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Economic Impact of Electric Power Industry Deregulation on the State of Washington: A General Equilibrium Analysis

Roger H. Coupal and David Holland

Electric power markets are being deregulated nationwide with different impacts depending upon current policies and historical circumstances from region to region. The Pacific Northwest, with its historic abundance of low-cost hydropower and dependence on public power, will experience deregulation as conditioned by this legacy. This analysis focuses on the economic impacts of deregulation on the State of Washington. A 31-sector computable general equilibrium model is used to evaluate the impacts on Washington's economy. In a most likely scenario, electricity exports expand to high-priced regions. The impact on the state economy is a reduction in gross state product as a result of higher electricity prices. Returns to capital increase, but returns to private capital and to labor decrease because much of the financial gain accrues to public power.

Key words: computable general equilibrium model, economic impacts, electricity deregulation

Introduction

The electric power industry across the nation is being deregulated at the wholesale price level. The policy change, in whatever form it finally takes, will have far-reaching impacts on electricity production and consumption by private and public utilities. Consumers and the environment will also be affected by deregulation. Moreover, the impacts will vary from state to state, and region to region. The objective of this study is to evaluate the likely impact of electric power deregulation on the economy of the State of Washington.

Electric power markets in the Pacific Northwest have a history that is distinct from electric power development in most other parts of the country, except for parts of the southeast where the Tennessee Valley Authority was created. Central to the development of electricity markets in the Pacific Northwest is the role of state and federal power-producing agencies.

Electricity pricing has been as much a political decision as an economic decision since the creation of the Bonneville Power Administration (BPA) in the early part of this century. An important motivation for creation of BPA in 1935 was to expand economic development by marketing power from federal hydropower projects, and also to counteract potential monopoly control of abundant hydropower resources in the Northwest which might stifle economic growth. BPA's original mandate was to "provide the most

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power at the lowest cost" through marketing federal hydropower to the regions' population centers (Tollefson).

Although BPA began as a low-cost competitor, BPA's relationship with the region's private power industry has evolved into one of accommodation and support to investor-owned utilities (IOUs). Over the years, IOUs, the aluminum industry, and other large energy-intensive industries,[1] public utilities, and cooperatives all forged special relationships with BPA, allowing preferential access to BPA's low-cost power and federal transmission lines. Subsequently, the agency saw its mandate broaden to include wheeling power to the Southwest (sending power on the western intertie), a disastrous experiment with nuclear power in underwriting the development of the Washington Public Power Supply System (WPPSS), wildlife conservation, and energy conservation mandates[2] (Myhra).

Electricity prices in the Pacific Northwest have traditionally been substantially lower than those in the rest of the nation, and have been an important factor in shaping economic development, especially in the eastern Washington economy. These price differences have come about through subsidized development financing and BPA's mandate to provide to the Pacific Northwest the most power at the lowest cost. As seen from figure 1, average retail revenues per kilowatt-hour (kwh) in Washington ranged from 40% of the national average in 1970 to just over 50% in 1994. For a more detailed comparison, a U.S. map is provided in figure 2 showing average revenue per kwh by state for 1994.

Electricity revenue per kwh in the Pacific Northwest utility industry for 1995 was approximately 60% of national average and 41% of revenue per kwh in California (U.S. Department of Energy 1996). These price relationships are now in the process of adjustment as state legislatures, regional political groups, and Congress deliberate changes in the marketing of electric power.

Institutional Background

Power planning in the United States is evolving from a production orientation to a more market-based orientation. One of the more important pieces of legislation for changing the orientation was the National Energy Act of 1978 (PL 95-617, 95th Congress) and associated laws—in particular, the Public Utilities Regulation and Policy Act (PURPA). PURPA required utilities to purchase power from small producers and cogenerators at their avoided cost. PURPA also allowed marketing flexibility at the wholesale level. It attempted to encourage power production to more sustainable forms of energy and, as a result, diversified the sources of supply to the wholesale market.

More recently, the Energy Policy Act of 1992 (PL 102-486, 102nd Congress) enhanced wholesale markets by creating a new class of power generators that are exempt from traditional constraints imposed over much of the previous century. The Energy Policy Act made it easier to enhance wholesale marketing of electric power and authorized the Federal Energy Regulatory Commission (FERC) to facilitate sharing of regional

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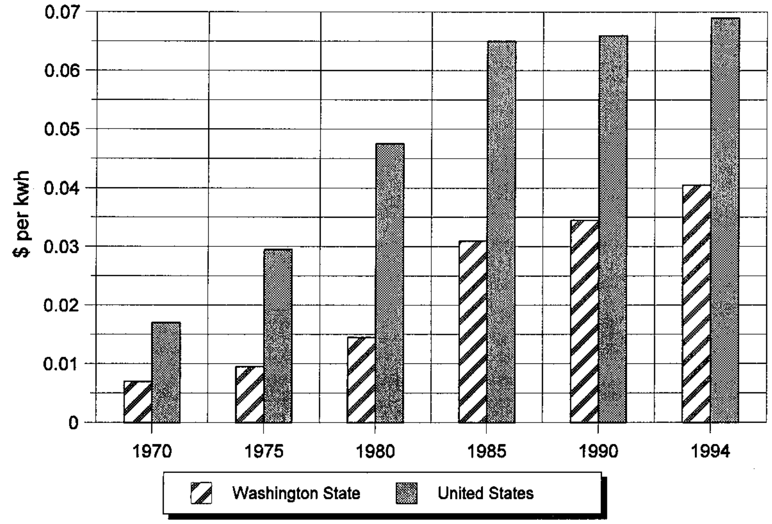
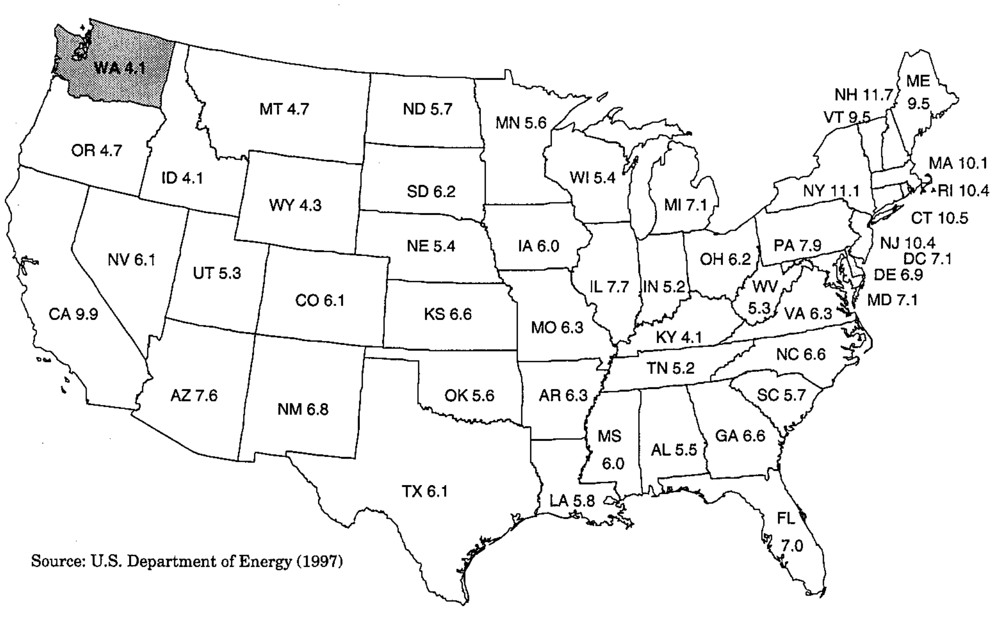
[1] These industries, known collectively as direct service industries (DSIs), are a collection of aluminum producers, chemical plants, and paper mills (though not all plants in those sectors) allowed to purchase load directly from the BPA instead of the local utility.

[2] The WPPSS experience saddled BPA with a huge debt which must be repaid from power revenues.



Source: U.S. Department of Energy (1997)

Figure 1. Average revenue ($/kwh), 1970–1994, Washington State and the United States



Source: U.S. Department of Energy (1997)

Figure 2. Average revenue (¢/kwh), 1994, by state

transmission lines. This most recent legislation provides the greatest potential for change in the electric power industry for customers and generators alike.

FERC Order 888, enacted in April 1996, was meant to correct anti-competitive practices by utilities with transmission lines. Order 888 had two goals: to develop open access transmission systems, and to unbundle generation and transmission activities. The intended result is to increase wholesale competition by allowing new producers to compete with traditional suppliers and unbundle prices.

Electricity in the U.S economy has grown in importance relative to other forms of energy (U.S. Department of Energy 1997). Consumption of electricity in Washington State has been growing at an annual rate of 3.1% per year since 1970, and on a per capita basis at a rate of 1.1%. In Washington, BPA's electricity plays a major role in the production process of the aluminum industry, where electricity expenditures account for over 30% of the industry's total outlays. Other primary metal processing mills and paper mills come in a distant second. State and local government electric utilities incur a high percentage of expenditures on electricity because they purchase electricity from BPA. Electricity, unlike many other factors of production, is an input in virtually all Washington industries. Consequently, the indirect impacts of electricity price changes are widespread as a result of the large number of forward linkages to other industries.

Model Specification

In this analysis, a regional computable general equilibrium (CGE) model is developed for Washington State (Coupal). The model treats the regional economy as a trade region, namely a relatively open system of markets where firms, consumers, and governments interact (Mutti). Regional CGE models have been used to examine tax policy, and environmental and energy issues (Kraybill, Johnson, and Orden; Bergman). Recently, state-level CGE models of Ohio, Oregon, and Washington have been used for state tax policy analysis (Waters; Seung; Waters, Holland, and Weber; Uppadhaya). For a comprehensive discussion on the construction and structure of regional CGE models, see Partridge and Rickman.

The CGE model starts with changes in supply or demand in markets which are assumed to clear through endogenous price changes. Impacts in CGE models are generated not by accounting-type multipliers, but by equilibrating price and income changes in the markets modeled. For example, changes in the export price of a commodity produced by an industry lead to changes in export sales in an industry and, in turn, to changes in the equilibrium level of primary factors employed, which may then change the equilibrium price for those factors. The resulting changes in factor payments alter household income, which then affects household commodity consumption levels and tax payments, ultimately affecting the budgets of governments receiving those taxes. Finally, changes in commodity exports also influence the level of regional supply as industries maximize revenues by allocating production between the region and the rest of the world. Thus, changes then occur at the regional price level, prompting changes in regional consumption by households, firms, and governments.

The model used in the analysis is a 31-sector, short-run model of the Washington economy. (GAMS codes for the model are available upon request from the authors.) Industries maximize profits in perfectly competitive markets with capital fixed by sector. Key features of the model are described below.

Production Sectors

Industry sectors follow a common CGE format, where output is modeled as a Leontief specification with intermediate inputs and a value-added composite. The value-added composite is modeled with a Cobb-Douglas function (Dervis, de Melo, and Robinson; de Melo and Tarr; Ginsburgh and Keyzer). Total physical output for a particular industry i (X_i) is the real dollar equivalent of physical output, and V_i is the value-added composite for factors of production. The specification assumes strong separability between primary and intermediate factors, which allows one to specify output as a function of only primary factors (Dervis, de Melo, and Robinson):

$$(1) \qquad X_i = \min\left[\frac{X_i}{a_{ij}}, \frac{V_i}{v_{ij}}\right], \quad i = 1, \ldots, 31,$$

where a_{ij} and v_{ij} are fixed technical coefficients and value-added coefficients that determine the level of the respective input.

Output can be calculated directly through the composite valued-added function, where L is labor, F is proprietor, K is capital, and LND is land. Proprietor (owner-manager), capital, and land are expressed in dollar value terms, while labor is expressed in total jobs (or number of job equivalents). Production in seven agricultural sectors (ipa) is a function of labor, proprietors, capital, and agricultural land, and ava_{ipa} is a shift parameter:

$$(2) \qquad X_{ipa} = ava_{ipa} \cdot L_{ipa}^{lshare_{ipa}} \cdot F_{ipa}^{fshare_{ipa}} \cdot K_{ipa}^{kshare_{ipa}} \cdot LND_{ipa}^{\ln(share_{ipa})}, \quad ipa = 1, \ldots, 7.$$

Likewise, production in the nonagricultural sectors ($ipna$) is a function of all the primary factors excluding agricultural land (3), and $avna_{ipna}$ is a shift parameter for this block of equations:

$$(3) \qquad X_{ipna} = avna_{ipna} \cdot L_{ipna}^{lshare_{ipna}} \cdot F_{ipna}^{fshare_{ipna}} \cdot K_{ipna}^{kshare_{ipna}}, \quad ipna = 8, \ldots, 27.$$

Finally, the production function in the public sectors (up) is modeled with only labor and capital, and a shift parameter for industry ($avup$):

$$(4) \qquad \tilde{X}_{up} = avup_{up} \cdot L_{up}^{lshare_{up}} \cdot K_{up}^{kshare_{up}}, \quad up = 28, \ldots, 31.$$

The Cobb-Douglas structure for primary factors allows for factor substitution as factor prices change, while providing computational convenience. Industries maximize profits in perfectly competitive markets for their products and purchase inputs in perfectly competitive factor markets.[3] We assume constant returns to scale in all industries. The model also assumes BPA acts like a profit-maximizing firm. While this is a simplification, it may not be too unrealistic. BPA's mandate over the years has been to provide a maximum amount of power at a minimum cost, so differences in behavior may not be as substantial as if BPA operated as a monopoly.

[3] Most industries are comprised of relatively homogeneous firms and are aggregated and treated as one large firm.

BPA output is modeled using (4), but with an important caveat. Physical output is fixed for BPA because electricity production is based entirely on Columbia River flows. The agency can only generate electricity based on the level of flow in the Columbia River, and is assumed to have no real influence on how much water can be designated for electricity production. The reason for BPA's fixed output is that the river system is also used for agriculture, navigation, and wildlife whose claims are based on existing law. Also, regional water policy agencies like the Northwest Power Planning Council oversee the management of the river system. So the most BPA can do in the face of a price change is to adjust factor use, intermediate good purchases, or the proportion of output sold within the region and outside the region.

Households are comprised of three representative income groups: low (less than \$19,999 annual income), medium (between \$20,000 and \$39,999 in annual income), and upper (\$40,000 and greater in annual income).[4] Households maximize utility based on a Cobb-Douglas functional form. Consumption shares for commodities vary across income groups and are based on IMPLAN consumption functions (Minnesota IMPLAN Group). [Refer to the appendix for a full description of the data sources, including the social accounting matrix (SAM) used in developing the model.]

The household demand function for commodity i and household hh is specified as:

$$C_{i,hh} = cshare_{i,hh} \cdot \frac{HHYDP_{hh}}{P_i}, \quad i = 1, \ldots, 31; \; hh = 1, \ldots, 3, \tag{5}$$

where $HHYDP$ is household disposable income, P_i is price for commodity i, and $cshare_{i,hh}$ is the consumption share for household group hh and commodity i.

There are three types of government accounts: federal, state and local non-education, and state and local education. Federal government expenditures are assumed to be exogenous to the state's economy, with federal tax revenues endogenous. State and local government revenues and expenditures are treated as endogenous, and state and local government expenditures change as a result of changes in state and local revenues conforming to a balanced budget assumption at the state and local levels (Holland).

Government expenditure is specified as a fixed proportion function. The government expenditure function for each level of government is calculated as:

$$G_{i,gov} = drg_{i,gov} \cdot GOVTOT_{gov}, \quad i = 1, \ldots, 31; \; gov = 1, 2, 3, \tag{6}$$

where expenditures by government category (gov) for commodity i are a fixed proportion (drg) of total government expenditures.

Factor income is calculated based on labor earnings, proprietor's returns, and capital income. Labor payments are the sum across industries of the product of income per worker and number of workers ($LABPMT$) net of out-commuting ($RADJ$) and payroll taxes ($stax$):

$$LABY = LABPMT + RADJ - \sum_{gov} stax_{gov}, \quad gov = 1, 2, 3. \tag{7}$$

Similarly, proprietor's income is the sum across industries of the product of proprietor returns (PP) and number of proprietors (F_i) minus proprietor taxes ($ptax$):

[4] In 1990, the U.S. Bureau of the Census counted approximately 1.875 million households in Washington State. Approximately 31% were low income, 32% were middle income, and 37% were upper income.

(8) $$PROPY = \sum_i F_i \cdot PP - \sum_{gov} ptax_{gov}, \quad gov = 1, 2, 3.$$

Finally, capital income is the sum across private industries of the product between capital stock (K) and rental rate (R), land (LND) and rental rate (RL), minus federal interest payments by industry to the federal government (*fedint*), minus interest payments to state and local governments (*ssint*), interest payments by industry to the federal government, plus exogenous capital income (*exocapi*) generated out of the region but accruing to regional firms. Capital adjustment ($CADJ$) represents the capital payment generated in the state by industry but returned to owners outside the state:

(9) $$CAPY = \sum_{ip} K_{ip} \cdot R_{ip} + \sum_{ipa} LND_{ipa} \cdot RL_{ipa} - CADJ - fedint - ssint_{ned} + exocapi,$$
$$ip = 1, \ldots, 27; \; ipa = 1, \ldots, 7.$$

An important difference in the construction of this model as opposed to other models not focusing on electricity deregulation is the role government economic surplus from state and local electric utilities and BPA plays in the regional economy. The model identifies separate sectors for BPA and for state and local electrical utilities (refer to appendix table A1). Regional capital income (9) is summed across only private industry which adds to the gross product of the state. In the case of public enterprises like BPA, this income contribution is assumed to add to the national treasury but not the state's income. Returns to capital for state and local public electricity are assumed to feed into the income of state and local government, and therefore are components of capital income.

The model imposes a "small country" condition along the lines of de Melo and Tarr. Imports and exports by industries in the state are assumed not to affect the national price of goods and services. On the import market side, an Armington trade specification is used where the composite commodity produced and traded regionally is made up of both imported goods and regional supply. This trade equation is specified as a constant-elasticity-of-substitution (CES) functional form (Dervis, de Melo, and Robinson; Partridge and Rickman). Total demand for the composite commodity is maximized subject to a total budget constraint.

On the export side, a constant-elasticity-of-transformation (CET) function between regional supply and export supply is used (Powell and Gruen; Partridge and Rickman). The optimal combination of exports and regional quantity supplied is chosen to maximize industry revenue subject to the transformation function. This specification assumes regional supply and export supply for an industry are not perfect substitutes.

The specifications for both the CES supply/import equation and the CET supply/export equation assume there is not perfect substitution between commodities and services sold within the region and sold or purchased outside the region. While electricity produced for regional and nonregional markets may appear to be a perfect substitute (one electron is exactly like the next), in reality there are aspects that differentiate electricity. There are differences in reliability, contracts, interruptible supply, and peak load versus base load—all of which suggest the appropriate approach should not treat electricity inside the region as a perfect substitute for electricity outside the region.

Factor market demands are specified from the first-order condition for each industry. To account for empirically observable and persistent differences in average income per job across sectors, a wage distortion factor is included in the first-order conditions. Wage level WF is a function of output price net of the unit cost of intermediate goods PV_i, output X_i, and labor L_i in industry i. Parameters in the equation are the wage distortion factor (*wfdist*) and the factor share coefficient for labor (*lshare*):

$$WF \cdot wfdist_i = PV_i \cdot lshare_i \cdot \frac{X_i}{L_i}, \quad i = 1, \ldots, 31. \tag{10}$$

The local labor supply is fixed at the baseline, but a migration function allows changes in total labor supply based on relative wage changes between the region and the rest of the United States. Labor migration (*LMIG*) is a function of labor income within Washington State, baseline Washington labor income, and existing labor supply:

$$LMIG = \beta \cdot \ln\left(\frac{LABY}{LABYo}\right) \cdot LTOT, \tag{11}$$

where β is the elasticity of migration (calculated from Treyz et al.), *LABY* is the labor income after the counterfactual shock, *LABYo* is the labor income at the baseline, and *LTOT* is the total labor supply in the state. The specification assumes that at the baseline, labor income is in equilibrium with the rest of the United States. A shock occurs and either increases regional labor income relative to the nation or decreases it, which then causes a change in migration. Total proprietors' capital is fixed for the region but allowed to shift between sectors of the economy. Both capital and agricultural land are fixed by sector, but labor is assumed perfectly mobile across sectors.

Investment is financed by regional savings from households and retained earnings from regional firms, as well as by outside sources. Total gross regional investment is treated as exogenous with outside capital flows adjusting to equate total savings with regional investment.

A solution to the system of nonlinear equations simultaneously optimizes the consumer, producer, and trade problems described above. Equilibrium relationships between commodity supply and demand, and investment and savings, along with the constraints to the four optimization problems described above, ensure a solution to the entire system of equations.

Scenario Description

The following analysis measures the economic impact on the Washington State economy of allowing the power produced by BPA, public power (defined here as state cooperatives, municipal agencies, and public utility districts), and IOUs to be freely tradable across regions. Deregulation means power-generating firms and agencies must rely on their own resources and management skills to remain economically viable.

As BPA and other Washington producers, both public and private, look at markets outside the region, regionally produced power is more likely to be sold to higher-cost regions at a price higher than within the region. Before deregulation, the regional price difference was not as relevant to BPA because of institutional constraints. After deregulation, competitive pressure and reallocation of product will force the Washington price of public and private power upward. In other words, one of the main results of deregulation in the short run will be an increase in the proportion of power exported by low electricity price areas to high electricity price areas with consequent upward price pressure in the low-price region—in this case Washington.

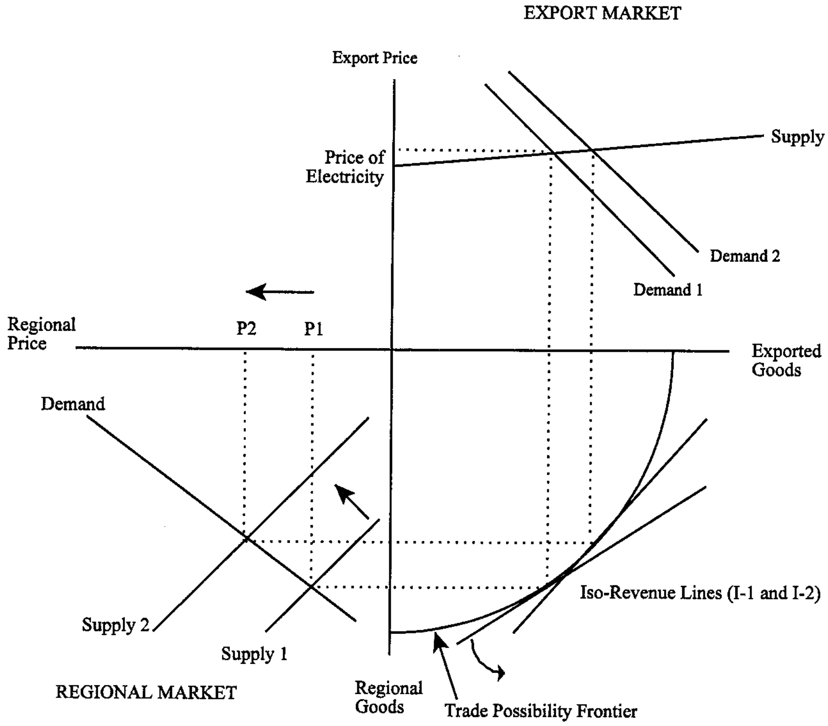


Figure 3. Schematic representation of the regional impact of an increase in electricity trade

This scenario is illustrated schematically in figure 3. Allowing BPA more flexibility to sell to higher-priced regions is modeled as if it were a shift in export demand. BPA and IOUs then allocate power to those markets. A shift in export demand for BPA power will increase the export price received by BPA for export power (upper right quadrant of figure 3). This, in turn, will encourage BPA to shift along its production transformation curve to sell more of its output to more profitable markets outside the region (lower right quadrant). The optimal mix of regional and exported supply will shift in favor of exports. The regional supply curve shifts up along the regional demand (lower left quadrant), resulting in a higher price for power sold in the region.

The regional power price must increase due to bidding pressure occurring as a result of deregulation, thereby providing BPA more opportunity to exploit lucrative export markets outside of Washington. The argument that regional electricity prices will rise is supported in an analysis by the Energy Information Agency, which predicted prices will rise in the Northwest as a result of deregulation (U.S. Department of Energy 1997).[5] The agency also predicts increased exports of electricity out of the region.

Deregulation will not only require a readjustment of energy prices and use within the region, but also will give consumers and producers more flexibility to sell to and purchase from markets outside the Northwest Power Pool. In the case of BPA, the difficulty in selling to export markets has been historically imposed through its regional mandate

[5] It should be pointed out that the same report argues there is already a large amount of trade between the Northwest and Southwest, and any further expansion into lucrative Southwest markets will tax the system's reliability even more than now. Such a result would necessarily restrict or at least slow down access to these lucrative markets.

and federal regulations. While deregulation will not necessarily eliminate those restrictions, it is likely to provide an incentive to weaken or circumvent them. This increased access to markets outside the region will eventually drive the regional price toward national prices.

To simulate this effect in the CGE model, we parametrically increase the external prices (export and import prices) of electric power. The rationale here is that with the inception of deregulation, more markets open for BPA and IOU power, compelling regional consumers to compete with external customers. Export and import prices for electricity are increased by 5%, 10%, and 15%.

Impact of Electricity Deregulation

Implementing a policy of electricity deregulation is in reality a complex process dealing with transition rules and network problems.[6] The scenario modeled evaluates the impact of a change to a fully flexible regional market. In this scenario we do not model various paths to deregulation, only the end result of the policy change. Because the average price for electric power in Washington is significantly less than the average price in the Southwest and the rest of the nation, a reallocation of supply seems likely to occur where electricity will be sold to markets with higher potential returns. The result will be an increase in electricity exports from Washington.

In response to more access to higher-priced markets, IOUs will increase output. However, BPA and public power's respective output is fixed because output is a function of water flow, and the Columbia River system has multiple uses. This constrains the agency's ability to increase power production in the face of increasing demand. Nevertheless, it is assumed the agency will be able to adjust the share of production to either exports or in-state markets.

Increased exports of regional public and private power raise total output of the electric power industry, but only through an increase in production by the IOUs (table 1). Given a relative external price increase of between 5% and 15%, the IOUs respond to higher export prices by increasing production from 2.2% to 7.4%. BPA and public power are constrained to maintain the same level of overall production. However, higher export prices for electricity generate higher gross revenues for all electricity industries by shifting more production to exports and increases in the regional price. Regional electricity price increases range from 3% to 10% for both BPA and IOUs, an increase representing roughly 66% of the assumed increase in external prices. IOU and BPA revenues correspondingly increase.

BPA electricity exports as a proportion of total electricity output increase from 8.5% at the baseline to over 27% at a price increase of 15% (table 2). A similar shift occurs with IOUs. IOUs increase their export share to almost 25% with a 15% increase in price. Other regional industries show a small decline in exports as the Washington economy becomes less competitive due to higher electricity cost. Those sectors of the economy which are relatively more dependent on electricity inputs stand to lose the most. In particular, the direct service industries, such as aluminum, experience large decreases in output. State and local electric utilities also experience a reduction in output because of their dependence on BPA electricity.

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[6] For a discussion of network economics of power supply, see Kahn, Bailey, and Pando.

Table 1. Total Industry Output and Regional Supply Price Changes Under Alternative Parametric Increases in the External Price of Electricity

		External Electricity Price Changes					
		5% Increase		10% Increase		15% Increase	
Industry Sector	Baseline ($ mil.)	Total Production	Relative Price[a]	Total Production	Relative Price[a]	Total Production	Relative Price[a]
Other Livestock	837	-0.1%	1.00	-0.2%	1.00	-0.2%	1.00
Cattle	570	-0.0%	1.00	-0.1%	1.00	-0.1%	1.00
Field Crops nonirrigated	654	0.1%	1.00	0.1%	1.00	0.1%	1.00
Field Crops irrigated	229	0.1%	1.00	0.1%	1.00	0.1%	1.00
Fruit/Veg Crops eastern	1,680	0.0%	1.00	0.0%	1.00	0.0%	1.00
Fruit/Veg Crops western	227	0.0%	1.00	0.0%	1.00	0.0%	1.00
Commercial Fishing	385	0.5%	1.00	1.0%	1.00	1.5%	1.00
Ag Services, Forestry & Fisheries	965	0.3%	1.00	0.6%	1.00	0.9%	1.00
Metal Mining	162	-1.4%	0.99	-2.8%	0.98	-4.1%	0.97
Other Mining	1,329	-0.1%	1.00	-0.2%	1.00	-0.2%	1.00
Construction	16,899	-0.1%	1.00	-0.1%	1.00	-0.1%	1.00
Food Processing	7,163	-0.3%	1.00	-0.6%	1.00	-0.9%	1.00
Logging	1,596	-0.0%	1.00	-0.0%	1.00	-0.0%	1.00
Timber	4,376	-0.4%	1.00	-0.7%	1.00	-1.1%	1.00
Paper	4,146	-0.6%	1.00	-1.3%	1.00	-2.0%	1.00
Chemicals	5,444	-0.3%	1.00	-0.5%	1.00	-0.8%	1.00
Aluminum Products	2,611	-9.9%	1.01	-19.6%	1.02	-28.9%	1.03
Manuf. Primary Metals	843	-5.9%	1.01	-11.8%	1.01	-17.4%	1.02
Aerospace	16,643	-0.2%	1.00	-0.5%	1.00	-0.7%	1.00
Manufacturing Other	13,877	-0.4%	1.00	-0.9%	1.00	-1.3%	1.00
Rail Transport	542	-0.4%	1.00	-0.7%	1.00	-1.0%	1.00
Motor Freight	2,357	-0.5%	1.00	-1.0%	1.00	-1.4%	1.00
Water Transport	1,123	-0.3%	1.00	-0.6%	1.00	-0.9%	1.00
Electric Services (IOUs)	1,280	2.2%	1.03	4.7%	1.06	7.4%	1.09
Other TCPU[a]	8,364	-0.0%	1.00	-0.1%	1.00	-0.1%	1.00
Trade	22,163	-0.2%	1.00	-0.3%	1.00	-0.5%	1.00
Services	54,751	-0.1%	1.00	-0.1%	1.00	-0.2%	1.00
State & Local Govt Electric Utilities	3,582	0.0%	1.04	0.0%	1.09	0.0%	1.13
BPA	994	0.0%	1.03	0.0%	1.06	0.0%	1.10
State & Local Govt	10,271	-0.6%	1.00	-1.1%	1.01	-1.7%	1.01
Federal Government	5,039	-0.0%	1.00	-0.1%	1.00	-0.1%	1.00
SUMMARY							
BPA Production	994	0.0%		0.0%		0.0%	
IOU Production	1,280	2.2%		4.7%		7.4%	
Public Power	5,039	0.0%		0.0%		0.0%	
Other Sectors	185,245	-0.3%		-0.7%		-1.0%	

[a] Relative price is the price of the commodity related to the baseline.
[b] TCPU = Transportation, Communication, and Public Utilities.

Table 2. Exports and Regional Supply, Proportions of Total Industry Output (TIO) as a Result of Increases in Electricity Export Prices

Industry Sector		Baseline Proportions of TIO	Resulting Proportions of TIO with External Electricity Price Changes: 5% Increase	10% Increase	15% Increase
BPA	Exports	8.5%	13.0%	16.3%	27.8%
	Regional Supply	91.5%	87.0%	83.7%	72.2%
IOUs	Exports	7.4%	11.1%	14.5%	24.9%
	Regional Supply	92.6%	88.9%	85.5%	75.1%
Public Power	Exports	37.5%	38.8%	39.3%	43.3%
	Regional Supply	62.5%	61.2%	60.7%	56.7%
Other Sectors	Exports	46.0%	45.9%	45.8%	45.5%
	Regional Supply	54.0%	54.1%	54.2%	54.5%

As the regional price of electric power increases, total output in other sectors dependent on electric power decreases, changing the equilibrium prices in those respective markets. Aluminum supply decreases along the aluminum demand curve, resulting in a higher regional price for aluminum (though lower revenues, since demand for Washington aluminum is elastic). Aluminum is affected far more dramatically than any other Washington industry (table 1). Other sectors with modest impacts are mining, wood and paper products, and state and local government electric utilities. Increased electricity prices reduce product supply for those sectors, but the slowdown in other sectors that purchase those sectors' outputs also reduces quantities demanded. Even though electricity is a small part of most industries' cost structures, it has a significant effect throughout the economy because of its substantial inter-industry linkages.

As conditions in the product markets change, employment and wages drop and labor migrates outside of the state. The small increase in labor demand from BPA and IOUs is overwhelmed by the reduction in labor demand in the rest of the economy (table 3). A 15% export price increase results in a loss of over 22,000 jobs in Washington. A slight drop in the wage level helps mitigate the loss of jobs, but labor nonetheless leaves the region as the Washington wage drops in relation to wages outside the region. With increased costs of both electricity and other inputs that depend on electricity, demand for labor is shifted down in electricity-dependent sectors. This drop in wages and labor employed can also be seen in the impact of factor payments in general. Economywide, labor and proprietor income drop under the deregulation scenario, but returns to capital increase, mainly due to increased profits in the IOUs and BPA. As a result, there is a slight decrease in the gross state product of Washington.

The positive economic gains in the electric power sectors do not compensate for the negative impacts on the rest of the economy as measured by gross state product (table 3). Gross state product declines by $180 million to $500 million with a 5% to 15% increase in the export price of BPA and IOU power, respectively. There is an increase in returns to capital, which potentially mitigates the negative effects of lower wages for all consumer groups (and especially the medium- and high-income groups). However, much of the capital income leaks out of the state economy as payments to outside capital owners or to the federal treasury. Household income drops for all income classes by as

Table 3. Income and Tax Changes (percent changes from the baseline)

Description	Baseline	External Electricity Price Changes 5% Increase	10% Increase	15% Increase
Gross State Product (GSP) ($ mil.)	113,561	-0.16%	-0.31%	-0.44%
Private GSP w/o IOUs ($ mil.)	85,388	-0.28%	-0.61%	-0.92%
Labor (No. of Jobs)	2,775,586	-0.28%	-0.55%	-0.81%
Avg. Compensation per Job and % Change ($)	23,278	-0.07%	-0.14%	-0.21%
Short-Run Returns to Capital	24,806	0.28%	0.28%	1.71%
Household Income:				
▸ less than $20,000	8,377	-0.10%	-0.20%	-0.30%
▸ $20,000 to $40,000	26,015	-0.22%	-0.42%	-0.62%
▸ greater than $40,000	61,271	-0.26%	-0.51%	-0.75%
Government Revenues and Taxes:				
▸ Federal Capital Surplus	446	3.61%	7.61%	11.85%
▸ State & Local Govt Enterprise Surplus	734	9.04%	17.98%	26.86%
Other Taxes:				
▸ Excise Tax	889	-0.09%	-0.17%	-0.23%
▸ General Sales Tax	4,024	-0.10%	-0.18%	-0.24%
▸ Business Tax	2,116	-0.10%	-0.18%	-0.25%
▸ Commercial Property Tax	1,318	-0.25%	-0.49%	-0.72%
▸ Residential Property Tax	983	-0.25%	-0.48%	-0.71%

much as 0.3% for low income and 0.75% for the highest income class for a 15% increase in export electricity prices.

The negative impacts of rising electricity prices also affect government revenues. Property tax revenues drop by as much as 0.7% (table 3). Moreover, BPA's capital payments are remunerated to the federal treasury and do not accrue to Washington State households. BPA payments to capital increase by $16 million for a 5% increase in export prices and $52 million for a 15% increase in export prices.

In summary, as BPA and IOUs shift power to out-of-state markets, the increased regional electricity cost imposed on other in-state industries reduces the quantity of labor demanded and equilibrium wage. The change in cost structure of BPA's customers makes them less competitive in their respective export markets, resulting in lower exports, less employment, and less profit in most sectors. The aggregate result on the distribution of income in Washington is an increase in capital income and a decrease in wage and proprietor income. It should be noted that the increased capital income accruing to BPA does not lead to increased income for Washington households, but instead mostly leaks out of the state economy in the form of payments to the federal treasury.

Conclusions

While deregulation will facilitate penetration of lucrative export markets by the Northwest's power producers and will have a positive impact on electric power producers, there are important negative consequences on the state's economy. Increased electricity exports create an important opportunity for BPA, and improve the financial position of the IOUs significantly, but electricity-dependent industries, especially aluminum, are damaged by the policy change. In the aggregate, lower wages benefit many industries, but households suffer a loss in wage income. The overall impact translates to lower wages, lower employment, and lower industry profits except for the power generators.

The findings reported above show a largely negative picture of electric power deregulation on the economy of Washington State. Several caveats are in order. First, the degree to which markets in the Southwest can actually be penetrated by producers in the Northwest and elsewhere is unknown. The main reason for embarking on a national policy of electricity deregulation is to moderate regional differences in electricity prices and lower the cost of electricity. This would be done through innovation and competition, presumably competition from producers outside the region. However, if there are sufficient institutional and capacity constraints to impede such regional reallocations, then the export price shocks modeled may not take place.

Second, there may be transmission capacity limitations in the short run which, at the very least, will slow regional market integration. These limitations likely will not remain in the longer run if there is a potential for a higher return by selling inter-regionally. Moreover, IOUs in the Northwest, BPA, and British Columbia (BC) Hydro are already providing power into these markets.

Finally, the analysis does not assume strategic behavior on the part of the direct service industries. It is possible some affected industries will be able to secure cheaper power than the model shows and will be less negatively affected than indicated by the model.

The analysis does indicate increased returns to both private and public power producers. If the increased revenues of BPA could be kept in the region, they could be used to offset growing salmon recovery expenditures in Washington and would no longer represent a leakage from the regional economy.

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Appendix: Data Sources

The data used to calibrate the model come from a social accounting matrix (SAM) developed for the base year of 1990 for the State of Washington. Baseline data for development of the SAM were constructed from nonsurvey-based input-output accounts generated by IMPLAN (Minnesota IMPLAN Group). Regional accounts were then adjusted to be consistent with other sources of regional data. Factor payments were adjusted to be consistent with the U.S. Department of Commerce, Regional Economic Information System data on personal income, employment, and gross state product data. Total industry output estimates were adjusted to be consistent with 1990 state agricultural statistics (Washington State Department of Agriculture), the U.S. Department of Commerce 1990 annual survey of manufacturers, utility industry statistics, and BPA annual reports. Finally, with data from the Washington State Department of Revenue, state government revenue flows were decomposed into types of revenues: property taxes, sales taxes, and excise taxes. The result was a SAM consistent with official sources of data on income, employment, output, and taxes.

The model is a 31-sector model of the Washington economy. The sectoral breakdown is presented in table A1, below.

Table A1. Sector Aggregation and SIC Codes for the Washington State CGE Model

Sector Name	SIC Codes	Sector Name	SIC Codes
Ag–Other Livestock	02	Other Primary Metal Processing	33 (excl. aluminum)
Ag–Cattle	02	Aerospace	372–376
Ag–Nonirrigated Field Crops	01	Other Manufacturing	22, 2431, 34, 39, 321–329, 30, 31, 341–49, 35, 36, 371, 4, 5, 9, 373, 38, 39
Ag–Irrigated Field Crops	01		
Ag–Eastern WA Hortic. Crops	01		
Ag–Western WA Hortic. Crops	01		
Commercial Fishing	09	Rail Transportation Services	40
Ag Services, Forestry & Fisheries	07	Motor Freight & Warehousing	42
Metal Mining	10	Water Transportation	44
Other Mining	12–14	Electric Services	491
Construction	17	Other TCPU[a]	45, 46, 47, 48, 492–7
Food Processing	20–23	Trade	50–59
Logging	241	Services	60–76
Timber	242, 3, 4, 9	State & Local Govt Enterprises	NA[b]
Paper	26	State & Local Electric Utilities	NA
Chemicals	28	Federal Govt Enterprises	NA
Aluminum	3334, 3353–55, 61	Federal Govt Electric Utilities	NA

[a] TCPU = Transportation, Communication, and Public Utilities.
[b] NA = not applicable.

Two sets of parameters cannot be calibrated from existing data: the trade elasticities of substitution and transformation. These elasticities govern the responsiveness of industries and consumers to purchase or sell commodities outside of the region. Elasticities at the national level have been estimated for the United States and Canada by Reinert and Roland-Holst, and by Shiells, Stern, and Deardorff. Reinert and Roland-Holst reported elasticities for U.S. manufacturing sectors ranging from 0.01 to 3.49. While there is no existing study of state or even multi-state estimates of elasticity of substitution and transformation, we assume the smaller the economy, the higher the transformation elasticity for most industries. For trade transformation elasticities, comparisons of U.S. and Canadian estimates suggest such a relationship between the larger U.S. economy and the smaller Canadian economy (Burniaux et al.). Estimated trade elasticities of substitution for Canada ranged from 5 to 6 for manufacturing and agriculture, and 0.2 to 5 for services. Transformation elasticities for Canada were generally higher than estimates for the United States. Assumed elasticities of substitution and transformation are presented in table A2.

Table A2. Elasticities of Substitution, Transformation, and Labor Migration

Sector	Elasticity of Import Sub-stitution	Elasticity of Export Trans-formation	Sector	Elasticity of Import Sub-stitution	Elasticity of Export Trans-formation
Other Livestock	1.5	8.0	Aluminum Products	1.2	8.0
Range and Ranch Fed Cattle	1.5	8.0	Manuf. Primary Metals	1.2	8.0
Field Crops nonirrigated	1.5	8.0	Aerospace	1.2	8.0
Field Crops irrigated	1.5	8.0	Manufacturing Other	1.2	8.0
Fruit/Veg Crops eastern	1.5	8.0	Rail Transport	1.2	8.0
Fruit/Veg Crops western	1.5	8.0	Motor Freight	1.2	8.0
Commercial Fishing	1.5	8.0	Water Transport	1.5	8.0
Ag Services, Forestry & Fisheries	1.5	8.0	Electric Services (IOUs)	20.0	20.0
Metal Mining	1.5	8.0	Other TCPU[a]	1.5	8.0
Other Mining	1.5	8.0	Trade	0.4	8.0
Construction	1.5	8.0	Services	0.4	8.0
Food Processing	1.5	8.0	State & Local Govt Elec Utils	0.4	8.0
Logging	1.5	8.0	BPA	20.0	20.0
Timber	1.5	8.0	State & Local Government	0.4	0.7
Paper	1.5	8.0	Federal Government	0.4	0.7
Chemicals	1.5	8.0			

Elasticity of Labor Migration[b] = 0.8

[a] TCPU = Transportation, Communication, and Public Utilities.
[b] Derived from Treyz et al.

The model is represented by 1,302 endogenous variables and 1,253 equations, with 49 predetermined variables. The system is solved by GAMS (Brooke, Kendrick, and Meeraus) using a mixed complementarity solver (PATH).