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Economic Development Assistance to Professional and Technical Services

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Abstract. A computable general equilibrium model is used to compare the economic impact of subsidies between professional and technical services, high-technology manufacturing and traded services. The results suggest that the largest increase in aggregate real income is a factor tax deduction on capital to high-technology manufacturing. A factor tax deduction for the purchase of labor within professional and technical services industries increases aggregate real income in comparison to the same subsidy awarded to high-technology manufacturing or traded services. However, subsidies to either high-technology manufacturing or traded services result in increased income inequality. Only a subsidy to traded services decreases income inequality.

1. Introduction

For several decades, United States employment growth in services-producing industries has outstripped that of the goods-producing industry. In the period between 1970 and 1997, employment in services-producing sector increased by nearly 55 million jobs. During the same period, nonfarm goods-producing employment grew by approximately five million jobs (U.S. Department of Commerce 2001). This rapid growth in employment in the services-producing sector has stimulated a great deal of interest in their prospective role in state economic development policy. Their potential role may be heightened if these industries are capable of increasing aggregate real income or decreasing income inequality.²

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² Economic development includes monetary, equity and public good elements. For purposes of this article, the examination is restricted to changes in aggregate real income and income inequality. From the perspective of this study, employment within an industry is important in the sense that these may be profitable industries expanding in output which increases the demand for and incomes of workers. Employment is an economic development concern for at least two other reasons not included in this examination. Hirasuna (1994) showed that employment growth may lead to income growth. And, the risk of a subsidized enterprise shutting down may

Some states have included services-producing industries in their economic development efforts. The state of Oregon's Economic and Community Development Department has the statutory duty of improving the competitiveness of the state's traded sector industries including traded services (ORS 285A.045).³ In accordance with this duty, the state has participated in several economic development efforts. For example, the State has helped form professional service associations. It has appropriated money to the state's university in order to increase the number of its engineering graduates. The state of Minnesota does not mention services-producing industries in statute, but does not exclude them from their economic development efforts. The Minnesota Department of Trade and Economic Development awarded a handful of their economic development loans to high-skill, high-wage producer services. These loans were largely awarded to professional and technical services enterprises in smaller metropolitan areas. Examples of such industries include management consulting services, engineering services and computer programming services. Most of the loans are for enterprises residing outside of the Minneapolis-St. Paul metropolitan area.

This paper examines the economic development potential of a group of high-wage, high-skill, export capable producer services. For purposes of this study, these industries are termed professional and technical services. Using a computable general equilibrium model, this study compares the income effects with subsidies to high-technology manufacturing and traded services.⁴

The comparisons with high-technology manufacturing and traded services help place the results in context with other scholarly literature related to this subject. High-technology manufacturing was chosen because it is another high-skill, high-wage export capable industry. Traded services was chosen because, past studies have focused on this group of industries.

Two subsidies are used for the modeling experiment—a factor tax deduction on capital, and a factor tax deduction on labor. The subsidies help reduce a price distortion caused by a tax on the specific factor. The subsidies are compared on the basis of percent changes in aggregate real income and income inequality.

be minimized if the employees were in a growing industry, and if there were barriers to working for other industries, such as inter-industrial skill differences.

³ Oregon Revised Statutes, Section 285A.045 (1999).

⁴ The study is not an examination of targeting. More work would be required before making a conclusion about the viability of a targeted policy approach over other approaches. Instead, it merely provides information on the viability of whether subsidies to these industries have the potential to raise income or lower income inequality. This may be useful to states that provide many or relatively few subsidies to these industries.

2. In Context With Previous Literature

Previous literature on services-producing industries often concerned itself with the characteristics of two industry segments. These segments are traded services and producer services. Studies documented the growth in employment, location characteristics and their relationship to income and employment in the regional economy.

Traded services

Services-producing industries which are capable of exporting or importing across state boundaries are traded services. Past studies have identified such industries as a potential source for economic development. Most studies focus on the export capability of these services. Some suggest that these industries bring export dollars into the state which will circulate from business-to-business with producers purchasing inputs from other producers.⁵

Some have examined the characteristics of establishments engaged in services-producing exports. These studies identify characteristics that raise the likelihood that an enterprise will engage in exports. For example, the location of ownership may make a difference. An establishment which is a headquarter may be more likely to export their services (Porterfield and Cox 1991, Porterfield and Pulver 1991, Smith 1984). Beyers et al (1985) suggest that branch plants may be less likely to export outside the state. Porterfield and Cox (1991) did not find a statistically significant relationship to branch plants. Some examined the size of the establishment. Porterfield and Cox (1991) found that larger establishments are significantly related to increased exports. However, Beyers et al (1985) found no significant relationship. Also, some gave consideration to the location of the establishments. Porterfield and Cox 1991 found that rural services-producing establishments are less likely to export than their urban counterpart.

Others have examined the employment characteristics of export capable services. Adrianacos and Gruidl (1992) examine whether employment growth in export-capable services leads to employment growth in other local services and in goods-producing industries. The authors construct a vector auto-regression model estimating the change in industry employment with lagged changes in own and other industry employment. They find in constructing an impulse response model that employment growth in export capable services industries does not have significant effects on employment growth in goods-producing industries. However, the opposite may be true,

⁵ Increased exports may be tied to other potential explanations for income growth. For example, productivity changes through the adoption of new technology, or changes in the organizational structure of an enterprise may contribute to an increase in exports and an increase in income growth.

employment growth in goods-producing industries does lead to statistically significant employment growth in export-capable services and local services.

Hirasuna and Pulver (1998) construct a computable general equilibrium model and conduct policy experiments comparing subsidies to traded services and manufacturing. They find that subsidies to traded services or manufacturing may potentially increase aggregate real income. The largest increase is from a tax deduction on the purchasing price of capital for manufacturing industries. However, this subsidy also raises income inequality by the largest percentage. Other subsidies to traded services may raise aggregate real income in comparison to manufacturing. Hirasuna and Pulver (1998) find that a tax deduction on the purchasing price of labor, increases aggregate real income in comparison to manufacturing. Moreover, income inequality slightly diminishes when the subsidy is awarded to traded services.⁶

Producer services

Enterprises that sell their services to other producers are producer services. Other enterprises purchase producer services presumably because it is cheaper than producing it themselves. For example, some enterprises may hire out for legal services. Some will hire services and maintain them internally. Scholarly observers of these industries suggest that this internal production can be substantial (Coffey and Bailly 1992). However, from an economic development standpoint, producer services identify a particular group of enterprises, separate from manufacturing, which may have been overlooked in the past.

Some suggest that producer services enhance productivity and economic efficiency by allowing enterprises from all economic sectors to contract out for services that would be infrequently used, or would otherwise be too costly to keep within their organization (Hansen 1994). Producer service enterprises can secure income by providing services to several clients, possibly from several industries.

Employment growth in producer services has been remarkable and is well documented by authors like Beyers (1992). Some have examined the sources of growth in producer services. For example, Coffey and Bailly (1992) offer four hypotheses: (1) the move towards product specialization has increased the demand for research and development, marketing and other producer services; (2) a rapid influx of new technologies and techniques enhanced the need to purchase services to implement or maintain the new production process; (3) an increasingly complex international market-

⁶ There are many differences between Adrianacos and Gruidl (1992) and Hirasuna and Pulver (1998). Adrianacos and Gruidl (1992) examine employment growth in general. Hirasuna and Pulver (1998) discern growth by the type of subsidy. Also, Hirasuna and Pulver (1998) compare manufacturing industries and traded services. Adrianacos and Gruidl (1992) compare all goods-producing industries. Finally, the studies have different industries included as traded services.

place creates the need to help manage information; and (4) increased governmental intervention and regulation may require more assistance from producer services.

Much of the literature finds that producer services tend to concentrate in urban spaces. Drennan, Tobier and Lewis (1996) suggest that larger urban places are best able to attract these services. This is particularly true of high-skill producer services. Large pools of skilled and specialized labor may reduce the hiring and recruiting costs and may contribute to urban agglomeration in high-skill producer services. Drennan, Tobier and Lewis (1996) suggest that this potential advantage bestowed upon larger cities may have contributed to a divergence in metropolitan income growth. Driven by increased demand for producer services, larger metropolitan areas gained in income in comparison to smaller cities.⁷

Some have examined how producer services might fit in relation to the urban hierarchical system of cities set forth by Christaller (1966), Losch (1954) and others. Esparza and Krmenc (1994) suggest that the recent developments of information technology may be contributing to the collapse of a multi-level hierarchy into a two tier constellation. Larger cities house the bulk of specialized services such as banking and finance and other high-skill services. These cities frequently trade with each other on a national and international scale. Smaller cities provide services on a more local scale. They nestle underneath the trade of the larger cities purchasing specialized producer services from these large hierarchical centers.

Others may concur about the presence of world class cities and the role that producer services may play within them (e.g., Taylor and Walker 2001 and Sassen 1999). They suggest that these large cities serve as knowledge complexes where advanced producer services thrive in economic activity. However, Taylor and Walker (2001) suggest that even among world class cities, a much more complex hierarchical form may exist in which enterprises from different industries and different geographical origins may choose different types of cities to locate their offices. They examined forty-six producer service enterprises in accountancy, advertising, law, banking and finance finding a sizeable eight distinct location patterns.

Some have examined whether producer services can lead to income or employment growth. Ó Huállachain (1992) conducts a regression analysis. The author uses industrial employment data to first conduct a factor analysis identifying factors, or groups of industries. Taking these factors, Ó Huállachain (1992) then conducts two regressions to estimate the 1977 factor groupings contribution to per capita income and total employment growth for the

⁷ The authors construct a regression model estimating the percent change in median family income for metropolitan areas from 1979 to 1989 with two variables—the share of producer services in gross regional product and the share of manufacturing in gross regional product.

years 1977 to 1986. The regression results suggest that high-technology manufacturing, high order services and insurance, are three of five industry groupings which positively correlate with per capita income and employment growth.⁸

McDonald (1992) constructs a regression model, with slight modifications to ÓHuállachain (1992) industry groupings, and estimates the contribution of different factors to producer services employment growth. The author finds that the percent change in employment in financial and legal services is driven by the percent change in per capita income and percent change in population.⁹ McDonald (1992) finds that employment growth in business and professional services is driven by employment growth in other industries.

The distinction between producer services and traded services is more than a conceptual exercise in categorizing and characterizing industries. There may be implications related to the success of any economic development effort. Some producer services are not traded services (e.g., detectives and protective services). Alternatively some traded services are not producer services (e.g., hotels and lodging services).

Accordingly, this study focuses on industries at the apex between traded and producer services; a set of high-wage, high-skill export capable producer services. By building a computable general equilibrium model, this study examines the potential income impact of tax deductions on the purchasing price of capital or labor. One of the differences from previous studies is the set of industries. Past studies by Hirasuna and Pulver (1998) and Ó Huállachain (1992) examine broader categories of services-producing industries. For example, both studies include many industries within the two-digit SIC category of business services (USEOP 1987). However, business services are a diverse set of industries with many occupational skill profiles (Grubb and Wilson 1992). Another difference is that Ó Huállachain (1992) does not examine factor tax deductions on capital or labor which may have different income impacts. The impact from factor tax deductions is the central focus of this study.

3. The Structure of the Computable General Equilibrium Model

The primary advantage of using a computable general equilibrium model is that it captures certain aspects of the economy that may not be born out with other statistical analyses. Other approaches are useful and should be considered when evaluating a policy, but may consist of ex-post investigations with essentially reduced forms that lack the necessary detail to cap-

⁸ High order services include real estate, security brokers, legal services, and business services.

⁹ McDonald used the difference in logs to represent percent changes.

ture all the relevant market mechanisms. For example, in this model subsidies are awarded to a small subset of services-producing industries and the effects are examined upon changes in the level of aggregate income and in income for three separate groups. In considering policy results, the ideal would be to have several time series and CGE models under a variety of market and policy scenarios. If the models produce similar results, then there may be more reason for constructing policies. If the models produce conflicting results, then consideration may be given to which models incorporate the most salient assumptions.

The model is a static, open, general equilibrium model. There are 21 industries, 18 labor occupations, and two types of capital—variable and specific. The model consists of a simultaneous system of equations that correspond to consumer and producer behavior, and market clearing conditions. These equations are in the Johansen style which expresses exogenous and endogenous variables in percent change form. Besides the discussion below, Appendix A lists the equations along with detailed descriptions. This is intended for those wishing to understand the structure of the model and for those looking to build such models. Appendix B lists the derivation of the Johansen form of several selected equations. This allows greater understanding of how these equations were constructed. Before beginning, it is useful to note that the model is of the state of Wisconsin. Many of the elasticities and parameters come from Wisconsin data and the results may be less applicable to other states or regional economies.

Consumers choose between goods and services based upon their preferences. Given their budget, consumers are assumed to choose the bundle of goods and services that maximizes their level of satisfaction. Preferences are modeled with a Cobb-Douglas utility function. The solution to this maximization problem is a set of consumer demand equations.

Under Johansen style general equilibrium models, Cobb-Douglas demand functions are equal to the percent change in income less the percent change in the own price for the good or service. The percent change in income is jointly determined with other equations. Percent change in the price of the good or service depends upon market trade conditions. For traded items, the percent change in the price of a good or service is fixed and set to zero by the modeler. As will be discussed in Appendix B, the price of non-traded items is endogenously determined by solving the system of equations.

Producers make goods or services by paying for a set of inputs. These inputs include primary inputs of capital and labor, and intermediate inputs (which are finished goods and services). For every given level of output, producers choose the bundle of inputs that minimizes their cost. Production is represented by a Constant Elasticity of Substitution (CES) production function for primary inputs and a Leontief production function for intermediate

inputs. Under a CES production function, an increase in wages for an occupation will make producers minimize cost by substituting away from labor in that occupation and by purchasing other inputs. In a computable general equilibrium model, the final outcome depends upon the interaction of all producers, from all industries, and from all consumers, which is mathematically determined by solving the simultaneous system of equations.

To close the model and set the conditions for the exchange of goods and services, a set of market clearing conditions are included. The market for goods and services are characterized by two simplified states---traded and non-traded. For traded goods and services, producers and consumers can purchase goods and services within and outside of the state boundaries. A small open economy is assumed in that the aggregate supply curve is perfectly elastic. That implies the price of traded goods and services is fixed, exogenous and set by enterprises from the rest of the world.¹⁰ Consumers and producers are assumed too small to influence international prices.

The market clearing conditions for inputs help close the model and they determine payments to income. There are separate assumptions for labor, variable capital and specific factor. These assumptions are described below and a table detailing the assumptions is in Appendix C.

Non-traded services are services where it is too costly or otherwise impractical to significantly export or import across state boundaries. In this model, only several services-producing industries are non-traded. For these non-traded services, the price is set endogenously and is equal to the intersection of within state consumer demand and producer supply.

In the factor market, fixed endowments of capital and labor are assumed. A fixed endowment in labor implies no labor force growth through migration, or by new entrants into the labor force. It was felt that in the short-run, labor would not significantly respond to small increases in wages. Instead, short-run barriers may significantly impede the movement of labor across regions. For example, renters are bound to leases. Homeowners must wait to sell their homes. Families may wait until the end of the school year, if not longer, before moving to another state. Also, workers from other states may be unaware of economic development policy changes or small changes in wages from other states. Finally, there was a preference toward minimizing on the number of parameters without established empirical estimates. Data would likely have to be inferred for the migration of labor by occupation. Moreover, migration can be separately studied in the model by increasing

¹⁰ An alternative is to assume quality differences between goods and services produced within and outside the state (e.g., Deardorff and Stern 1986). The assumption could make a difference. For example, if producers from other states refuse to purchase in-state professional and technical services, it could substantially alter results. However, without empirical evidence to construct parameters, it was decided to adhere to the simpler open economy model.

the endowment of labor.¹¹ Under the no-migration assumption, the labor market clears with the equilibrium wage determined at the intersection of the fixed endowment of labor and aggregate demand.

Variable capital is traded across state boundaries and it is assumed that the price is held fixed and equal across regions. The endowment of capital is apportioned between sales within and outside the state.

Specific factors are endowments of capital fixed in short-run supply. Examples of specific factors include buildings, heavy equipment and land. This is capital that remains constant in the face of short-term market fluctuations. For each industry, the price of the specific factor is determined by the intersection of demand and the endowment of the specific factor. If demand for the specific factor increases the quantity remains fixed with the endowment and the price of the specific factor increases.

Using this model, the income effects of subsidies to professional and technical services are compared with subsidies to high-technology manufacturing and traded services. The two subsidies are a factor tax deduction on the purchasing price of capital and a factor tax deduction on the purchasing price of labor. The factor deductions help reduce a pre-existing distortion from a state business income tax. For purposes of this model, the business income tax is modeled with a tax on the specific factor.

To allow comparison across subsidies, a fixed dollar amount is selected. Each of the state subsidies equal approximately \$2 million. A fixed dollar amount is chosen because states may be more likely to allocate expenditures based upon dollars spent rather than percent changes. Capital and labor subsidies are modeled as a percentage discount on the market price for each factor.

Aggregate real income is used to evaluate the policy options. The Gini coefficient is used as a single quantifiable measure of income inequality.¹²

4. Data Sources and Aggregating Industries

Data for the CGE model come from several sources. Impact Analysis for Planning (IMPLAN) is used to retrieve cost shares for intermediate and primary inputs. The Wisconsin Department of Industry, Labor and Human Relations provided industry-occupation data.¹³ Cost shares for each occupation by industry are calculated with data on occupational wage rates from the *1980 Census of Population and Housing*. Scholz (1987) provided data on

¹¹ Hirasuna (1994) finds that by increasing the endowment of labor by a percentage equal to the State of Wisconsin's labor force projections leads to an increase in aggregate real income and a decrease in income inequality.

¹² The Gini is used because policy comparisons can be somewhat ambiguous without a consistent measure of income equality across all policies.

¹³ Now the Department of Workforce Development. Because this data includes some private information, the data is not publicly provided.

capital shares in each industry and capital income for each household type. Appendix C lists data that uses information from Scholz (1987). Also, more information on the parameters can be found in Hirasuna (1994).¹⁴

Except for high-technology manufacturing, most industries were grouped together based upon how well they matched up to several criteria. For high-technology manufacturing, the industries were grouped using previous research by Barkley, Dahlgran, and Smith (1988). Although these industries showed some variation in employment growth rates, they tended to be similar in that they were high-skill, high-wage manufacturing industries.

The criteria used to group the remaining industries are: (1) industries with similar Standard Industrial Code (SIC, United States 1987), (3) industries with similar employment bases, (4) industries with similar rates of employment growth, (5) industries with different occupational skill requirements, (6) traded industries, and (7) industries which sell all of their output to other industrial producers. Table 1 lists the final industry groupings. Appendix C lists the industries within the professional and technical services and high-technology manufacturing industries.¹⁵

The criteria serve the purpose of grouping industries from the perspective of an economic development practitioner. Grouping together industries with similar SIC codes helps assure that these industries maintain similar input structures. Grouping industries with large employment bases (i.e., large location quotients) may help identify industries with a comparative advantage.¹⁶ The occupation-skill criterion helps cluster high skill industries into like groupings. These industries are often included in industrial economic development policies.¹⁷ Traded industries were separated from non-traded industries.¹⁸ Industries which sell their output to other industries help separate producer services from consumer services.¹⁹

¹⁴ Or, by contacting the author.

¹⁵ Traded services include transportation and communication; wholesale trade; lower order services; professional and technical services; and health and nonprofit services. Tourism is traded, but it is assumed that the demand from outside the state is perfectly inelastic. This was assumed, since most of the visitors to Wisconsin would likely be business trips and given evidence on demand for air flights, the demand would be inelastic.

¹⁶ Industries with large employment bases are industries with larger state-wide location coefficients.

¹⁷ Since industries with high-skill requirements tend to pay higher wages, industries were grouped together based upon their wages paid to workers.

¹⁸ Traded industries are identified using survey methods from past literature and by using information from IMPLAN.

¹⁹ IMPLAN was used to indemnify these industries.

Table 1: Industry Groupings

Industry
Agriculture
Mining
Construction
High Tech. Durables
M&E Nonelectrical
Food, Textile, & Clothing
Other Nondurables
Paper Products
Printing & Publishing
High Tech. Nondurables
Primary & Fabricated Mineral
Electronic Durables
Transportation & Communication
Wholesale
Nontraded Consumer Services
Lower Order Services
Professional Services
Nontraded Producer Services
Tourism
Health & Nonprofit Services ²⁰
Government & Specialty Industries

The professional and technical service industry is not the same as the two-digit SIC classification for professional services. Instead, the industry incorporates several different SIC divisions.

5. Results

This section presents the results from comparing subsidies among professional and technical service, high-technology manufacturing and traded services.²¹ Table 2 lists percent changes in real income, wages, and the Gini coefficient. The percent change in real income is given for three income groups—low (<\$20,000 per year), medium (\$20,000 to \$40,000 per year), and high (>\$40,000).

The economic development policies examined here are factor tax deduction on capital and a factor tax deduction on labor. Both are policies which may be implemented by state governments. Compari[sons will be made on the basis of changes in aggregate real income and income inequality.

²⁰ This is cited as health and human services in Hirasuna and Pulver (1998).

²¹ High-technology manufacturing includes durable and non-durable.

Table 2: Percent Changes in the Level of Income Distribution for Factor Tax Deductions on Capital and Labor Awarded to High -Technology Manufacturing, and Professional and Technical Services.

	Capital			Labor		
	Professional and Technical Services	High-Tech . Manufac- turing	Traded Services	Professional and Techni- cal Services	High-Tech. Manufac- turing	Traded Services
[1] Subsidy rate (s of 100)	7.06	12.49	2.61	4.96	3.31	0.9
<i>Real Income</i>						
[2] Low	0.13	-0.03	0.35	0.13	-0.03	0.34
[3] Medium	-0.01	0.23	0.1	-0.02	0.17	0.19
[4] High	1.87	2.22	0.65	2.06	1.68	0.31
[5] Aggregate	0.65	0.84	0.34	0.72	0.64	0.26
[6] Gini	1.58	5.44	0.87	4.83	4.14	-0.01
<i>Wages by Group</i>						
[7] Blue Collar	-0.39	0.27	-0.19	-0.43	0.21	-0.16
[8] White Collar	1.72	1.63	0.6	1.92	1.25	0.47
[9] Office and Clerical	0.35	0.17	0.57	0.39	0.12	0.53
[10] Aggregate	0.23	0.50	0.29	0.26	0.38	0.32

Factor Tax Deduction on Capital

A factor tax deduction on capital lowers the purchasing price of capital paid by producers. The lower price may overcome barriers to communities which result in an inefficient allocation and an under-investment in capital. By providing an added financial incentive, employers may be able to purchase more capital, adding to the productive capacity of the enterprise and possibly increasing the demand for labor. Factor tax deductions can be offered through grants, reduced interest rates, or favorable repayment terms. For purposes of this paper, it is assumed that the factor tax deduction is awarded for the purchase of variable capital.²²

A factor tax deduction on capital lowers the cost to the producer and increases output. Increased output increases the demand for labor and other inputs. The combination of increased demand for labor and assumed fixed endowment of labor has the effect of raising wages in the state as subsidized enterprises successfully hire workers from competing industry-enterprises within the state.²³ As other enterprises compete for labor, they try to lower

²² Variable capital is estimated as a percentage of payments for rent and interest.

²³ With a fixed endowment of labor by occupation, the equilibrium wage is at the intersection of aggregate demand for labor in that occupation and the endowment for labor in the same occupation. The capital subsidy has the effect of decreasing cost and increasing output, thereby in-

their cost by substituting away from occupations with wage increases and substituting towards other inputs. The subsidy also increases the demand for the subsidized industry's specific factor. Fixed in short-run supply, new buildings are not constructed and the specific factor remains constant in the short-run. Instead, increased demand results in an increased price for the specific factor. The increased income from wages and the specific factor results in increased demand by consumers, thereby increasing the demand for goods and services. The price of traded goods and services remains constant as producers from outside the state will bid underneath any attempt by within state producers to raise their prices. The price of non-traded items increase as to help pay for the increased cost of production resulting from increased output and from increased wages. All of these adjustments take place in the model. Mathematically, the final adjustment to the factor tax deduction on capital and the resultant change in income and income inequality is solved with the simultaneous system of equations.

As with all of the subsidies, it is assumed that total state government expenditures equal \$2 million. The percent change in the subsidy rate, listed in Table 2, corresponds to this allocation. This allows for another approach, which is to compare elasticities.

The largest increase in aggregate real income comes from a capital subsidy to high-technology manufacturing.²⁴ Aggregate real income increases by 0.84 percent which is the largest increase of all the subsidies to capital or labor. The next highest increase for capital subsidies is to professional and technical services at 0.65 percent. Traded services provided the smallest percent increases with 0.34 percent.

The increase in income might occur because the factor tax deduction reduces the distortion caused by the tax on the specific factor. Past studies have examined the relevance of pre-existing factor tax distortions when examining the impacts of factor tax deductions (Bovenberg and Goulder 1997, Goulder et al 1997, and Hirasuna 1994). Hirasuna (1994) constructs an analytical general equilibrium model, finding that there is a limit to the size of the factor tax deduction before aggregate real income begins to decrease.²⁵

creasing the demand for labor. Increased demand by an industry shifts aggregate demand outward causing increased wages, increased quantity demanded by the subsidized industry and decreased quantity demanded by other industries.

²⁴ The percent change in the subsidy rate partly depends upon the pre-existing subsidy rate and corporate income tax rate. This is because the corporate income tax rate can be passed onto the cost of other factor inputs via the homogeneity condition. The subsidy reduces the wedge placed upon some of the factor inputs. Tax and Subsidy information come from the Wisconsin Department of Development. Since the Wisconsin Department of Development did not offer any economic development subsidies to services-producing industries, subsidies on manufacturing industries were applied to services-producing industries.

²⁵ The model includes two traded industries, one non-traded industry, one mobile factor for variable capital, one specific factor for labor and one fixed factor for heavy equipment. The

Regardless of the industry, a factor tax deduction on capital raises income inequality. The Gini coefficient increases by 5.44 percent for the subsidy to high-technology manufacturing; by 1.58 percent for a subsidy to professional and technical service industry; and by 0.87 percent for a subsidy to traded services.

Factor Tax Deduction on Labor

A factor tax deduction on labor lowers the wage cost of labor. This deduction can lubricate market processes by diminishing historical or institutional barriers, by compensating for a lack of a skilled labor pool, or by neutralizing resource misallocation caused by immobile labor or wage rigidities. An example of such a policy is a targeted job tax deduction where employers pay lower taxes for each additional unit of labor hired.

The way a factor tax deduction on labor circulates through the economy is similar to a factor tax deduction to capital. The factor tax deduction is applied to all occupations hired by the industry. The tax deduction lowers costs, increases output, increases demand for labor and increases wages. In response to the higher wages, enterprises from unsubsidized industries seek to minimize cost by substituting away from the higher wages, and decreasing output. The gains in wages and in specific factor income result in net increased aggregate real income.

A factor tax deduction to professional and technical services increases aggregate real income by a larger percentage than to any other industry. The percent change in aggregate real income is 0.72 percent for professional and technical services; 0.64 percent for high-technology manufacturing; and 0.26 percent for traded services.²⁶

In either subsidy to professional and technical services, or to high technology manufacturing, the subsidy raises income inequality. The Gini increases by 4.83 percent in professional and technical services and by 4.14 percent in high-technology manufacturing. Income inequality slightly diminishes when a labor subsidy is awarded to traded services. For this industry income decreases by 0.01 percent.

6. Conclusions

The general conclusions of the analysis is that some economic development assistance to professional and technical service industries may increase aggregate real income in comparison to high-technology manufacturing and to traded services. However, a factor tax deduction on capital to high-technology manufacturing increases aggregate real income by a larger per-

specific factor for labor recognizes the possibility of inter-industrial skill differences and differences in wages.

²⁶ These changes are fairly large when considering the amount of the subsidy was two million dollars and the percent change in aggregate real income is for the entire state.

centage than any other subsidy examined. Subsidies to traded services provide the smallest increase in income inequality.

The results from this model lead to two primary policy implications. First, economic development practitioners need not exclude professional and technical services and they may even explicitly consider them in their economic development efforts. These industries may provide income increases which are somewhat similar to high-technology manufacturing. The other consideration is that economic development practitioners concerned about income inequality may wish to consider subsidizing a broader industry grouping like traded services. Employment in these industries are less concentrated in high-skill white collar occupations.

In awarding factor tax deductions to high-technology manufacturing and professional and technical services, economic development practitioners might consider the long-term effects of these subsidies. For example, they might consider ways to ameliorate the negative impacts incurred when high-skill workers from subsidized industries lose their jobs during times of cyclical unemployment. Or, they might identify and implement policies that remove barriers, or otherwise assist lesser skilled workers into better paying positions.

Work can be done to refine the data and the model. Developing better parameter estimates and finding better sources of data is a never ending pursuit. Future refinements to the model include a more salient depiction of the producer's decision between externally hired producer services, which are intermediate inputs, and internally hired producer services, which are primary inputs.²⁷ Other models may incorporate micro-data on the working poor in order to examine whether industrial policies might help decrease the rate of poverty. Another addition may be to explicitly model the provision of publicly provided goods and services such as roads and schools. Finally, models may incorporate dynamic decisions and they may incorporate migration decisions in order to conduct more industry comparisons.

There are many research possibilities related to policy and professional and technical services. More industry comparisons might be conducted. Some may even consider a policy that reduces taxes to all industries yet assures adequate funding for state provided public goods. More can be understood about professional and technical services. Some might consider the potential for these industries to locate in non-metropolitan areas. Studies may examine whether the recent information technologies might help remove any barriers to location in rural areas. Studies may evaluate amongst the alternative ways to soften the income inequality effects by providing

²⁷ Under the current study externally hired producer services modeled with a Leontief production function and internally hired producer services modeled with a CES production function. The demand for intermediate inputs and the demand for primary inputs are linked and jointly determined by the percent change in output.

means for better paying jobs. Finally, there may eventually be enough evidence of states providing economic development assistance to services-producing industries to conduct some empirical analyses. It might be possible to conduct some case studies, and eventually, time series analyses.

Appendix A: Equations to the Model

The CGE model used here is in the Johansen style which is the same style used for the ORANI model (Dixon et al. 1982 and Horridge et al. 1993). It is different from other non-linear CGE models where calibration is used to solve for an equilibrium. Here, no calibration is used. Instead, the model is already closed and is a linear system of equations with exogenous and endogenous variables in percentage change form. The advantage to such a model is that it is simpler to construct.²⁸ Also, because it is a computable general equilibrium model, it accounts for both producer and consumer behavior.

This appendix lists the equations to the model. Computable general equilibrium models inevitably include many parameters and variables. There are many subscripts to the model, but they are needed for accuracy. To help simplify the discussion, tables A.1 and A.2 list the variables and parameters. The variables are denoted with a hat to signify percent change form (i.e., $\hat{x} = dx/x$). All other remaining symbols are parameters to the model. By definition, they are held constant and will not be denoted with a hat.

There are many exogenous variables and only the variables for capital and labor subsidies will be shocked. The remaining exogenous variables will be set to zero throughout this experiment, but they are included in the model description. This is, because it makes it easier to understand the original form of each equation. Also, it provides a good general framework for other models.

Household Income and Expenditure

Consumer behavior is described with the following set of income and demand equations. Equation A.1 lists the percent change in income for each household type (m =low, medium and high income). The percent change in income equals share weighted percent changes in payments to labor, specific factor, and capital. The shares, denoted by gamma (γ_m), are equal to the factor payment divided by the group's income. The first three terms, enclosed in parentheses, represent the percent change in income payments to labor, specific factors and variable capital. The variables in each of the parentheses are the sum of the percent change in the input price plus the percent change in the factor endowment. The income equation is after tax income and it substitutes out the share weighted percent change in net government expenditures. By using share weighted changes, it implies that the cost for the sub-

²⁸ A disadvantage to the model is that it constructs linear approximations for each equation and conducts comparative static exercises. Like all comparative static exercises, valid estimates are limited to small changes in variables.

sidies is financed by an income tax with a rate equal to the current proportion of taxes paid with the consumer's income.²⁹

$$\hat{M}_m = \sum_{l=1}^L \gamma_{ml} (\hat{w}_l + \hat{L}_l) + \sum_{i=1}^{21} \gamma_{miz} (\hat{w}_{iz} + \hat{z}_i) + \gamma_{mk} (\hat{w}_k + \hat{K}) - \gamma_{mG} \hat{G} \quad (A.1)$$

Equation A.2 represents consumer demand and is derived from a Cobb-Douglas utility function. The utility maximizing demand for each good and service (j) equate the percent change in consumption to the difference in the percent changes in income and the price of the good or service. The derivation of the Johansen form of the equation is in Appendix B.

$$\hat{C}_{mj} = \hat{M}_m - \hat{P}_j \quad (A.2)$$

Factor Demands, Factor Prices, and the Zero-Profit Condition

The following equations describe producer behavior. The demands for primary factor inputs of capital, specific factors and labor are listed in equations A.3, A.4 and A.5. The equations are derived from a Constant Elasticity of Substitution (CES) production function where the objective is to minimize cost subject to an output constraint. The percent change in the demand for a factor input equals the percent change in output supply (\hat{x}_i) less the combination of elasticity and cost share weighted changes in input prices. For example, a one percent increase in the wage of engineers, all other things held constant, increases the quantity demanded for computer scientists, mathematicians and other occupations by a percentage equal to $\epsilon_i \omega_f$, where sigma (ϵ_i) denotes the elasticity of substitution for industry i and omega (ω_f) denotes the share of primary factor cost. The subscript f indexes all inputs.

In saying this, it is useful to note that this is a computable general equilibrium model and that some things are not held constant. In a computable general equilibrium, an increase in wages for an occupation will cause other producers to substitute away from the higher wages. The market equilibrium is determined by the adjustments of all producers. Mathematically, this is determined by solving the simultaneous system of equations. See Appendix B for the derivation of the Johansen form of this equation.

$$\hat{k}_i = \hat{X}_i - \sigma_i \left(\hat{w}_{ik} - \sum_{f=1}^{K+L} \omega_{if} \hat{w}_{if} \right) \quad (A.3)$$

$$\hat{z}_i = \hat{X}_i - \sigma_i \left(\hat{w}_{iz} - \sum_{f=1}^{K+L} \omega_{if} \hat{w}_{if} \right) \quad (A.4)$$

²⁹ This is similar to the subsidy being funded out of the state's general fund where revenue is generated through an income tax. There is no lag subsidy amount and income taxes to finance the subsidy because a balanced budget is assumed.

$$\hat{l}_{il} = \hat{x}_i - s_i (\hat{w}_{il} - \sum_{f=1}^{K+L} w_{if} \hat{w}_{if}) \quad (\text{A.5})$$

The demand equations show separate factor input prices for each industry which is needed to model tax deductions on the purchasing price of capital or labor. The tax deductions act as a subsidy and place a wedge between the price paid by producers and the price received by workers (or capital owners). Equation A.6 lists the percent change in the factor input price equating it to the percent change in the subsidy rate and the percent change in the wage paid to workers (or capital owners).³⁰

$$\hat{w}_{if} = \hat{s}_{if} + \hat{w}_f \quad (\text{A.6})$$

Demand for intermediate inputs is represented with a Leontief production function. The equation shows that the percent change in the demand for intermediate inputs equals the percent change in output.

$$\hat{x}_{ij} = \hat{x}_i \quad (\text{A.7})$$

Equation A.8 lists the zero-profit condition which is an accounting identity documenting the distribution of revenue to all inputs. The zero-profit condition states that the percent change in total revenue equals revenue share weighted changes in factor costs. The left hand side of the equation lists the percent change in total revenue as the percent change in the price and the output of the good or service. The right hand side lists share weighted percent changes in payments to each of the factor inputs. Here the revenue shares are for industry i and is represented with the parameter θ_i . The percent changes of each of the costs are enclosed within parentheses. Corresponding to the equation, the factor payments are to intermediate inputs, labor, capital and specific factor. Each term in parentheses lists the percent change in the price of the factor and the percent change in the quantity of the factor. The variable \hat{a}_{iz} is a tax on the specific factor which helps finance government expenditures, this variable is exogenous and held constant throughout the policy experiments.

$$\hat{p}_i + \hat{x}_i = \sum_{j=1}^{21} \theta_{ij} (\hat{p}_j + \hat{x}_{ij}) + \sum_{l=1}^L \theta_{il} (\hat{w}_l + \hat{s}_{il} + \hat{l}_{il}) + \theta_{ik} (\hat{w}_k + \hat{s}_{ik} + \hat{k}_i) + \theta_{iz} (\hat{w}_{iz} + \hat{z}_i) \quad (\text{A.8})$$

³⁰ A tax on specific factors also places a wedge between the price paid by producers and the price received by specific factor owners. The difference from the subsidy is that the price paid is higher rather than lower.

Market Clearing Conditions for Outputs and Factors

The market clearing conditions help close the model and they specify which goods and services are traded and which factors migrate across state boundaries. Equation A.9 is the market clearing condition for goods and services. The percent change in output in industry i equals the share weighted percent changes in intermediate input demand, consumer demand and net trade. The parameter ϕ_i is the share of output in industry i . In this model, the only non-traded industries are services industries. The non-traded services industries' net trade variable (\hat{e}_i) is, by definition, exogenous and equal to zero. That is, no imports, no exports and no percent changes in either. Under this null net trade condition, the price becomes endogenous and the percent change in the price is determined by the intersection of supply and demand curves. Alternatively, if the good or service is traded, then the net trade variable is endogenous and the supply from producers outside the state is perfectly elastic which implies a fixed and exogenous price.

$$\hat{x}_i = \sum_{j=1}^{2I} f_{ij} \hat{x}_{ij} + \sum_{m=1}^3 f_{mi} \hat{c}_{mi} + f_i \hat{e}_i \quad (\text{A.9})$$

The market clearing condition for the endowment of labor in each occupation is listed as equation A.10. The percent change in the endowment of occupation l equals the share weighted changes in the demand for that occupation. The shares f_{il} is the proportion of workers in occupation l that is hired by industry i . No migration implies that the endowment for labor remains fixed and the percent change in the endowment equals zero. Under that scenario, wages are endogenous and are determined by the intersection of the endowment for labor and the aggregate demand for labor in occupation l . Behaviorally, this implies that an increased demand for labor from an industry prompts enterprises from the industry to raise wages in order to attract labor away from other industries. In the face of higher wage costs, other industries decrease their demand for labor and the equilibrium wage rates are reached when all industries have finished adjusting to current market conditions.³¹

$$\hat{L}_l = \sum_{i=1}^{2I} f_{il} \hat{l}_{il} \quad (\text{A.10})$$

The endowment for capital is listed in equation A.11. The percent change in the endowment equals the share weighted changes in the supply of capital into each region. For this policy study's experiments, the endowment for capital is assumed fixed. Also, the market price of capital is assumed fixed

³¹The adjustment is within the framework of a static model. That is, the path of adjustment is not modeled, only the percent change from the beginning to the ending state.

and equal within and outside the state. Holding both the endowment and the price of capital fixed effectively holds variable capital income constant throughout these experiments.

$$\hat{K} = \sum_{i=1}^{2I} \sum_{m=1}^3 \left(\mathbf{k}_{mi}^{\text{home}} \hat{k}_{mi}^{\text{home}} + \mathbf{k}_{mi}^{\text{row}} \hat{k}_{mi}^{\text{row}} \right) \quad (\text{A.11})$$

The supply of capital inside the state and outside the state help close the model with respect to capital and are the equations listed as A.12 and A.13. The supply of capital to industry i depends upon the price of capital both within and outside the state.

$$\hat{k}_{mi}^{\text{home}} = \mathbf{e}_{mi}^{\text{home, row}} \hat{w}_k^{\text{row}} + \mathbf{e}_{mi}^{\text{home, home}} \hat{w}_k^{\text{home}} \quad (\text{A.12})$$

$$\hat{k}_{mi}^{\text{row}} = \mathbf{e}_{mi}^{\text{row, home}} \hat{w}_k^{\text{home}} + \mathbf{e}_{mi}^{\text{row, row}} \hat{w}_k^{\text{row}} \quad (\text{A.13})$$

The percent change in net government expenditures (\hat{G}) equals the percent change in subsidy payments less the share weighted percent change in tax revenue from the specific factor. The shares ($\mathbf{q}g$) denote the proportion of each subsidy, or specific factor tax, to net government expenditures. The terms enclosed in parentheses correspond to percent changes in subsidy to labor, the subsidy to capital and tax revenue from the specific factor. For the first two sets of enclosed parentheses, the percent change in subsidies, is composed of three terms, the percent change in the subsidy rate plus the percent change in the input price and the percent change in the quantity of the input. The percent change in specific factor tax revenue is given by the term enclosed in the parentheses on the bottom row of the equation. It is the sum of percent changes in the specific factor tax, the percent change in the specific factor price, and the percent change in the specific factor itself.

$$\begin{aligned} \hat{G} = & \sum_{i=1}^{2I} \sum_{l=1}^L \mathbf{q}_{gil} \left(\left(\frac{s_{il}}{1-s_{il}} \right) \hat{s}_{il} + \hat{w}_l + \hat{l}_{il} \right) + \sum_{i=1}^{2I} \mathbf{q}_{gik} \left(- \left(\frac{s_{ik}}{1-s_{ik}} \right) \hat{s}_{ik} + \hat{w}_k + \hat{k}_i \right) \\ & + \sum_{i=1}^{2I} \mathbf{q}_{giz} (\hat{w}_{iz} + \hat{z}_i) \end{aligned} \quad (\text{A.14})$$

Outcome Measures: Aggregate Real Income and Income Inequality

To help evaluate the policies, the model includes the following outcome measures. These measures serve as the basis of cross-industry comparisons for the prospective subsidies. The percent change in real income for each household type is given by equation A.15 and equals the percent change in

nominal income less the percent change in the price index ($\hat{P}_m = \sum_{j=1}^{2I} g_{mj} \hat{P}_j$). The shares (q_{mi}), are consumption shares for a good or service j .

$$\left(\frac{\hat{M}}{\hat{P}} \right)_m = \hat{M}_m - \sum_{j=1}^{2I} g_{mj} \hat{P}_j \quad (\text{A.15})$$

Aggregate nominal income is used in calculating aggregate real income. It equals the share weighted percent changes in income for each household type. The income shares are denoted by μ (m_m) and equal the proportion of original income within the group divided by aggregate nominal income.

$$\hat{M} = \sum_{m=1}^3 m_m \hat{M}_m \quad (\text{A.16})$$

Aggregate real income equals the percent change in aggregate nominal income less the percent change in the price index.

$$\left(\frac{\hat{M}}{\hat{P}} \right) = \hat{M} - \sum_{j=1}^{2I} \sum_{m=1}^3 g_{mj} \hat{P}_j \quad (\text{A.17})$$

Percent changes in the Gini coefficient A.18 equals the elasticity weighted sum of percent changes in real income for each group.³² The equation is similar to aggregate nominal income in that it is a linear equation in income. The difference is the Gini coefficient weights income for each group rather than uses income shares. For the Gini, the weights (q_m) give lower income households higher weights. Appendix B lists the derivation of this equation.

$$Gini = \sum_{i=1}^3 q_i \hat{M}_i \quad (\text{A.18})$$

The following tables serve as a key to the variables and parameters in the model. Table A.1 lists the variables with their names. And table A.2 lists the parameters.

³² It is per capita income, but in these experiments, because the size of the subsidies are relatively small, labor does not move between household income classes. Under such a case, the percent change in aggregate real income equals the percent change in per capita real income.

Table A.1: Variable List for the CGE Model

Variable	Variable Names	Exogenous	Endogenous
M_m	Aggregate nominal income for group m		3
W_l	Price of labor in occupation 1,		18
L_l	Resource endowment of labor in occupation 1	18	
$K_{mi}^{home}, K_{mi}^{row}$	Resource endowment of variable capital and quantity supplied within outside of the state	43	
W_{iz}	Price of the specific factor for industry I		21
Z_i	Quantity of specific factor in industry I	21	
$W_k, W_k^{row}, W_k^{home}$	Price of capital, price for the rest of the world and within the state. For purposes of this study, these prices are equal.	3	
G	Government budget constraint		1
$(M/P)_m$	Aggregate real income by group m		3
p_j	Price of goods and services	18	3
C_{mj}	Consumer demand for good j by household m		63
k_i	Quantity of capital demanded by industry I		21
X_i	Output from industry I		21
$W_{ik}, W_{il} \text{ if } W_{iz}, W_{il}$	Price paid for input by industry I		420
l_{il}	Quantity of labor demanded from industry i for occupation 1		378
x_{ij}	Quantity of intermediate input demanded by industry i for input j		441
$S_{il} S_k$	Tax deduction on purchasing price of capital or labor in industry i	399	
τ_{iz}	Tax on specific factor in industry I	21	
e_i	Net trade for good or service I	3	18
M	Aggregate nominal income		1
(M/P)	Aggregate real income		1
Gini	Gini coefficient		1
Total	Total number of variables	528	1414

Table A.2: List of Parameters for the CGE Model

Parameter	Parameter Names
$\phi_{mf}, \phi_{miz}, \phi_{mk}$	Share of income from labor, specific factor, and capital for group m
ϕ_{mG}	Share of net government expenditures to income for group m
ϕ_{mj}	Share of expenditure on item j from group m
ϵ_i	Elasticities of substitution for industry I
α_{if}	Share of primary factor cost to total primary factor cost
γ_{ij}	Cost share for intermediate input
$\gamma_{if}, \gamma_{ik}, \gamma_{iz}$	Share of primary factor cost to total cost
$\phi_{ij}, \phi_{mj}, \phi_j (=x_{ij}/X_j, C_{mj}/X_j, e_j/X_j)$	Industry, consumption, and excess demand market shares
$\phi_{if}^p (=l_{if}/L_i)$	Share of capital (or labor) to total quantity of capital (or labor)
$K_{mi}^{home}, K_{mi}^{row}$	Share of capital supplied by household type m in industry i within (home) and outside (row) the state
$e_{mi}^{home, home}, e_{mi}^{home, row}, e_{ni}^{row, home}, e_{ni}^{row, row}$	Elasticities of supply of capital from outside the state (row) and within the state (home) in industry I
$\gamma_{gif}, \gamma_{gik}, \gamma_{giz}$	Share of payments on tax deductions to labor, capital and share of tax revenue from specific factor tax to net government expenditure
\boxtimes_m	Share of income for group m
γ_i	Weights to the Gini coefficient for group (m=1,2,3)

Solving the System of Equations Comprising the CGE Model

The equations to the CGE model form a simultaneous system of linear equations which can be solved using matrix algebra. To start, the above equations must be put into matrix form. Each equation is expressed as linear equations with each variable separated by addition. The linear system of equations can then be placed in a matrix with each equation representing a row and each variable representing a column.

$$AX = BY \quad (\text{A.19})$$

The matrix A is a mxm matrix of partial elasticities, shares and other parameters which are multiplied against the exogenous variables. The vector X represents a $mx1$ vector of exogenous variables which are in percentage change form and are denoted with a hat (^) in Appendix A. The matrix B represents the nxn matrix of parameters multiplied against the endogenous variables and Y is the $nx1$ vector of endogenous variables.³³ The solution to the model can be found by taking the inverse of B and multiplying it against A . That is:

$$B^{-1}AX = Y \quad (\text{A.20})$$

Each element in the matrix $(B^{-1}A)$ is an elasticity in a general equilibrium context. To see this, let \hat{y}_i represent the percent change in an endogenous variable in the vector Y . Let \hat{x}_j represent the percent change in an exogenous variable in the vector X . The elasticity of variable y_i with respect to x_j equals \hat{y}_i / \hat{x}_j which equals the element in row i and column j of the matrix of coefficients $(B^{-1}A)$. That element is the elasticity after solving the linear system of equations that describe the general equilibrium economy.

Policy experiments can be conducted by setting all exogenous variables to zero, except those needed for the experiment. In this study, the subsidy rates to capital and labor (\hat{s}_i) were individually set to non-zero values. After multiplying the vector of exogenous variables (X) against the matrix of coefficients $(B^{-1}A)$, the vector (Y) yields the solution for the percent changes in aggregate income and income inequality.

³³ If the variable is not in the equation, then its coefficient effectively equals zero.

Appendix B: Derivation of Equations

This appendix derives several selected equations used in the CGE model which are described in Appendix A. Below are derivations for the Johansen form of the Cobb-Douglas demand function, the Constant Elasticity of Substitution primary input demand function and the Gini coefficient. To simplify matters, some of the subscripts are repressed which will not alter the calculations.

The Cobb-Douglas Consumer Demand

The function can be written as,

$$C_j = \delta_j \frac{M}{P_j} \quad (\text{B.1})$$

where delta (δ_j) is a parameter that dictates consumer preferences. Converting the above equation into the Johansen form, the first step is to take the log of both sides.

$$\ln(C_j) = \ln(\delta_j) + \ln(M) - \ln(P_j) \quad (\text{B.2})$$

The total differential of the above equation equals.

$$\frac{dC_j}{C_j} = \frac{dM}{M} - \frac{dP_j}{P_j} \quad (\text{B.3})$$

This states that the percentage change in consumption of good j is linearly dependent on the percentage change in income and the own price of good j . The preference parameter (δ_j) cancels out of the equation because it is a constant. Using a hat (^) to denote variables in percentage change form, the above equation can be rewritten as (equation A.2):

$$\hat{C}_j = \hat{M} - \hat{P}_j \quad (\text{B.4})$$

The Constant Elasticity of Substitution (CES) Demand

This function, for primary inputs of capital and labor, is derived through cost-minimization and can be written as (Horridge, et al 1993):

$$I_l = X \left(\sum_{f=1}^{K+L} \delta_f \left(\frac{d_l w_f}{d_f w_l} \right)^{r/(r+1)} \right)^{1/r} \quad (\text{B.5})$$

Rearranging terms yields:

$$l_l = X d_l^{1/(r+1)} \left[\frac{w_l}{w_{ave}} \right]^{-1/(r+1)} \quad (\text{B.6})$$

where $w_{ave} = \left(\sum_f^{K+L} d_f^{1/(r+1)} w_f^{r/(r+1)} \right)^{(r+1)/r}$. Taking the log of both sides leads to the following:

$$\ln(l_l) = \ln(X) + 1/(r+1) \ln(d_l) - 1/(r+1) (\ln(w_l) - \ln(w_{ave})) \quad (\text{B.7})$$

Taking the total differential yields:

$$\hat{l}_l = \hat{X} - \mathbf{s} (\hat{w}_l - \hat{w}_{ave}) \quad (\text{B.8})$$

where $\mathbf{s} = 1/(r+1)$ and w_{ave} can be written in percentage change form as:

$$\hat{w}_{ave} = \sum_f^{K+L} \omega_f \hat{w}_f \quad (\text{B.9})$$

The term (ω_k) equals the share of primary input cost. This can be shown by first noting that ω_k can be written as:

$$w_f = \frac{d_f^{r/(r+1)} w_f^{r/(r+1)}}{\sum_{k=1}^{K+L} d_k^{1/(r+1)} w_k^{r/(r+1)}} \quad (\text{B.10})$$

Now, take the original CES demand function and multiplying against its corresponding input price:

$$w_l l_f = X d_f^{1/(r+1)} w_f^{r/(r+1)} w_{ave}^{1/(r+1)} \quad (\text{B.11})$$

By taking the above equation, summing across all primary inputs and placing into the denominator, the resultant share equation is obtained. Substituting in the equation for the weighted average for all primary inputs yields the input demand equation (see equations A.3, A.4 and A.5).

$$\hat{l}_l = \hat{X} - \mathbf{s} (\hat{w}_l - \sum_{f=1}^{K+L} w_f \hat{w}_f) \quad (\text{B.12})$$

The Gini Coefficient

The measure of income inequality is equal to:

$$\text{Gini} = 1 + \frac{1}{N} - \frac{2}{N^2 M} (m_1 + 2m_2 + 3m_3 + \dots + Nm_N) \quad (\text{B.13})$$

where $m_1 > m_2 > m_3 > \dots > m_N$ is real income for individuals, \bar{m} is average per capita real income and N is the total number of individuals. The Gini coefficient provides lower income earners with higher weights. The weights are such that transfers from higher income units to lower income units will decrease income inequality as measured by the Gini.

The CGE constructed for this paper allows for three income groups. To construct the Gini coefficient all individuals within each group were assumed to have the same income. Therefore the Gini can be simplified to:

$$Gini = 1 + \frac{1}{N} - \frac{2}{N^2 M} (I_1 M_1 + I_2 M_2 + I_3 M_3) \quad (B.14)$$

The weights can be calculated as follows:

$$I_1 = (1 + 2 + 3 + \dots + I_1) = \frac{I_1(I_1 + 1)}{2}, \quad (B.15)$$

$$I_2 = ((I_1 + 1) + (I_1 + 2) + (I_1 + 3) + \dots + (I_1 + I_2)) = I_1 I_2 + \frac{I_2(I_2 + 1)}{2} \quad (B.16)$$

and

$$I_3 = ((I_1 + I_2 + 1) + (I_1 + I_2 + 2) + (I_1 + I_2 + 3) + \dots + (I_1 + I_2 + I_3)) = I_3(I_1 + I_2) + \frac{I_3(I_3 + 1)}{2} \quad (B.17)$$

where

$$I_1 + I_2 + I_3 = N. \quad (B.18)$$

Taking the log of the Gini coefficient (B.14) yields

$$\ln(Gini) = \ln \left[1 + \frac{1}{N} - \frac{2}{N^2 M} (I_1 M_1 + I_2 M_2 + I_3 M_3) \right] \quad (B.19)$$

With respect to this analysis, the weights do not change. That is, it is assumed that the percentage changes in income for each group is too small for any economic unit to move into a higher income group. The total differential is then equal to:

$$\frac{dGini}{Gini} = \frac{-\frac{2}{N^2 M} (I_1 dM_1 + I_2 dM_2 + I_3 dM_3)}{1 + \frac{1}{N} - \frac{2}{N^2 M} (I_1 M_1 + I_2 M_2 + I_3 M_3)} \quad (B.20)$$

The above equation can be rewritten as (See equation A.18):

$$Gini = \sum_{i=1}^3 q_i \hat{m}_i \quad (B.21)$$

where θ_i is the elasticity of the Gini coefficient with respect to a change in group income and can be written as:

$$\eta = \frac{-\frac{2}{N^2M}I_iM_i}{1 + \frac{1}{N} - \frac{2}{N^2M}(I_1M_1 + I_2M_2 + I_3M_3)} = \frac{-\frac{2}{N^2M}I_iM_i}{G} \quad (\text{B.22})$$

The coefficient is less than zero which implies that a one percent increase in income decreases income inequality by θ_i .

Appendix C: Data and Assumptions

Table C.1 lists the primary factor inputs, including all of the labor occupations along with their key assumptions.

Table C.1 Factor Inputs and Their Market Assumptions

Input	Key Assumptions
Labor	
White Collar Occupations	
Executive, Administrative and Mgmt. Management Support	No Migration, Fixed Endowment, Endogenous Wages,
Engineers, Architects Surveyors	No Migration, Fixed Endowment, Endogenous Wages,
Natural Scientists	No Migration, Fixed Endowment, Endogenous Wages,
Computer Scientists, Math Scientists	No Migration, Fixed Endowment, Endogenous Wages,
Social Scientists, Recreation, Religion	No Migration, Fixed Endowment, Endogenous Wages,
Lawyers	No Migration, Fixed Endowment, Endogenous Wages,
Teachers, Librarians	No Migration, Fixed Endowment, Endogenous Wages,
Health Practitioners	No Migration, Fixed Endowment, Endogenous Wages,
Writers, Artists, Entertainers, Athletes	No Migration, Fixed Endowment, Endogenous Wages,
Sales and Marketing	No Migration, Fixed Endowment, Endogenous Wages,
Office and Clerical Occupations	
Clerical	No Migration, Fixed Endowment, Endogenous Wages,
Secretary, General Office	No Migration, Fixed Endowment, Endogenous Wages,
Data Processors	No Migration, Fixed Endowment, Endogenous Wages,
Service Occupations	No Migration, Fixed Endowment, Endogenous Wages,
Blue Collar Occupations	
Agriculture, Forestry, Fishing	No Migration, Fixed Endowment, Endogenous Wages,
Precision Products, Craft and Repair	No Migration, Fixed Endowment, Endogenous Wages,
Construction & Trades	No Migration, Fixed Endowment, Endogenous Wages,
Variable Capital	Mobile Across State Boundaries (i.e., Migration), Fixed Endowment, Fixed Price for Capital
Specific Factor	No Migration, Endowment is Fixed by Industry, Input Price is Endogenous With Separable Prices for Each Industry

Table C.2 lists the industries included in Professional and Technical Services and High Technology Manufacturing.³⁴

The elasticity of substitution (σ_i) for each industry is listed in Table C.3. The values were taken from Scholz (1987), who used a different industry aggregation than this study. Because the industry groupings were different elasticities were inferred based upon which industries best matched Scholz’s (1987) categories.

³⁴ The industries listed within the table are not SIC codes, but are industry names listed in IMPLAN.

Table C.2 List of Industries

Professional and Technical Services	High-Technology Durables –Cont.
Security and commodity brokers	Carbon and graphite products
Computer programming services	Electrical industrial apparatus
Management and consulting, services	Radio and TV receiving sets
Advertising	Phonograph records and tapes
Legal Services	Telephone and telegraph apparatus
Engineering, architectural services	Radio and TV communication equipment
Accounting, auditing, and bookkeeping	Electron tubes
High-Technology Durables	Semiconductors and related devices
Small arms	Electronic components, n.e.c.
Small arms ammunition	Aircraft
Other ordnance and accessories	Aircraft and missile engines and parts
Steam engines and turbines	Aircraft and missile equipment, n.e.c.
Internal combustion engines, n.e.c.	Engineering and scientific instruments
Farm machinery and equipment	Mechanical measuring devices
Construction machinery and equipment	Automatic temperature controls
Mining, machinery, except oil field	Surgical and medical instruments
Oil field machinery	Surgical appliances and supplies
Elevators and moving stairways	Dental equipment and supplies
Conveyors and conveying equipment	Optical instruments and lenses
Hoists, cranes, and monorails	High-Technology Nondurables
Industrial trucks and tractors	Complete guided missiles
Pumps and compressors	Ammunition, except for small arms
Ball and roller bearings	Industrial inorganic, organic chemicals
Blowers and fans	Gum and wood chemicals
Industrial patterns	Adhesives and sealants
Power transmission equipment	Explosives
Industrial furnaces and ovens	Printing ink
General industrial machinery, n.e.c.	Carbon black
Electronic computing equipment	Chemical preparations, not elsewhere
Calculating and accounting machines	Classified
Scales and balances	Plastics materials and resins
Typewriters and office machines	Synthetic rubber
Refrigeration and heating equipment	Cellulosic man-made fibers
Measuring and dispensing pumps	Organic fibers, noncellulosic
Motors and generators	Drugs
Industrial controls	Petroleum refining
Welding apparatus, electric	

Table C.3 Elasticity of Substitution for Each Industry

Industry	Elasticity of Substitution
Agriculture	0.61
Mining	1
Construction	1
High Tech. Durables	0.96
M&E Non-Electrical	0.96
Food, Textile & Clothing	0.88
Other Non-Durables	1.04
Paper Products	1.05
Printing & Publishing	1.05
High Tech. Non-Durables	1.04
Primary & Fabricated Mineral	0.96
Electronic Durables	0.87
Transportation & Communication	1
Wholesale	1
Non-Traded Consumer Services	1
Lower Order Services	1
Professional Services	0.74
Non-Traded Producer Services	1
Tourism	1
Health & Human Services	1
Government & Specialty Industries	1

Table C.4 lists income shares. Scholz (1987) provides income for more levels than that modeled with IMPLAN. Scholz’s income share data was aggregated to fit IMPLAN data.

Table C.4 Income Shares and Budget Shares

	Low	Medium	High
Income Share (μ)	0.217265	0.445351	0.337384

Table C.5 lists labor income shares. The shares were derived using data on Scholz (1987) to determine the proportion of income coming from capital or labor. The proportion divided among the different occupations is from wage information by occupation from the Wisconsin Department of Labor, Industry and Human Relations.³⁵ Source: Scholz (1987) and IMPLAN
Capital income shares were derived from Scholz (1987). The specific factor income shares were apportioned between household types with the same data from Scholz (1987). Data on specific factor income by industry comes from IMPLAN.

³⁵ Now the Department of Workforce Development.

Table C.5 Labor Income Shares (g_f)

Labor	Low	Medium	High
Exec., Admin. & Managerial	0	0	0.4639
Mgmt. Support Occupations	0	0	0.0888
Engr., Arch. & Surveyors	0	0	0.1392
Natural Scientists	0	0.0081	0
Comp scientists & math.	0	0.0226	0
Soc. Sci., Rec. & Religion	0	0.0507	0
Lawyers	0	0	0.06567
Teachers & Librarians	0	0.0250	0
Health Practitioners	0	0.0656	0
Writers, Artists & Entertainers	0	0.0127	0
Sales & Marketing	0	0.0707	0
Clerical	0	0.2303	0
Secretary, General Office	0.3271	0	0
Data Processors	0.1294	0	0
Service Occupations	0.4106	0	0
Ag., Forestry & Fishing	0.1328	0	0
Prec. Prod., Craft & Rep.	0	0.3165	0
Construction & Trades	0	0.1723	0

Table C.6 Capital and Specific Factor Income Shares (g_f)

Input	Low	Medium	High
Variable Capital	0	0.0057	0.0544
Specific Factor			
Agriculture	0	0.000733	0.006986
Mining	0	0	0.000001
Construction	0	0.000201	0.001914
High Tech. Durables	0	0.000001	0.000008
M&E Non-Electrical	0	0.000001	0.000009
Food, Textile & Clothing	0	0.000088	0.00084
Other Non-Durables	0	0.000039	0.000372
Paper Products	0	0.000138	0.001314
Printing & Publishing	0	0.000024	0.000229
High Tech. Non-Durables	0	0.000001	0.000008
Primary & Fabricated Mineral	0	0.000005	0.000047
Electronic Durables	0	0	0
Transportation & Communication	0	0.000637	0.006073
Wholesale	0	0.000123	0.001166
Non-Traded Consumer Services	0	0.000314	0.002991
Lower Order Services	0	0.000345	0.003293
Professional Services	0	0.000216	0.002059
Non-Traded Producer Services	0	0.011341	0.108065
Tourism	0	0.000041	0.000387
Health & Human Services	0	0.000074	0.000706
Government & Specialty Industries	0	0.005413	0.051579

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