 billion of crude oil and natural gas in 2003 (OILGAS-C, row 26, column (4) in Table 1), forming the basis of its large refined petroleum and natural gas distribution industries. About two-thirds of the cost of refined petroleum products in Washington comes from the cost of imported crude oil, based on the 2003 Social Accounting Matrix (SAM) for the state of Washington. A SAM is typically used to represent the circular flow of income in an economy, and is used for policy purposes to support disaggregated economy-wide modeling.

The relative size of other energy-intense commodities (asphalt, petrochemicals, nitrogenous fertilizer, phosphate fertilizer, and pesticides) is quite small compared to refined petroleum products (Table 1). The largest energy industry after refined petroleum products is the distribution of natural gas, with production of $1.4 billion (NATGAS-C). The other energy-intense industries are closely related to agriculture: pesticides, nitrogenous fertilizer, and phosphate fertilizer. These are relatively small industries, with production in the neighborhood of $100 million and imports on the order of two to four times higher than state production.

While most of the nitrogenous fertilizer is made by the nitrogenous fertilizer industry, some is also made by the manufacturing and fertilizer mixing industries. Likewise, phosphate fertilizer is made by the manufacturing industry, the nitrogenous industry, and the fertilizer mixing industry, but there is no phosphate fertilizer industry listed in the input-output accounts for Washington. In other words, phosphate fertilizer is made as a secondary product by industries in Washington.

Table 1. Commodity Supply, Exports, Imports and Absorption for Washington 2003 ($ Millions)

Row	Sector	Output (1)	Exports (2)	(1)-(2) (3)	Imports (4)	Absorption (3) + (4)
1	OILSEED-C	15.63	15.45	0.18	17.61	17.79
2	GRAIN-C	586.39	528.16	58.22	328.60	386.82
3	VEGETAB-C	893.99	552.93	341.06	151.43	492.49
4	NUT-C	0.43	0.33	0.11	35.30	35.41
5	FRUIT-C	1556.75	1231.34	325.41	197.44	522.85
6	NURSERY-C	367.72	221.22	146.50	226.10	372.60
7	ANIMAL-C	1522.66	362.39	1160.27	456.80	1617.07
8	LOGGING-C	1748.99	464.28	1284.71	35.99	1320.70
9	OTHCROPS-C	1028.61	780.53	248.08	58.55	306.63
10	FISHING-C	2109.06	2056.79	52.27	1247.78	1300.05
11	CONST-C	27735.91	2679.38	25056.53	653.28	25709.80
12	UTIL-C	1521.24	336.69	1184.55	0.00	1184.55
13	PRIVELEC-C	6490.58	1480.10	5010.49	457.69	5468.17
14	WHOLTRAD-C	17206.05	2262.81	14943.24	1308.24	16251.48
15	RETTRAD-C	24486.83	2990.80	21496.03	1933.88	23429.91
16	MIN-C	707.77	563.80	143.96	920.03	1063.99
17	FOOD-C	12553.87	7674.28	4879.59	8773.41	13653.00
18	FATS/OILS-C	185.26	166.21	19.05	434.19	453.24
19	MAN-C	67850.27	41179.92	26670.34	59769.85	86440.19
20	ASPHALT-C	208.01	3.12	204.89	137.57	342.47
21	PETCHEM-C	695.64	406.58	289.06	326.91	615.97
22	NITFERTM-C	113.81	92.48	21.33	188.40	209.74
23	PHOFERTM-C	31.68	15.75	15.92	135.34	151.27
24	PESTMAN-C	95.99	69.37	26.62	470.53	497.14
25	REFINED-C	7340.42	755.79	6584.64	1130.81	7715.44
26	OILGAS-C	171.71	8.63	163.08	6548.10	6711.18
27	NATGAS-C	1466.76	3.21	1463.55	735.79	2199.34
28	OTHSER-C	185000.00	61612.16	124000.00	66793.65	190000.00
29	AIRTRAN-C	2986.87	1892.58	1094.29	1273.79	2368.08
30	RAILTRAN-C	992.36	453.60	538.77	208.48	747.25
31	WTRTRAN-C	1769.46	1236.67	532.80	0.00	532.80
32	TRCKTRAN-C	3449.97	433.70	3016.26	634.50	3650.77
33	OTHTRAN-C	2817.46	1466.72	1350.74	565.73	1916.47
34	GOVTSPC-C	48747.87	1802.76	46945.11	1599.18	48544.29

Source: Author’s estimates based on IMPLAN data.

Two different industries produce electricity in Washington, with two different production functions: private power and public power. Public power is the far bigger supplier, and is more dependent on fossil fuel-based inputs in Washington. However, as noted in Table 1, each industry produces just one commodity: private electricity (PRIVELEC-C, row 13 in Table 1).

The relative size of the production of agricultural commodities as presented in the Washington SAM is also shown in Table 1. The important role of exports as a source of demand for Washington crops production (rows 1-6 in Table 1) is clearly evident. The demand for animal-based agricultural commodities (row 7 in Table 1) plays a much smaller role in the export market. The processed food industries include both fats/oils (FAT/OILS-C, row 18) and Food (FOOD-C, row 17). Together they produce over $12 billion in food supply (column (1) in Table 1), with exports of $7.7 billion (column (2) in Table 1). Food imports are over $8.7 billion (column (4) in Table 1), with absorption of food in Washington reaching $13.6 billion (column (5) in Table 1). This compares to $7.7 billion for the absorption of refined petroleum products (row 25 in Table 1).

The oilseed industry may play an important role in the expansion of biodiesel production in the future. However, the supply of oilseeds in Washington is shown to be quite small at $15.6 million (OILSEEDS-C, row 1, column (1) in Table 1). Actually, the state produced only $2.7 million of this supply; the rest, according to the input-output account, came from non-industrial sources such as sales by the federal government. In any event, most of the oilseeds pressed in Washington are imported (row 1, column (4) in Table 1). Another important potential source of supply for biodiesel production is from row 18, (FATS/OILS-C) fats and oils. This commodity category is an aggregation of three individual commodities: soybean processing, other oilseed processing, and fats and oils refining and blending. The supply of this commodity was $185.2 million in 2003 (row 18, column (1), in Table 1). The majority of this supply was from the fats and oil refining industry; the soybean and oilseed processing industries produced about 12 percent of the total. The size of the industry that would produce the feedstock for biodiesel was relatively small at the time of this study. Imports of fats and oils were $434 million, or more than twice the size of Washington production. Historically, Washington State has imported rather than produced this commodity.

A new Washington State regulation (SB 6508, known as the Renewable Fuel Standards legislation, approved March 30, 2006) requires that all diesel sold in the state must contain at least two percent biodiesel by December 2008. This requirement will increase Washington's biodiesel consumption to more that 20 million gallons per year, since the state uses more than 1 billion gallons of diesel per year (Bauman et al. 2006). At current prices, the value of this amount of biodiesel is nearly $50 million. (Compare this figure to the approximately $3 million value of annual production in the Washington oilseed industry in 2003.)

At least one large biodiesel plant (100 million gallons per year) is under development in Grays Harbor. The company, Imperium Renewables, plans to use a blend of feedstocks such as imported palm, soy, and canola oils, depending on the price (Bauman et al. 2006). Canola and canola oil can be produced in Washington, but it must compete with other feedstocks to be a viable source of biodiesel. In addition, canola must compete with the net return from other crops in order to be produced on a large scale by Washington farmers. These issues are under study by researchers at the Center for Sustaining Agriculture and Natural Resources at WSU. Various economic analyses have shown that market prices for canola need to increase about 20 percent from their current levels of $12/cwt to compete with other major crops in Washington State (Painter, Roe, and Hinman, 2006).

THE WASHINGTON CGE MODEL – DISCUSSION OF THE THEORETICAL MODEL

CGE models are multi-sector models of the economy. They are based on Walrasian general equilibrium models of market-clearing on both the product and the factor markets. CGE models have been primarily used to analyze tax and trade policies, but have also been used to examine the economic impact of energy price shocks at the national level. As in any neo-classical model, producers are assumed to be profit maximizers, and in typical CGE methodology they can sell their output either on the domestic market or on the export market, based on relative prices. Households maximize utility by consuming a mix of domestic and imported goods. The composition of domestic (state) supply depends on the relative prices of state products and imports.

In the Washington CGE model, households are modeled as a representative agent assumed to have Stone-Geary preferences and industries are modeled as representative producers assumed to have constant elasticity of substitution (CES) production technologies. There is endogenous determination of equilibrium prices (commodity prices and factor prices to clear the product and factor markets). Specific functional forms are used to capture the behavior of economic agents. The parameters of these functions are obtained by “calibration” to a dataset (usually a Social Accounting Matrix – a matrix showing income and expenditure flows in an economy) for a given year.

Like many other CGE models, a CES-type production function was used to model producer behavior. The Leontief-cum-CES production function for a given industry has fixed proportions of intermediate inputs, but capital/labor substitutions 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. The demand for labor and capital is derived from the first-order conditions of profit maximization taking into account the value-added or net price. The production function was configured to allow substitution between other labor and capital depending on the elasticity of capital/labor substitution.

CGE models allow for imperfect substitution between state-produced goods and goods from the rest of the U.S. (ROUS) and the rest of the world (ROW). An Armington function is used to capture the substitution possibilities between state-produced goods and imported goods for both firms and households. In other words, the Armington aggregate is a composite good consisting of state-produced and imported goods. The Armington function is of the CES type. The higher the value of the Armington elasticity, the easier is the substitution between state-produced and imported goods.

Since this is a regional model, we have used the Armington function at two levels. In the first stage, we allow for substitution between domestic goods (produced in Washington) and imported goods; in the second stage we differentiate between domestic imports (imports from rest of the United States) and foreign imports (imports from rest of the world), and allow substitution to take place between them. The foreign exchange rate is assumed fixed. Federal government expenditure and investment are exogenous in the model. State government revenues are endogenous and are assumed to drive state government expenditures.

As mentioned before, there is endogenous determination of Washington prices to clear all markets. Initially, consumer prices of domestic goods and imports, the world price of exports, and the exchange rate are all set equal to one. Prices of foreign goods and imports from the rest of the U.S are assumed to be exogenous, that is, these prices are assumed given. In this setting, we therefore make the "small" country assumption that Washington's production does not affect import or export prices. The consumer price index is set to be the numeraire.

The export supply function, derived from a constant elasticity of transformation (CET) function, specifies the value of exports as a function of the ratio of state-level and international export prices. The CET function defines the production possibilities available to a given industry, assuming exported products are differentiated from state-marketed products produced by a given industry. The regional export composite is a function of the price of exports to the rest of the U.S. and foreign sources. The price of a foreign-produced commodity is a function of the world price and the foreign exchange rate (assumed fixed in this model).

Import demand is the first-order condition obtained from the cost minimization problem of buying a given amount of the composite commodity. Composite commodity supply (Armington aggregate) is a function of the price of imports and the price of regionally produced goods. The regional import composite is a function of the price of imports from the rest of the U.S. and foreign sources.

Most of the parameters of the model are calibrated from an IMPLAN-based social accounting matrix (SAM). However, the Armington elasticities, the elasticity of transformation (CET) elasticities (counterpart of the Armington elasticities on the export side), the elasticity of capital/labor substitution in production, and the household income elasticity are all free parameters to be specified by the model user and based on the literature.

GAMS software (using the PATH solver) was used to construct and solve this model, a simultaneous system of non-linear equations. The GAMS code and model documentation representing the model equations is available from the author's web page. The model is initially solved to replicate the base year SAM by appropriately calibrating the parameters of the model. A 2003 social accounting matrix (SAM) for the state of Washington from the IMPLAN (Impact Analysis for Planning) database was used to construct a 27-sector model of the Washington economy (see Appendix 1 for the industry aggregation scheme) that features industry detail in the agricultural and energy sectors (IMPLAN, 2000). The CET and Armington elasticities were set equal to 2 except for crude oil and refined petroleum products. These products were assumed to be more tradable, so the trade elasticities for these commodities were set equal to 10.

EMPIRICAL MODEL - SIMULATION ASSUMPTIONS AND RESULTS

This simulation was performed in order to examine the effects of recent energy price shocks assuming short-run factor market behavior. (Capital was assumed fixed by industry, and labor was perfectly mobile across industries.) Labor was assumed to be perfectly elastic in supply across state borders. The elasticity of substitution between labor and capital was assumed to be 0.99. The model thus captures an economy with a fixed capital endowment and represents expected commodity and labor market adjustments in the relatively short-run, given the assumption of fixed sector-specific capital and no technical change.

In the simulation model, the rest of the world (ROW) and rest of the U.S. (ROUS) commodity export and import prices were treated as exogenous. The energy shock was simulated as an increase in the import and export price of selected energy commodities. The assumed increase in world prices for these commodities is summarized in Table 2 and represents the actual percentage change in U.S. fossil fuel-based energy producer price from 2003 to April 2006 (see Figure 1.) For example, the percentage increase in the price of refined petroleum products between 2003 and 2006 was an increase of 112 percent (Table 2). The CGE model then simulates the economic impact of the energy price shock under the assumption that all world and rest of U.S. prices except the energy commodities are unchanged. It could be argued that the choice of mid-2006 energy price levels overstates the price shock, since energy prices have decreased somewhat since that time. However, with just minor shocks in the world petroleum supply, oil and oil-based energy prices could return to the mid-2006 levels or even higher.

Table 2. Energy price shocks: 2003-2006

Sector	Base	Calculated	Difference	Percent Difference
PETCHEM-C	1	1.60	0.60	60
NITFERTM-C	1	1.44	0.44	44
PHOFERTM-C	1	1.26	0.26	26
PESTMAN-C	1	1.06	0.06	6
REFINED-C	1	2.12	1.12	112
OILGAS-C	1	2.24	1.24	124
NATGAS-C	1	1.44	0.44	44

Source: Author's estimates

Of course, Washington commodity prices are assumed to be endogenous and are allowed to adjust to clear factor and commodity markets as determined by the CGE model. Those industries that are heavy users of fossil fuels will experience the greatest increase in production cost, thus the most damage to their competitive position in state, national, and international markets. They will attempt to substitute other less expensive inputs for energy to the degree possible, but their options are limited by the Leontief specification of the intermediate inputs part of the production function. Producers in the refined petroleum industry and in the oil and gas industries were assumed unable to alter supply because of supply constraints in those industries. Therefore, the energy shock is a shock in the price of fossil fuel-based commodities, assuming that the Washington production of refined petroleum products remains constant. All other Washington industries were assumed to adjust production as required to clear their markets, subject to the conditions imposed by their increased energy costs, markets, and production technology.

It should be noted that world prices are assumed unchanged except for the fossil fuel commodities. In reality, these prices likely have risen as a function of the same increases in energy prices facing Washington producers. By assuming that rest of the world prices are unchanged, we are placing Washington producers at a slight disadvantage in terms of their actual competitiveness in export markets. In reality, the world price of a good or service may have actually increased as a function of increased energy cost (an upward and shift to the left in the commodity supply curve). In our model, those prices are treated as unchanged. The assumption that world prices are unchanged means that import prices are probably underestimated as a result of the energy price shock and the Washington economy has the advantage of buying lower priced imports than is actually the case. In the real world, the Washington economy adjusted to the energy shock along with changes in labor supply, world prices, capital markets and many other factors. This simulation abstracts from all of that and looks at the expected adjustment to just energy price increases, assuming other exogenous variables are unchanged.

Households will attempt to substitute away from the more expensive fossil fuel commodities, as permitted by the demand system and the price changes for the commodities that they buy. Of course, household demand is a function of both commodity prices and household income, so demand also changes as a function of changes in commodity prices and household income. In response to increased energy costs, industries reduce their workforce, which lowers household income.

Supply Response

The predicted changes in commodity supply in response to the energy price shock are detailed in Table 3. In Table 3 “Base” represents baseline (2003) commodity supply and “Calculated” represents counterfactual supply, i.e., supply levels determined by the CGE model. Of course, commodities requiring large inputs of fossil fuel are the most subject to cost increases, loss of competitive position, and loss of markets. As expected, transportation services are vulnerable to increased energy prices because of the role of fossil fuels in providing this service. For example, air transport experienced a 21.4 percent drop in supply (AIRTRAN-C, see row 29 in Table 3). Somewhat surprising was the fact that selected energy-based commodities also experienced large reductions in supply. In particular, natural gas distribution declined by 27 percent (NATGAS-C, row 27 in Table 3) and production of nitrogen fertilizer by 9 percent (NITFERTM-C, row 22 in Table 3). This result is a function of a cost-price squeeze for those commodities. The increase in the world oil and gas prices is putting cost pressure on the natural gas distribution industry. The pressure of rising costs results in a large reduction in the supply of natural gas distribution.

Electricity supply is another commodity that undergoes a huge reduction of $1.19 billion in supply, an 18 percent reduction (row 13 in Table 3). Again, this is a function of a downsized Washington economy (state gross product is reduced by 4.79 percent) but it is also due to the electricity production functions. For example, the production of electricity in the public sector shows major inputs of natural gas, presumably in the form of gas fired turbines. The 124 percent increase in the price of crude oil and gas reduces the competitiveness of these industries. The model shows a 25 percent increase in imports of electricity from outside the state to substitute for the more expensive state-produced product.

Among the agricultural commodities, the supply of fruit is reduced by 7.5 percent (row 5 in Table 3), a good bit larger than the percent decrease in any other crop. Compared to other crops, fruit production is shown to be a more intensive user of refined petroleum products, pesticides, and fertilizers per unit of output. Animal production, which includes both dairy and poultry, is shown to be more adversely affected by energy price shocks than any other major agricultural commodity, with a reduction of 9.9 percent in commodity supply (row 7 in Table 3). The animal industry is a heavy user of electricity and refined petroleum products, but, unlike crop-based agriculture, it is also a major buyer of many other manufactured inputs including crops for livestock feed. The net result is that animal-based production is more sensitive to the simulated energy shock than any other agricultural commodity. The model predicts that production of most agricultural commodities will decline by somewhere between one and three percent (rows 2, 3, 4, and 6 in Table 3).

Food manufacturing decreases by 4.8 percent, a bit less than the 6.4 percent supply reduction of manufacturing in general, indicating that food was actually less damaged by the energy shock than the rest of manufacturing (row 17 in Table 3). The fat/oils commodity, however, is one of the most damaged from the energy shock, with a reduction in predicted supply of 11.4 percent (row 18 in Table 3). The industry that produces the fats/oil commodity does not use fossil fuel-based commodities as a major part of its production process. However, the fats/oil commodity is the major input into the production of fats and oils. As household demand for this commodity decreased as a function of the reduction in household income and as inter-industry demand declined (the food industry and the manufacturing industry are important buyers of the fats/oil commodity), then commodity supply is reduced not only because of the reduction in demand, but because the fats/oil industry is using much less of fats/oil as a commodity input into the production of fats/oil.

Table 3. Predicted changes in commodity supply in response to the energy price shock

Row	Sector	Base	Calculated	Difference	Percent Difference
1	OILSEED-C	15.63	15.62	-0.01	-0.04
2	GRAIN-C	586.39	578.87	-7.51	-1.28
3	VEGETAB-C	893.99	881.61	-12.38	-1.38
4	NUT-C	0.43	0.42	-0.01	-3.42
5	FRUIT-C	1556.75	1447.12	-109.63	-7.04
6	NURSERY-C	367.72	363.81	-3.91	-1.06
7	ANIMAL-C	1522.66	1371.46	-151.2	-9.93
8	LOGGING-C	1748.99	1674.46	-74.52	-4.26
9	OTHCROPS-C	1028.61	1001.24	-27.37	-2.66
10	FISHING-C	2109.06	2053.37	-55.69	-2.64
11	CONST-C	27735.91	27306.64	-429.27	-1.55
12	UTIL-C	1521.24	1475.92	-45.32	-2.98
13	PRIVELEC-C	6490.58	5298.22	-1192.37	-18.37
14	WHOLTRAD-C	17206.05	16621.67	-584.38	-3.4
15	RETTRAD-C	24486.83	23765.47	-721.36	-2.95
16	MIN-C	707.77	660.57	-47.2	-6.67
17	FOOD-C	12553.87	11953.05	-600.82	-4.79
18	FATS/OILS-C	185.26	164.07	-21.19	-11.44
19	MAN-C	67850.27	63474.99	-4375.27	-6.45
20	ASPHALT-C	208.01	203.19	-4.82	-2.32
21	PETCHEM-C	695.64	702.85	7.22	1.04
22	NITFERTM-C	113.81	103.35	-10.47	-9.2
23	PHOFERTM-C	31.68	31.72	0.05	0.15
24	PESTMAN-C	95.99	96.03	0.04	0.04
25	REFINED-C	7340.42	7342.19	1.76	0.02
26	OILGAS-C	171.71	168.36	-3.36	-1.95
27	NATGAS-C	1466.76	1070.23	-396.53	-27.03
28	OTHSER-C	185198.44	181296.72	-3901.72	-2.11
29	AIRTRAN-C	2986.87	2347	-639.87	-21.42
30	RAILTRAN-C	992.36	924.68	-67.68	-6.82
31	WTRTRAN-C	1769.46	1649.96	-119.5	-6.75
32	TRCKTRAN-C	3449.97	3185.72	-264.25	-7.66
33	OTHTRAN-C	2817.46	2671.88	-145.58	-5.17
34	GOVTSPC-C	48747.87	47304.98	-1442.89	-2.96

Source: Author's estimates

Most of Washington's economy is not badly damaged by the energy price shock. The exceptions in agriculture are fruit production and animal agriculture, which experience supply reductions of 7.5 and 9.9 percent, respectively. Other parts of the economy that are very sensitive to this energy shock are the electricity production and transportation industries, especially air transportation, which experiences a 21 percent drop in supply. Other transportation services like truck and rail decline between 5 and 7 percent of baseline supply. One of the largest declines is the 18 percent drop in the provision of electricity. The food industry is damaged, with a 4 percent drop, but not as severely as the rest of manufacturing, which has a 6 percent decline relative to baseline. In response to the energy price shock, most of the rest of Washington's industries experience a decline in commodity supply of between one and three percent relative to baseline.

Price Response

The estimated effect of the energy price shock on prices received by Washington producers (supply prices) is summarized in Table 4. Changes in equilibrium producer prices generated by the energy price shock will not be evident in advance of solving the model, except perhaps in the case of the energy commodities themselves. The energy-based commodities experience an increase in the world price, which is translated into the Washington producer price on a nearly one to one basis (Table 4). For example, the supply price of crude oil (OILGAS-C) goes up by almost the same amount as the assumed change in world price (Table 4). For refined petroleum products, the increased cost of crude oil is passed along in the cost of production and the Washington supply price increases by 99 percent, compared to the 112 percent increase in the world price. The Washington supply price change is less than the world price change because crude oil cost is only two-thirds of the cost of refined petroleum and Washington refined petroleum is not a perfect substitute with rest of the world refined petroleum. Of course, the price that consumers face is a blend of the Washington producer price and the price of the imported commodity.

Producer price changes associated with the other energy commodities closely approximate the world price change with the exception of the distribution of natural gas. In the case for this commodity, the Washington producer price actually increases by a larger percent than the assumed change in world price. This is a function of the increased cost of feedstocks. This industry uses huge amounts of raw natural gas as its major input, which, because of limitations in the data, were combined with crude petroleum and assumed to increase in price by 112 percent while the world price of the final distribution of natural gas was assumed to increase by only 44 percent. The result is that the Washington distribution of natural gas appears to be the victim of a cost-price squeeze. The producer price of natural gas increases by 60 percent compared to the world price increase of 44 percent. In the simulation, the production of natural gas distribution (NATGAS-C) declines by 27 percent while imports of the commodity decline by only 5 percent because the imported commodity is cheaper than the Washington produced commodity. In actuality, the cost of the natural gas feedstock is overstated by the model because it is combined with crude petroleum.

Table 4. The estimated effect of the energy price shock on Washington producer prices

Row	Sector	Base	Calculated	Difference	Percent Difference
1	OILSEED-C	1.00	0.9997	0.000	-0.03%
2	GRAIN-C	1.00	0.9988	-0.001	-0.12%
3	VEGETAB-C	1.00	0.9960	-0.004	-0.40%
4	NUT-C	1.00	0.9997	0.000	-0.03%
5	FRUIT-C	1.00	1.0025	0.002	0.25%
6	NURSERY-C	1.00	0.9969	-0.003	-0.31%
7	ANIMAL-C	1.00	1.0363	0.036	3.63%
8	LOGGING-C	1.00	0.9789	-0.021	-2.11%
9	OTHCROPS-C	1.00	0.9934	-0.007	-0.66%
10	MISCAG-C	1.00	0.9999	0.000	-0.01%
11	CONST-C	1.00	1.0154	0.015	1.54%
12	UTIL-C	1.00	0.9775	-0.022	-2.25%
13	PRIVELEC-C	1.00	1.1596	0.160	15.96%
14	WHOLTRAD-C	1.00	0.9930	-0.007	-0.70%
15	RETTRAD-C	1.00	0.9978	-0.002	-0.22%
16	MIN-C	1.00	0.9968	-0.003	-0.32%
17	FOOD-C	1.00	1.0022	0.002	0.22%
18	OILSDPROC-C	1.00	1.0015	0.001	0.15%
19	MAN-C	1.00	1.0046	0.005	0.46%
20	ASPHALT-C	1.00	1.3155	0.315	31.55%
21	PETCHEM-C	1.00	1.5836	0.584	58.36%
22	NITFERTM-C	1.00	1.4453	0.445	44.53%
23	PHOFERTM-C	1.00	1.2531	0.253	25.31%
24	PESTMAN-C	1.00	1.0558	0.056	5.58%
25	REFINED-C	1.00	1.9892	0.989	98.92%
26	OILGAS-C	1.00	2.2331	1.233	123.31%
27	NATGAS-C	1.00	1.6035	0.604	60.35%
28	OTHSER-C	1.00	0.9963	-0.004	-0.37%
29	AIRTRAN-C	1.00	1.0328	0.033	3.28%
30	RAILTRAN-C	1.00	0.9964	-0.004	-0.36%
31	WTRTRAN-C	1.00	1.0050	0.005	0.50%
32	TRCKTRAN-C	1.00	1.0387	0.039	3.87%
33	OTHTRAN-C	1.00	0.9969	-0.003	-0.31%
34	GOVTSPC-C	1.00	1.0000	0.000	0.00%

Source: Author’s estimates

The other major increase in Washington producer price is the price of electricity, which is responsible for some of the economic damage to the state's economy from the energy shock. Although Washington's electricity is mainly supplied by hydropower, which is relatively immune from fossil fuel-based shocks, the production functions also involve consumption of large quantities of OILGAS-C and the simulated increase in supply price of this commodity is nearly 123 percent. This puts cost pressure on the producer price of electricity and the supply price is simulated to increase by nearly 16 percent.

According to the Northwest Power and Conservation Council, roughly 66 percent of Washington's electricity is hydro based with coal accounting for 17.7 percent, natural gas accounting for 6.4 percent and nuclear and cogeneration accounting for the rest. When the industry makes electricity with (OILGAS-C) it mainly uses natural gas. As noted previously, crude oil is combined with natural gas into a single commodity. It was not possible to separate the two in the SAM account. We used the world price for crude oil to represent the price for this commodity. As such, we may have overestimated the increased cost of natural gas (perhaps by about 50 percent), as noted in the previous discussion. As a result, the simulation overestimates the cost pressure on the electrical industry from increasing natural gas prices.

The only other commodities experiencing large increases in producer prices stemming from the energy price shock are the transportation sectors. Air transportation has about a 3 percent producer price increase and trucking has roughly a 4 percent increase (Table 4). Most other commodity producer price changes show a modest decrease rather than an increase (Table 4). This is a result of the shift in commodity demand functions that overwhelm the shift in commodity supply. The increase in energy price, other things being equal, shifts the supply curve for commodities using energy upward to the left. With no change in demand that leads to an increase in the market clearing commodity price. However, commodity demand is not constant. Domestic demand declines as a result of reductions in industry and household demand. Households demand declines due to increased prices and lower income. Foreign sales are reduced as well due to a loss of competitiveness in international markets. Therefore, when the reduction in demand is sufficiently large, the market clearing producer price will decline. Producer price falls for most agricultural commodities (Table 4). The exception is animal production, in which cost increases override the demand reduction, resulting in a 3 percent increase in producer price. The rest of the commodity producer prices show very little change from baseline prices as a result of the energy price shock.

Labor Market and the Overall Economic Response

The labor market is affected dramatically by the energy price shock. The change in employment by industry is shown in Table 5. Recall that the economic model simulates a short-run scenario where capital is fixed by sector. This means that as the industry experiences increases in cost or reductions in demand for its product, it cannot reduce production by reducing capital. With capital fixed, the only option in this simulation is to reduce labor. As a result, much of the downward economic adjustment falls on the number of workers employed in a given industry. In essence, as the economy adjusts to the price shock and most industries downsize, capital is being substituted for labor as a function of the elasticity of substitution specified in the industry production function. The supply of labor is assumed to be perfectly elastic with

Table 5. Changes in employment by sector (Number of Jobs)

Row	Sector	Base	Calculated	Difference	Percent Difference
1	OILSEED-A	43.70	39.41	-4.29	-9.82%
2	GRAIN-A	14351.27	12455.45	-1895.82	-13.21%
3	VEGETAB-A	7389.22	7035.31	-353.92	-4.79%
4	NUT-A	4.40	4.00	-0.40	-9.15%
5	FRUIT-A	23278.05	20625.82	-2652.23	-11.39%
6	NURSERY-A	4616.19	4523.89	-92.29	-2.00%
7	ANIMAL-A	18701.69	16293.26	-2408.43	-12.88%
8	LOGGING-A	8830.42	7841.39	-989.03	-11.20%
9	OTHCROPS-A	7914.96	6954.40	-960.56	-12.14%
10	FISHING-A	11379.51	10473.57	-905.94	-7.96%
11	CONST-A	233242.26	227954.57	-5287.69	-2.27%
12	UTIL-A	698.09	652.21	-45.88	-6.57%
13	PRIVELEC-A	2069.10	2290.12	221.02	10.68%
14	PUBELEC-A	11048.99	6560.84	-4488.15	-40.62%
15	WHOLTRAD-A	122307.40	116230.17	-6077.23	-4.97%
16	RETTRAD-A	389580.85	373230.60	-16350.26	-4.20%
17	MIN-A	3733.98	3226.47	-507.51	-13.59%
18	FOOD-A	39230.28	36010.18	-3220.09	-8.21%
19	FAT/OILS-A	157.01	126.16	-30.85	-19.65%
20	MAN-A	232739.86	213293.98	-19445.88	-8.36%
21	ASPHALT-A	459.69	445.41	-14.28	-3.11%
22	PETCHEM-A	181.35	202.33	20.98	11.57%
23	NITFERTM-A	123.80	104.95	-18.85	-15.23%
24	FERTMIX-A	77.78	81.57	3.79	4.88%
25	PESTMAN-A	100.86	101.90	1.04	1.03%
26	REFINED-A	2258.61	2258.61	0.00	0.00%
27	OILGAS-A	567.86	567.86	0.00	0.00%
28	NATGAS-A	1457.10	861.29	-595.80	-40.89%
29	OTHSER-A	1772224.70	1709509.40	-62715.35	-3.54%
30	AIRTRAN-A	12680.07	8572.74	-4107.33	-32.39%
31	RAILTRAN-A	3368.22	2982.81	-385.42	-11.44%
32	WTRTRAN-A	3363.80	2936.37	-427.43	-12.71%
33	TRCKTRAN-A	30965.53	27192.62	-3772.91	-12.18%
34	OTHTRAN-A	26720.49	24530.48	-2190.02	-8.20%
35	GOVTSPC-A	555478.13	530738.96	-24739.16	-4.45%

Source: Author’s estimates

perfect mobility across industries and the state border. Therefore, the labor market adjusts by reducing the number of jobs in most industries, with the exception of the fossil fuel-based industries. In reality, both labor and capital would adjust to the price shock, so fewer jobs would be lost. However, labor is more mobile than capital, generally, so one would expect a much larger adjustment in the labor sector, at least initially.

The net job loss in the Washington economy is 164,000 jobs (the sum of column 3) or roughly 4.6 percent of all jobs (Table 5). There is job loss in almost every industry in Washington, with the exception of the energy sectors and investor-owned utilities. There are large job losses in the public electricity sector as this industry is more sensitive to the energy price shock and privately produced electricity substitutes for publicly produced electricity. Manufacturing loses over 19,000 jobs and over 62,000 jobs are lost in the services sector. Air transportation loses 4,100 jobs or 32 percent of its workforce. Trucking loses 3,800 jobs or about 12 percent of its workforce (Table 5).

Agriculture loses about 8,400 jobs over all of the agricultural industries represented. Most of the lost jobs are in the grain, fruit, and animal industries. It is interesting to note that while most agricultural industries experience employment losses in the range of 4 to 13 percent of their labor force, nurseries experience only about a 2 percent decline. Nursery jobs are one of the least affected major Washington industries.

Gross Domestic Product and the Consumer Price Index

The change in GDP (gross domestic product) is an indicator of the overall damage to the economy arising from the price shock. GDP captures loses in returns to capital and losses in wages and indirect business taxes. Baseline Washington State GDP (gross domestic product) was approximately $238 billion in 2003 (Table 6). The simulated loss in GDP was roughly $11 billion or about 4.8 percent of baseline GDP. This shows the overall vulnerability of the economy to the price shock and includes the large gains in capital returns earned by the energy sectors.

Table 6. Impact on the state CPI (consumer price index), and GDP (gross domestic product)

	Base	Calculated	Difference	Percent Difference
Consumer Price Index	1.00	1.0168	0.0168	1.68
Gross Domestic Product ($ Millions)	238632.55	227200.54	-11432.00	-4.79%

Source: Author's estimates

The inflationary pressures on households generated by the energy price shock are summarized in the consumer price index (CPI). Consumer prices are a weighted average of state produced goods and services and imported goods and services as representative households buy a bundle of Washington and imported goods and services. As noted in Table 6, once the price shock works its way through the economy, the Washington consumer price index increases by a fairly modest 1.68 percent. Most of that change is reflected in the price increase of the energy commodities, but price increases for other commodities such as electricity and transportation services like air transportation and truck transportation also contribute to upward pressure on the price index.

Changes in Household Welfare

Changes in net income per household (where net income is defined as gross household income including borrowing less household saving, household income taxes and overseas transfers) in Washington is shown in Table 7. Households are depicted by income class from low (HHD1) to high income (HHD9). For example, the lowest income group of Washington households had an average net household income of approximately $32,912 per household while the highest income group earned roughly $141,916 net income per household[1]. The counterfactual household income (representing the impact of the energy price shock) is shown in the second column and the difference between baseline and counterfactual income is shown in column 3. For the lowest households this was a reduction in net household income of $261 and for the highest income households the reduction was $5938 (Table 7). The percent reduction in net income per household ranges from roughly one percent of baseline income for the lowest group to roughly four percent for the highest income group.

The loss in household income does not reflect the loss in household welfare because it does not account for the loss in household buying power stemming from the energy price shock. Equivalent variation (EV) accounts for price changes as well as income changes, as both factors affect household utility. EV shows this loss in utility as a function of the equivalent loss in income under the assumption of baseline prices. The utility loss for a household is a function of the loss of household income and increased commodity prices resulting from the energy price shocks. The negative equivalent variation per household may be compared to loss in average net income per household that reflects just the loss in household income. EV reflects income effects as well as price effects on household welfare stemming from the energy price shock.

The equivalent variation measure shows that the damage to welfare of low income households stems more from price effects than from changes in household income (illustrated by the third and fourth columns). For high income households the opposite is true; income changes (represented by the Difference column) dominate income and price effects (shown in the EV column). Since equivalent variation is a measure of both price and income effects rather than simply a measure of change in household income, it is an appropriate measure of the simulated loss in household well-being associated with the energy price shock.

[1] It may be noted that the net income of the third household group (HHD3) is lower than the second household group (HHD2). This is explained by the fact that HHD3 pays income tax at higher rate and has a higher rate of household saving than HHD2. This results in a lower net household income for HHD3 than for HHD2.

Table 7. Average Net Income per Household ($) in 2003

	Base ($)	Calculated($)	Difference($)	Equivalent Variation($)
HHD1	32912	32651	-261	-739
HHD2	38000	37347	-653	-1209
HHD3	37174	36234	-939	-1495
HHD4	44209	43039	-1170	-1776
HHD5	59698	57828	-1871	-2620
HHD6	68327	65696	-2631	-3488
HHD7	94828	91228	-3600	-4500
HHD8	115369	110687	-4682	-5775
HHD9	140916	134978	-5938	-7271

Source: Author's estimates

SUMMARY AND CONCLUSIONS

The purpose of this paper is to assess the possible damage to the Washington economy stemming from energy price shocks under the assumptions that the economy continues to operate with the existing production technology and there are no changes in public policies. In this sense, this analysis provides an upper bound on actual economic damage because it does not consider potential economic benefits from improved energy efficiency.

As the economy responds to increased energy prices, industries that use large inputs of fossil fuels lose their competitive position in state, national, and international markets and, as a result, reduce production of goods and services. The damage to the state of Washington was a loss of 164,000 jobs, which is roughly 4.6 percent of total jobs in the economy. Gross state product measured as returns to capital and labor declines by roughly $11 billion or about 4.8 percent of baseline GSP, despite the fact that returns to capital increase by over 200 percent in the oil and gas industries as well as many of the fossil fuel industries. On balance, the simulation model may have overestimated the damage done to the competitive position of Washington firms in national and international markets because of the assumption in this study that world prices are unchanged in these markets. World energy prices also generated price increases that affected international businesses, for example, the transportation industries. With additional research, this could be factored into the model.

As expected, the industries that are most damaged by the energy shock include the transportation industries and, somewhat surprisingly, the electricity industries. Part of the electricity impact is the result of general equilibrium effects resulting from damage to the entire economy. Electricity is a commodity that is used by virtually every industry as well as by households and governments. On the supply side, the model may have overestimated the sensitivity of the industry to energy shocks as the result of a price shock more representative of crude oil than natural gas.

Overall, the model predicts a 6.4 percent decline in the output of manufacturing in Washington State. Manufacturing of fats and oils was predicted to show a strong reduction in supply of 11.4 percent, assuming no change in import and export prices. Selected agricultural commodities were strongly impacted, such as the fruit industry with a 7.5 percent reduction in supply and animal agriculture with a 9.9 percent reduction.

This simulation show how vulnerable the Washington economy is to energy price shocks given existing production technology and markets. An important message of this analysis is that much of this economic damage can be avoided by the adoption of more energy efficient technology and by expanding the usage of renewable fuel sources. In the case of agriculture, substitution of renewable energy sources for non-renewable sources may help alleviate these energy shocks. In fact, the transition to a more energy efficient economy and one more dependent upon renewable energy will offer business opportunities and potential for job creation in Washington. For an excellent discussion of the emerging economic opportunities in connection with increasing energy efficiency and increased reliance on renewable energy, see the section on possible adjustments to climate change in the recently released report on climate change and the Washington economy (Bauman et al.).

Regarding Washington agriculture, one of the opportunities for economic growth as well as for a reduction in emissions is the expansion of the biofuels industry, especially biodiesel. From an economic development perspective, the substitution of Washington produced biodiesel for petrodiesel, much of which is imported (See Table 1), allows fuel dollars to produce multiplier effects within the state. This flow would otherwise be exported from the state in the form of payments for imported fuel or payments to state refineries that are totally dependent on non-Washington crude oil feedstocks. The real questions here are whether the in-state oilseed producing industry can be competitive with other sources of imported feedstocks for biodiesel and whether the production of oilseeds in Washington can be an attractive alternative crop across many production regions in Washington, from the cool maritime climate with ample rainfall in western Washington to the irrigated areas of central Washington to the dryland annual cropping areas in eastern Washington. These are questions that are beyond the scope of this paper and will require more detailed micro cost and returns studies for a definitive answer.

The economic model in this study can be modified to reflect more accurate production processes for both oilseed production and for the production of oil from oilseeds. Then it would be feasible to undertake a sensitivity analysis first of the likely economic impact of the large (100 million gallons) plant in Grays Harbor in terms of the resulting supply response in Washington for both oilseed production and oil from oilseeds. Secondly, it would be possible to explore combinations of seed oil prices and oilseed prices that would be necessary to stimulate an important supply response from these industries in Washington.

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APPENDIX 1:

Table A-1. Model Sectoring Scheme

Industry	Sectors Included (Sector No. Corresponds to IMPLAN 2003 Sectoring Scheme)
Oilseeds	1
Grains	2
Vegetables	3
Nuts	4
Fruit	5
Greenhouse and Nursery	6
Other Crops	7-10
Animal and Poultry	11-13
Logging	14
Fishing	15-17
Construction	33-45
Mining	20-29
Utilities	32
Private Electrical Power	30
Public Electrical Power	495,498
Wholesale Trade	390
Retail Trade	400-412
Fats and Oils	52-54
Food	48-91
Manufacturing	46,47, 92-389 except energy
Oil and Gas	19,27-28
Refined Petroleum and Pipelines	142,396
Asphalt	143-144
Petrochemicals	144-148
Natural Gas Distribution	31
Nitrogenous Fertilizer	156
Phosphatic Fertilizer	157
Fertilizer Mixing	158
Pesticides	159
Services	18, 449-494
Air Transportation	391
Rail Transportation	392
Water Transportation	393
Truck Transportation	394
Other Transportation	395,397
Government Industry and Special Sectors	496-509

Source: IMPLAN (Impact Analysis for Planning) database industry aggregation scheme.