REGIONAL DEVELOPMENT – A COMPUTABLE GENERAL EQUILIBRIUM (CGE) ANALYSIS OF THE BENEFITS TO LOCAL RESIDENTS, COMMUTERS AND MIGRANTS

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I dedicate this degree to my mother Barbara F. Dean who, attended college while raising two children, holding a full time job and managing all of our household affairs. I hope to someday live up to her legacy of self-sacrifice.

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CHAPTER I

INTRODUCTION

Problem Statement

Throughout the U.S., regional communities tout economic growth as the panacea for all that ails. Economic development holds the promise of an increased tax base, increased quantity and variety of jobs, more amenities and a greater sense of community pride. The terms "development" or "growth" are often used to justify state, local, or even federal tax policies or business location incentives. Many Americans accept the idea that "if growth depends on the passage of a particular initiative then I must vote for the initiative...," whatever the initiative is. This willingness to support these "growth" initiatives is puzzling given that there is disagreement among regional economists about the nature and beneficiaries of such initiatives.

This "beneficiary" question might be of particular interest to low-income residents of a city, county, or other community considering a new pro-growth package aimed at attracting new business. Conventional wisdom holds that new jobs will attract migrants who relocate due to employment prospects or real-wage differentials. Indeed, Bartik (1991) finds that 77 percent of all new jobs within a state go to in-migrants. Topel (1994) and Greenwood (1997) found evidence that higher skilled workers exhibit greater propensities to migrate and thus quickly move to take advantage of local labor demand policies. Where does this leave lower skilled laborers? Certainly persistent poverty areas are testimonies to the inability or perhaps unwillingness of low income or low skilled laborers to relocate to take advantage of better prospects. How do these mobility issues impact high and low skilled workers, and, in the end disparate households? If such policies are implemented, do the local laborers actually receive the benefits or do the benefits primarily accrue to migrants or even commuters?

Existing regional economic models inadequately address the effectiveness of development policies. They tend to focus on aggregate growth benefits but fail to address the specific income benefactors. Input-output models are inadequate due to general elastic labor supply assumptions. The elastic assumptions derive from perfect labor mobility assumptions. While this may be largely true in the U.S., input-output models shed no light on the magnitude of the benefits that accrue to original residents.

Econometric models lack detailed industry composition and linkages. Insufficient time-series data exist to econometrically reveal all the channels of influence between regional and extra-regional labor markets. Morgan, Mutti and Partridge (1989) argue that econometric models are incapable of completely revealing structural interdependencies that exist in a local economy because of the absence of required time-series data on key features of regional economies. They are also much less able to establish the interdependencies that exist between local economies. Econometric models are better suited for estimating reduced-form relationships, e.g., the percentage reduction in the poverty rate for a percent increase in employment growth. This is of little assistance in the formulation of policies to promote job growth and income maximization for residents.

Regional Computable General Equilibrium (CGE) models are perhaps best suited to address this issue. They offer the flexibility to incorporate economic linkages and econometric behavioral estimates to implement a wide spectrum of assumptions. This flexibility allows the modeler to provide the appropriate level of detail where necessary to address very specific, and often, complex linkages.

To speak to the specific benefits of regional development policies, one must understand the impact of policy changes on local residents, commuters and migrants as well as changes to income distribution between dissimilar income groups. To date, the focus of most regional CGE models has been the broad community impacts of economic development or tax policy changes with little discussion of the issues listed above[1]. These existing regional models typically address household income in the aggregate as returns to aggregate factors of production (Morgan et al. 1989; Morgan et al. 1996; Groenewold et al 2003) or may even distinguish between rural and urban income as in the case of farm subsidy reduction policies (Kilkenny 1993) but fail to address the size distribution effects of policy changes. Kim and Kim (2003) address income distribution using 10 representative households but miss the mark by assuming a fully mobile homogeneous labor supply. This assumption removes the possibility of differing migration responses among heterogeneous labor groups to labor demand shocks. Given the assumption of homogeneous labor, it is difficult to distinguish who benefits from local demand policies - local (low-skilled) residents or new (high-skilled) migrants. Employing both heterogeneous households and skill groups would allow migration

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[1] See Partridge and Rickman (1998) for a survey of the literature.

responses to be accurately incorporated into the model yielding more accurate policy prescriptions[2].

Study Objectives

This study attempts to quantify the affect of local development policies on local residents, commuters and migrants. A Computable General Equilibrium model for Oklahoma (OKCGE) is developed to address these effects. An additional component of the model is the distribution of these effects among nine distinct household types. These results will provide policymakers with more complete information to address specific community issues such as growth and income distribution.

The specific objectives of this study are:

1. To construct a consistent data set for a regional area that includes multiple households with disparate incomes, two labor skills and imports and exports.
2. To develop a general equilibrium model that addresses the broad effects of local development efforts to identify the benefactors of the initiative policies.
3. To discuss policy implications and suggest areas for further research.

Study Organization

The historical background for regional development policies and the underpinning assumptions for the model used in this study are outlined in Chapter 2. The model is derived and its technical features are discussed in Chapter 3. Chapter 4 details the specific data sources and development of the micro-consistent data set. Chapter 5

[2] Persons unable to work because of mental or physical disabilities require specific assistance policies and are not addressed here.

presents the specific results from simulations and Chapter 6 discusses the study conclusions and areas for further research.

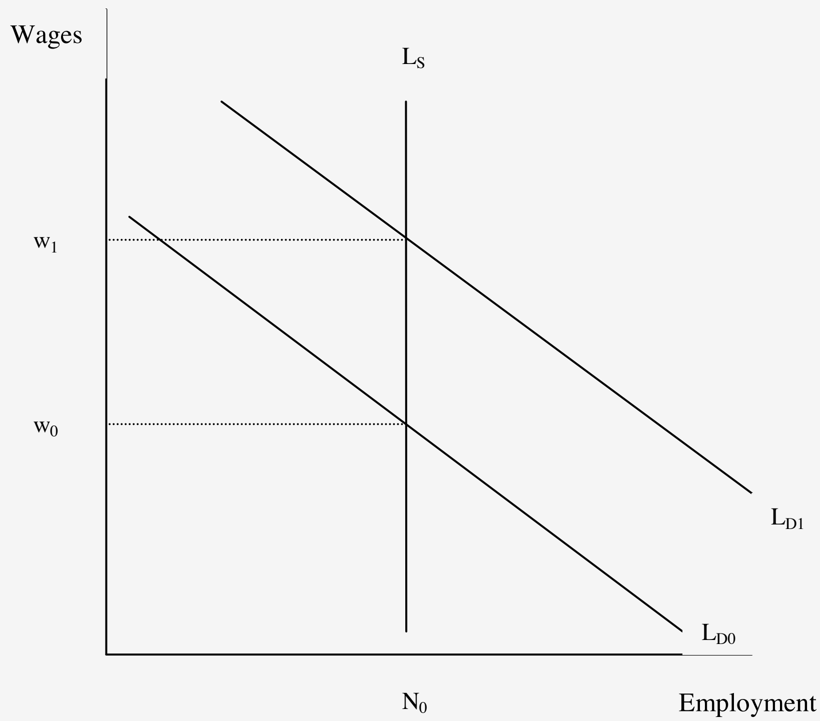
CHAPTER II

THEORETICAL BACKGROUND

Who Benefits from Regional Development?

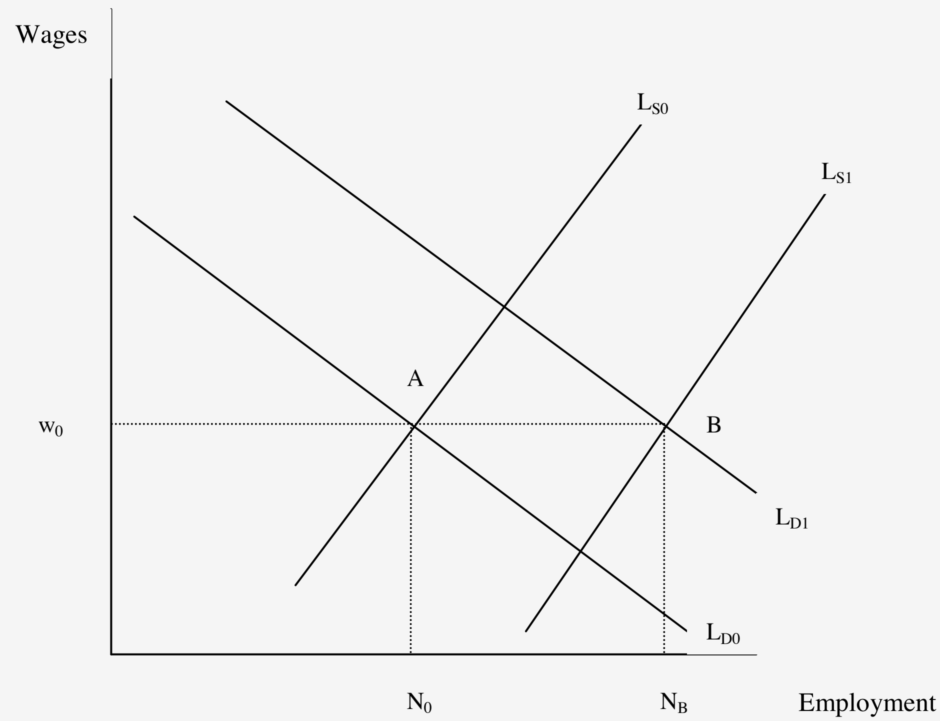
The question of who benefits from local development policies has been on the minds of researchers for some time. The issue is tightly integrated with other labor market questions that have garnered serious study. In 1971, a seminal paper written by Muth discussed whether labor migration caused job growth or job growth caused labor migration. This paper set off a vast series of studies addressing this same topic. Consider a local labor market. There is a supply of labor based on local residents, commuters, and, in the medium to long run, migrants. The demand for labor is derived from local production activities. Suppose there is an increase in labor demand. As the labor demand curve shifts to the right, the effects on wages and employment growth depend on the elasticity of the demand for labor and the elasticity of the labor supply. If the demand curve is relatively elastic and the supply curve is inelastic due to high participation rates and no migration possibilities, the increase in labor demand will lead to higher wages with little or no employment growth (see Figure 2.1). This position is untenable in the U.S. due to the mobility of labor.

Figure 2.1: Labor Market – Inelastic Supply



A second possibility in this argument is that a labor demand increase causes employment growth (and possibly wage increases). Suppose that the labor supply is relatively elastic due to potential migrants. Neo-classical analysis indicates that an increase in labor demand will increase employment through migration. The supply increase should continue until point B on Figure 2.2 is reached leaving wages unchanged and local residents unaffected. This stems from the nearly perfect mobility of the U.S. labor force (Blanchard and Katz, 1992). Indeed, Marston (1985) indicates that 'shocks that disturb the steady-state relationship among the unemployment rates of metropolitan areas tend to be eliminated by mobility within a year'.

Figure 2.2: Labor Market – Elastic Supply



There is another strain of research that indicates local job growth directly benefits local residents (Bartik, 1991, 1993, 2001, Partridge and Rickman, 2003). There are a couple of reasons for this view. First, Cross (1988) and Bartik (1991, 1993) point to possible hysteresis effects – movement from initial trend to a new permanent trend due to some known or unknown shock. Bartik (1993) puts it this way: ‘Hysteresis effects may occur because short-run job experience increases human capital. For example, local growth may cause some local residents to have jobs in the short-run who otherwise would be out of work. These local residents learn skills and increase their self-confidence and reputation among employers. These local residents will be more employable in the long-run.’

Another argument for local resident effects stems from the possibility that labor migration responses are less than perfect, especially in the short-run. Partridge and Rickman (1997) point to dispersions in state unemployment rates as evidence for this argument. Eberts and Stone (1992) find that wage differentials are more persistent over time than unemployment differentials. Surely, wage and unemployment differentials can exist as other utility differentials such as amenities cause increased migration to some areas, but limit migration to others (Roback 1982, Beeson and Eberts 1989, Treyz et al. 1993, Rauch 1993). Indeed, unemployment rate differentials, wage differentials, and participation rate differentials all point to some labor market inflexibility.

Assuming some inflexibility for reasons listed above, labor market adjustment is multifaceted providing opportunity for local nonparticipants, migrants and commuters. Local nonparticipants benefit from local information concerning labor opportunities. Nonparticipants will move to fill excess labor demand if participation rates are low[3]. Where labor force participation rates are high, local residents are likely to receive less direct wage benefit of development policies.

Consider Figure 2.3. Suppose the labor demand curve shifts to the right as in L_{D1}. Seeing new employment opportunities, local nonparticipants respond by increasing their supply of labor to L_{S1}. Eberts and Stone (1992)[4] state that employers adjust employment rather than wages in response to disturbances and that wage differentials exist longer than unemployment differentials between regions. At the current wage w_0 and employment

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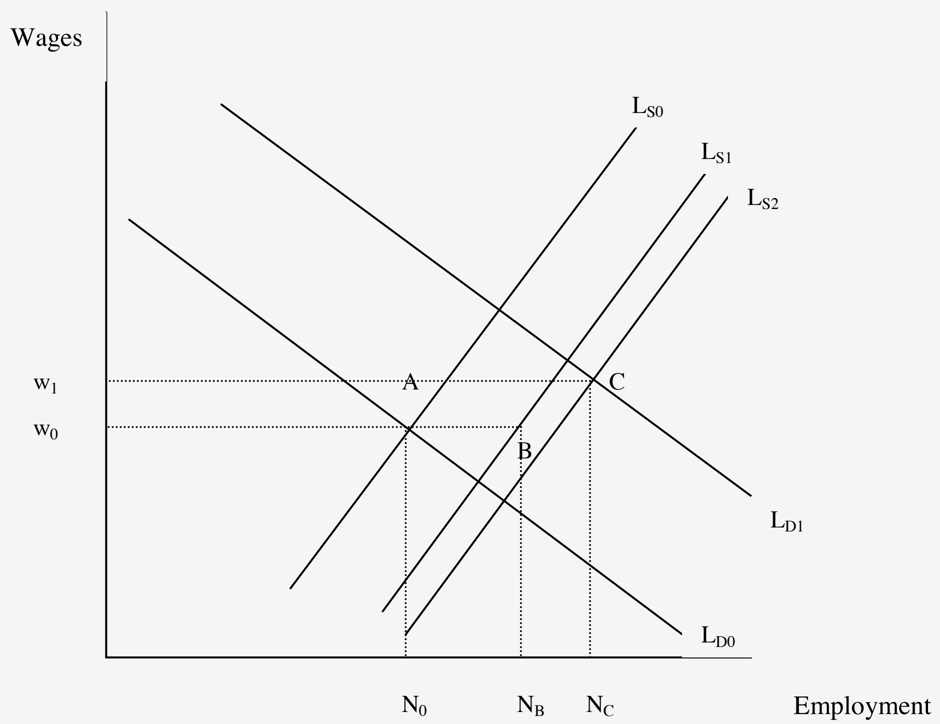
[3] When participation rates are high, it is less likely that nonparticipants are actually discouraged unemployed workers and more likely that their labor supply choice is one made from a preference to pursue leisure or home based activity.
[4] See page 128.

N_B there still exists an excess demand for labor. In a full employment economy, excess labor demand alone isn't enough to entice migration to underserved areas (Partridge and Rickman, 1997). Likewise, potential commuters won't pursue opportunities that increase commute cost while providing no increase in their nominal wage. Indeed, choosing to pursue this commuting opportunity would yield a net wage loss indicating irrational behavior ceteris paribus.

When nonparticipants don't alleviate the entire excess labor demand, the excess demand leads firms to slowly increase wages (w_1) to attract additional workers. The increase in wages causes increased commuting as nominal wages less commuting costs outpace nearby nominal wages. Migrants respond when real wages increase relative to U.S. real wages. Wage, migration, participation, and commuting responses continue until final equilibrium is reached at C with wage w_1 and employment N_c.

Figure 2.3: Labor Market – Elastic Supply with Increased Participation



What Figures 2.2 and 2.3 point out is that employment increases when labor demand shocks occur. When labor is fully mobile and responsive to excess demand, wages are unaffected as migration quickly responds to mitigate all excess demand as in Figure 2.2. When migrants are unresponsive to excess demand either because of full employment conditions nationally or for low amenity areas, increases in local labor force participation rates and commuting can increase the welfare of local and nearby residents. However, incomplete local and commuter responses may fail to alleviate the entire excess demand causing wage increases and thus long-term migration. The result is higher employment and wages as in Figure 2.3.

The Timing of Benefits

Identifying the timing of potential benefits to local residents is a difficult task subjective to a variety of local factors such as labor force participation rates, labor mobility and the proximity of potential commuters, local amenities and industry and labor skill mix. However, understanding the timing of the results would lead to benefits to both researchers and policymakers. First, the timing of the responses from each potential labor force participant cohort determines the magnitude of benefits that accrue to each. Knowing the magnitude of yearly responses by local nonparticipants sheds light on the adjustment of wages and thus the response of commuters and migrants. Second, policymakers might be more likely to participate in development policies if they know when the benefits could be expected. The nature of election cycles might affect the willingness of politicians to implement short versus long run policies.

Most studies concerning development policy benefits are undertaken using econometric methods and discuss only the long-run results. Bartik (1993) points out that most regress the change in employment rates, labor force participation rates or net migration rates on job growth over some period of time (Muth 1971, Bradbury et al. 1982, Plaut 1982, Greenwood and Hunt 1984, Gordon 1985, Greenwood et al. 1986, Summers 1986, Bound and Holzer 1991, and Eberts and Stone 1992). He states that the problem with these models is that they don't examine both the long and short run effects of job growth. He claims that only Bartik (1991, 1992), Gruidl and Pulver (1991), and Blanchard and Katz (1992) examine both the short and long run effects of job growth. Even still, they don't report the specific timing of the benefits.

While demonstrating that Input-Output (IO) models effectively replicate the long run results given by Computable General Equilibrium (CGE) models, McGregor, Swales and Yin (1996) estimate that the effects of job growth on the local economy are 95% complete by period 12. However, they don't differentiate the beneficiaries of those effects. They use a generic labor supply elasticity to represent labor responses to demand shifts. Additionally, there appears to be no correlation between their term "period" and an actual passage of time. This fails to provide the timeframe expectation policymakers require.

Providing an accurate account of the timing of specific responses is difficult because correct period-by-period econometric estimates are unavailable. In the opinion of this author, any attempt to model the timing of these responses using, for example, a dynamic CGE model is likely to lead to faulty assumptions and thus policies. For this reason a static CGE model is used to estimate the long run impacts only.

Income Distribution Effects

Another feature of the OKCGE is the determination of income distribution effects. The model includes nine household income groups and two labor skill sets. Treyz et al. (1993) found that employment possibility has a greater impact on migration than wages. Other studies (Flaim and Sehgal 1985, Topel 1986) point out a divergence in migration propensities between low and high skilled labor. Migration can be more costly (relative to income) to low income households than to higher income households. Certainly this divergence creates a discrepancy in outcomes for varying household groups. One would expect a policy targeted to low-income households to have a greater impact on local workers then one targeting high-income households.

Topel (1986) found that wages have the greatest variance among groups with the least mobility. This would lead one to conclude that in low participation/high poverty areas, changes in employment possibilities are likely to impact local low skilled employment more than regions where low skilled workers are fully participating and employed. Only when local low skilled markets become "tight" requiring increased wages will low skilled workers migrate. Including two skill sets provides the ability to report results on income distribution that would otherwise be omitted.

What is a Region?

To answer the fundamental questions of this paper, we must first decide what constitutes a region. Policymakers are likely concerned about the location of their voters. From this standpoint, one might consider sections of cities, entire cities, rural townships, counties, multi-counties, or even states (Blanchard and Katz, 1992). At some point, however, the size of the region is so large that specific regional policies may not provide relevance to all regional citizens. For instance, development policies implemented in the western half of a state may increase the income of western residents and provide a boost to statewide income measures, but leave eastern residents seeing only minimal to zero local impact.[5]

Perhaps the best way to delineate a region is to ensure the boundaries encompass the local labor market. In cities, a local labor market may be a central city, a central city and surrounding (midtown) areas, a group of suburbs, or perhaps a mix of all of the

[5] It is possible that increases in government revenues from increased tax revenues may lead to additional spending in the eastern part of the state. Those effects are not considered in this paper.

above. Most studies[6] define a city as a Metropolitan Statistical Area (MSA) due to data availabilities. An MSA often includes multiple counties clustered by proximity and labor markets. This study looks at the Oklahoma City MSA which includes the Oklahoma City labor market and therefore defines the region as the area that accounts for that labor market. The region is described in two parts – the central region which encompasses Oklahoma County, and the nearby region which includes the remaining counties surrounding Oklahoma County. The Oklahoma Department of Commerce estimates that the surrounding counties provide 25% of the Oklahoma City MSA labor market participants. The nearby region includes the following counties: Canadian, Cleveland, Grady, Lincoln, Logan and McClain.

Why Oklahoma County?

When policymakers define a policy for a specific region, they need to delineate the potential benefactors. In the U.S., many regions cross multiple city, county and sometimes state boundaries. Within each physical boundary there may be many political boundaries as well. Political boundaries provide unique regional decision areas responsive to the whims of local voters. If we assume that elected officials behave rationally, they seek to maximize their utility function, which requires that they win local elections. Assuming that politicians increase utility by winning elections, their fates may lie with their ability to increase the economic viability of their voter region of influence. As Haughwout and Inman (2002) point out, the nearby regional jurisdictions may have development goals that are joined directly or indirectly with those of the local region.

[6] For a typical example see Eberts and Stone (1992)

Specifically, they describe benefits that accrue to suburban areas from central city development. Quigley (2002) discusses cooperation among rural jurisdictions. Some of the more obvious benefits include centralized amenities such as entertainment, transportation networks (air, rail, access to interstates, etc.), social organizations, and other civic and private enterprises. Many of these amenities serve to make the central city more productive by attracting a skilled labor force and increasing various agglomeration effects. These agglomeration effects may accrue to a smaller degree to the nearby suburban areas as increased population leads to decentralized demand for civic and business services and amenities. Additionally, increased population leads to a larger tax base and economic growth. Much of the growth can be attributed directly to increased income from workers who reside within the suburb and commute to the central city. In this case the growth of the central city can directly impact suburban income.

In a metropolitan area, commuters play a significant role in the labor market. The availability of a large commuter pool provides policymakers opportunities to participate in broader regional initiatives due to a larger pool of potential beneficiaries. However, suburban policymakers may be reluctant to cooperate with metropolitan initiatives for two reasons. First, they are likely to benefit from the passage of metropolitan growth initiatives whether they provide support for the initiatives or not (the classic free-rider problem). There is little incentive for them to provide financial support if they perceive the central city will fund the initiative alone. Second, suburban policymakers have difficulty quantifying the benefits. Politicians are unlikely to provide funding without adequate quantification. This study will provide an estimate of the direct income benefit that accrues to nearby regions due to increased commuting to the central metropolitan area.

The state of Oklahoma has five Metropolitan Statistical Areas[7]. With the exception of Oklahoma City and Tulsa, Oklahoma MSAs are relatively small and have largely rural commuter pools. The Oklahoma City MSA has the largest labor force (571,166 participants[8]) and is the most central, pulling commuters from most of the counties throughout the state. As outlined in Chapter 4, Oklahoma County has a significant number of workers already commuting from the surrounding counties, indicating that regional cooperation is a potentially attractive option likely to yield growth benefits to all of central Oklahoma. Oklahoma County provides a unique opportunity to study the important questions addressed in the study.

The majority of U.S. production, consumption and labor force data are organized at the county level. The Minnesota IMPLAN Group consolidates county level data from a variety of government and private sources to obtain a balanced database also organized at the county level directly reflecting the organization choices of the input data sources. These organization issues require that the model be built around Oklahoma County rather than the Oklahoma City MSA.

CGE Analysis

Regional economists have many modeling tools at their disposal to address a variety of local and state questions. Some of the more popular include input-output

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[7] Oklahoma MSAs include: Enid MSA, Fort Smith MSA, Lawton MSA, Oklahoma City MSA and Tulsa MSA. Source: OMB Bulletin 08-01, Office of Management and Budget, November 20, 2007.
[8] Oklahoma Employment Security Commission: Oklahoma Labor Force Data 2007

analysis, export base analysis, econometric analysis and forecasting, and CGE modeling. Input-output (IO) analysis is frequently used in impact studies to estimate long run output and employment effects deriving from some policy stimulus or business endeavor. IO analysis is appropriate when the general structure of the economy is assumed to remain constant and slack resources exist in the short run or capital and labor are perfectly mobile in the long run (McGregor, Swales and Yin, 1996). Examples of IO use include impact studies of sports teams, constructions projects, universities, and development organizations on local or state economies.

Economists often use IMPLAN, RIMS or other IO tables to calculate direct, indirect and induced effects that derive from a specific project. IO tables employ fixed proportion production and consumption coefficients to provide an estimate of the direct changes to production and consumption resulting from the policy change. Keynesian multipliers are calculated and used to estimate indirect growth due to the additional expenditure resulting from increased household and firm income. The technology does not allow substitution of inputs or changes in prices making it unsuitable for studying policy effects when resources are constrained. In the absence of slack resources, Keynesian multipliers tend to overstate aggregate effects as the availability of inputs limits production. Neo-Classical theory would require price adjustments resulting from input shortages leading to input substitution and more modest growth. IO analysis lacks this flexibility and is unsuitable for this effort.

As stated earlier in this chapter, most studies of migration and local labor markets tend to be econometrically based and long run focused. Econometric models yield important results but lack flexibility when modeling specific features. In some circumstances they are excellent for estimating elasticities or aggregate results but lack the theoretical underpinnings necessary to model specific economic linkages required for model flexibility and detailed reporting. This inability renders an econometric implementation inappropriate.

There is a long tradition of using CGE models to address a variety of policy questions. Their mathematical flexibility provides the pallet necessary to model a wide swath of behavior not available using other techniques such as input-output or econometric analysis. Indeed, CGE models can and often do incorporate the economic linkages of IO models while allowing empirically tractable substitution and feedback effects inherent in econometric models. They are quite popular for tax policy analysis (Ballard et al. 1985, Shoven and Whalley 1992, Iregui 2001), development policy analysis (Dervis et al. 1982, Lofgren et al. 2002), poverty reduction analysis (Adelman and Robinson 1979, Filho and Horridge 2004), and statewide policy analysis (Berck, Golan, and Smith 1997).

CGE models are tailored to meet the needs of the analyst. For instance, tax policies may be concerned with revenue generation and economic loss due to changing tax scenarios, but less interested in development or income distribution effects. Poverty reduction policies may be less interested in tax revenue or overall economy effects and more interested in size distribution effects. As such, the specific interest of the modeler dictates the model details. CGE models allow each analyst to tailor the economic details to address each question specifically without concern for tertiary policies or results.

The OKCGE is designed to provide understanding about the regional effects of local development policy on the implementing and surrounding (and perhaps cooperating) regions. Specifically, the questions addressed by the OKCGE are:

1. What benefits accrue to local residents from development?

2. How much income accrues to surrounding counties?

3. What impact do development policies have on the distribution of local income?

These specific questions are addressed using a CGE model that incorporates regional income and expenditure linkages and a detailed local labor market that specifically models local, commuter and migrant worker behavior.

CHAPTER III

REGIONAL CGE MODEL SPECIFICATION

To assess the regional benefits of development policies, a multi-nested CGE model must be used to assess the intricacies of firm and household decisions. Firms are the primary producers of goods and services and households derive utility from consuming goods and services and spending time in leisure activities. In addition to local households and firms, economic agents who exist outside the study region actively participate in the regional model. Extra-regional firms provide goods and services that are imported by local households for consumption and local firms for use in the production process as intermediate goods. Extra-regional households participate in the domestic region as migrants and commuters who make location and commuting decisions based on regional real wages and amenities. Other facets of any CGE model that must be addressed include saving and investment and federal and local government decisions. Each is developed in detail later in this chapter.

The model uses a consistent syntax for greater readability. Variables begin with capital Latin letters. All subscripts are excluded except where uniquely required for ease of reading. Price variables begin with a capital “P” and contain a descriptive language consistent with the related quantity variables. Lower case Greek letters/words are used to denote empirical and calibrated parameters. Most parameters include additional English descriptors to enhance readability. Benchmark values of all variables are denoted with lower case Latin letters and end in the number zero. Model equations, parameter and variable definitions are given in Appendix A.

The OKCGE is a traditional static CGE model that reports long run results derived from dynamic flows of capital and labor into the region. It incorporates the usual flows of goods, income, and inputs. Figure 3.1 represents the regional flows represented in the model.

Firms produce commodities using value added factors and intermediate inputs. Firms supply commodities to, and purchase intermediate inputs from extra-regional and local sources. Local demand for commodities comes from firms (intermediate inputs), households, and local and federal governments. Local firms also fulfill a portion of investment demand.

Households purchase goods for consumption using income from factors supplied and other exogenous income sources.[9] Local households and commuters own the initial labor endowment of both skilled and unskilled labor. Labor demand shocks can be met by increased labor force participation rates, migration or increased commuting.

The specific model equations are detailed within this chapter. A comprehensive equation flow diagram is included below as Figure 3.2 for quick reference.

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[9] See Chapter 4 for a complete specification of exogenous sources

Figure 3.1 – Regional Economic Flows

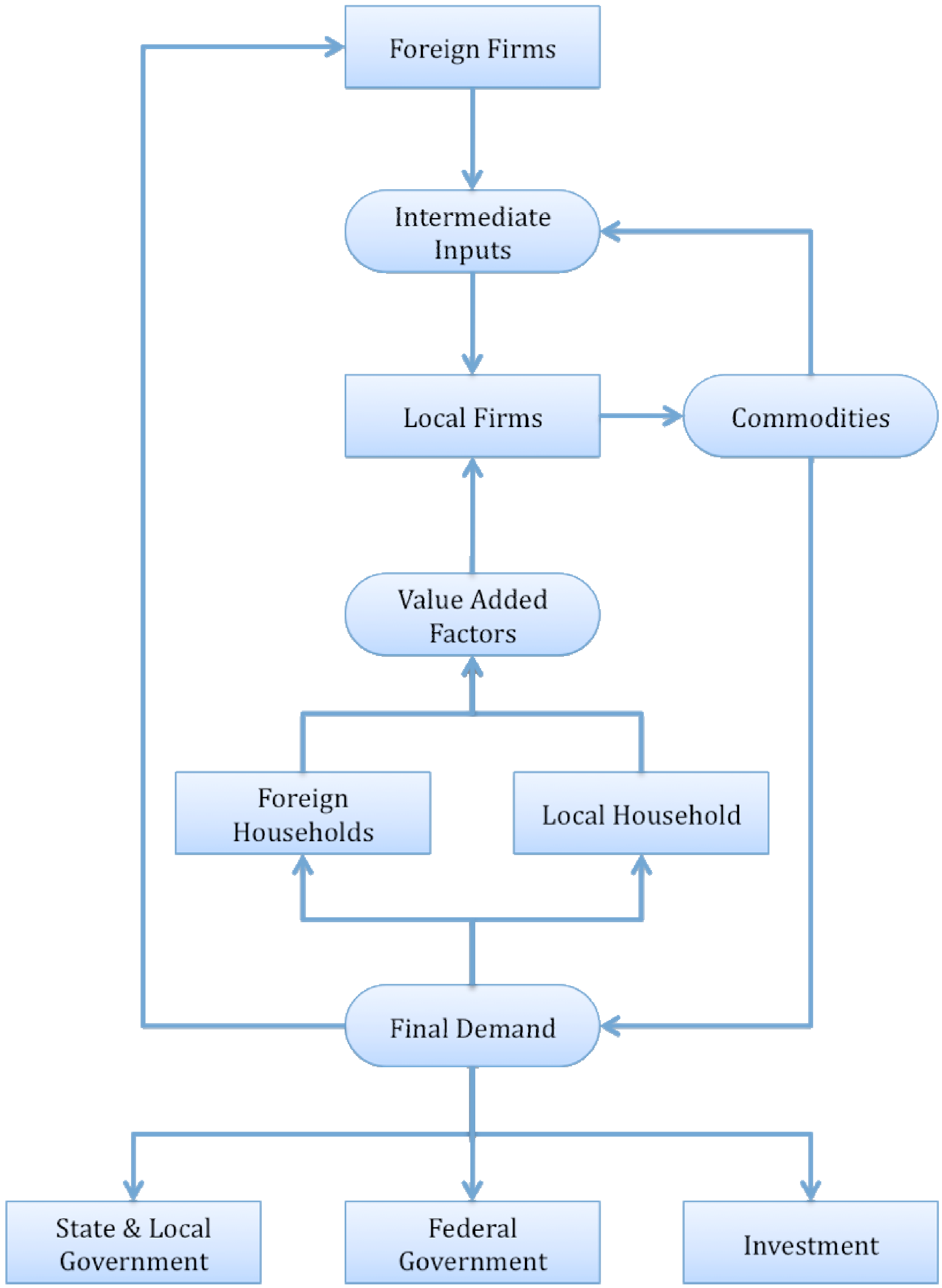
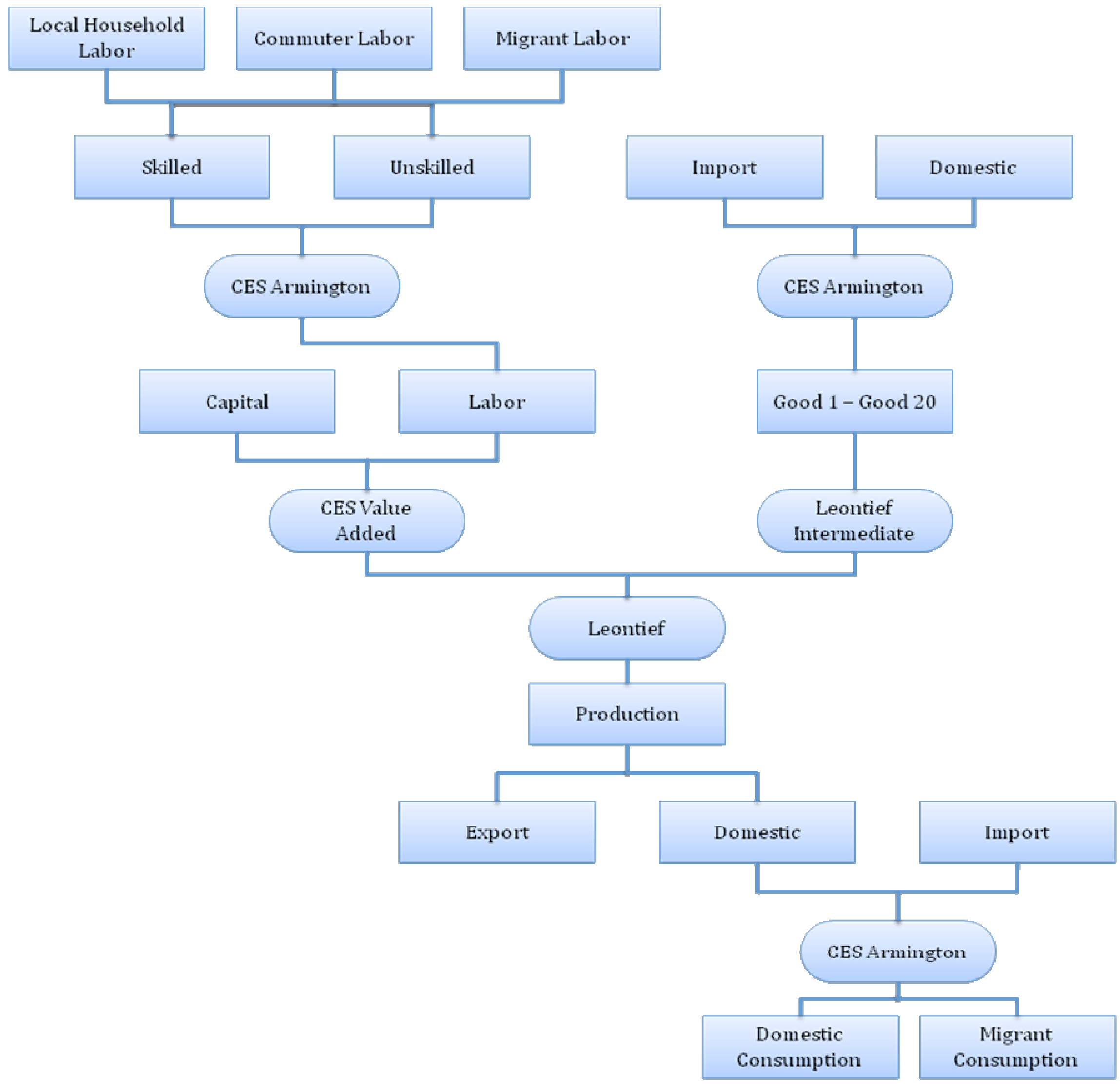


Figure 3.2 – Equation Flow Diagram



Production

The production technology is multi-tiered to represent the complexity of assumptions for the regional economy. At the top of the production 'nest,' is sectoral production. A Leontief production function is used for complementary input of intermediate goods and value added factors. Production sectors determine the quantity of value added and intermediate goods inputs based on benchmark shares and sectoral output.

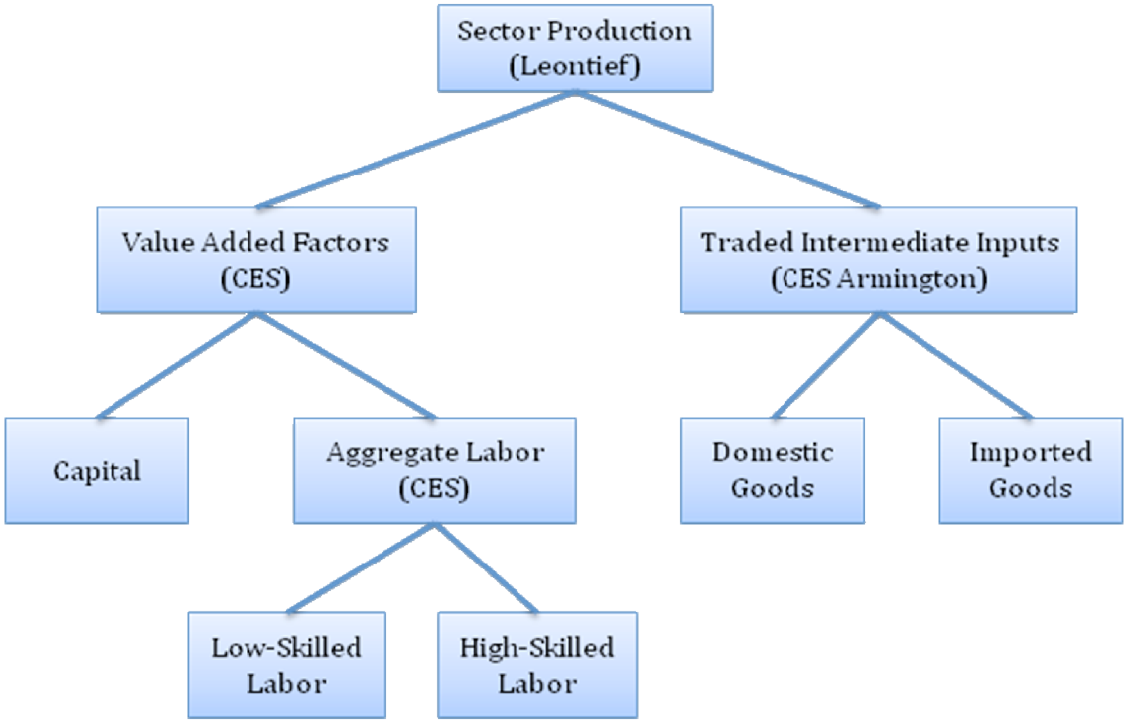
Below the top level Leontief function, the model aggregates capital and aggregate labor into a Value Added Constant Elasticity of Substitution (CES) function. Capital is nonspecific while labor is the aggregate of two labor skill types, high and low skilled labor (see Chapter 4 for detailed specification). These skill types are aggregated at a lower level of the production nest via another CES function. The Value Added CES function incorporates aggregated labor from the lower level nest and capital. The Value Added CES function allows for smooth substitution between aggregate labor and capital based on an empirical elasticity of substitution.

Locally produced or imported goods may be used as intermediate inputs. An Armington (1969) CES function is used to determine the quantity of imported intermediate input goods. This function allows for imperfect substitution of local and imported goods based on price and perceived quality differences.

Local production is consumed locally or exported. Typical international CGE models incorporate a Constant Elasticity of Transformation (CET) function to transition production from local to export goods as exported goods typically have different quality requirements based on export region. However, as Berck et al. point out (1997), in a U.S.

regional model, most exports are shipped within the U.S. Because of largely universal standards within the U.S. most regional exports tend to have little variance with regard to quality. Therefore a CET function is not necessary. The entire production nest is graphically represented in Figure 3.3.

Figure 3.3: Production Nest



The model includes 20 firms representing 19 aggregated production sectors and one aggregated government. Each firm maximizes a fixed-coefficient (Leontief) production function. For every dollar of production, the firm chooses a fixed fraction of value added factors of production and intermediate input goods as inputs into the production process. The firms' production function is given by:

(3.1) TotalOutput = min(ValueAdded/VACoefficient, Intermediate/INTCoefficient)

Here, TotalOutput represents total production for a given sector i. All sectors incorporate the same production function. ValueAdded represents aggregate value added factors to meet sectoral demand and Intermediate represents aggregate intermediate inputs required by the sector. VACoefficient and INTCoefficient represent the Leontief shares of each input.

Value Added

At the second level of the nested production function, two value added factors of production, capital and aggregate labor, are combined via a Constant Elasticity of Substitution (CES) aggregator function.

$$\textbf{(3.2)}\ TotalOutput = \alpha F(\gamma F \cdot CapitalDemand^{-\rho F} + (1 - \gamma F) \cdot LaborDemand^{-\rho F})^{-1/\rho F}$$

Where αF is a CES shift parameter, γF is a CES share parameter and ρF is a transformation of the CES elasticity of substitution σF such that:

$$\textbf{(3.3)}\ \sigma F = 1 / (1 + \rho F)$$

For each level of output the firm faces value added costs equal to the dollar value of capital and aggregate labor inputs. The dual problem faced by the firm is the minimization of these costs subject to the CES aggregator function given in (3.2). This is represented by the LaGrangian function:

$$\textbf{(3.4)}\ \mathcal{L}(CapitalDemand, LaborDemand, \lambda) = PLabor \cdot LaborDemand + PCapital \cdot CapitalDemand + \lambda \cdot (TotalOutput - \alpha F(\gamma F \cdot CapitalDemand^{-\rho F} + (1 - \gamma F) \cdot LaborDemand^{-\rho F})^{-1/\rho F})$$

By differentiating (3.4) with respect to the value added factors and the LaGrange multiplier λ, the individual factor demands are determined. Capital demand is given by:

$$\textbf{(3.5)}\ CapitalDemand = \gamma F^{\sigma F} \cdot PCapital^{-\sigma F} \cdot (\gamma F^{\sigma F} \cdot PCapital^{(1-\sigma F)} + (1 - \gamma F) \cdot PLabor^{(1-\sigma F)})^{\sigma F/(1-\sigma F)} \cdot (TotalOuput / \alpha F)$$

Aggregate labor demand is given by:

$$(3.6)\ LaborDemand = (1 - \gamma F)^{\sigma F} \cdot PLabor^{-\sigma F} \cdot (\gamma F^{\sigma F} \cdot PCapital^{(1-\sigma F)} + (1 - \gamma F) \cdot PLabor^{(1-\sigma F)})^{\sigma F/(1-\sigma F)} \cdot (TotalOuput/\alpha F)$$

Aggregate labor price is given by the labor demand zero profit equation (3.7). Each firm's aggregate labor price is determined by the quantity and price of high and low skilled labor employed. Aggregate labor demand is the sum of low and high skilled labor demanded.

$$(3.7)\ PLabor \cdot LaborDemand = PLaborH \cdot LaborHDemand + PLaborL \cdot LaborLDemand$$

The model further segregates labor into two skill types – high and low skilled. Demand for each skill type is derived similarly to capital and aggregate labor above with the dual problem of minimizing labor expenditure subject to the CES aggregator function for high and low skilled labor. Producer cost minimization requires that demand for each labor skill type be given by (3.8) and (3.9) respectively:

$$(3.8)\ LaborHDemand = \gamma L^{\sigma L} \cdot PLaborH^{-\sigma L} \cdot (\gamma L^{\sigma L} \cdot PLaborH^{(1-\sigma L)} + (1 - \gamma L) \cdot PLaborL^{(1-\sigma L)})^{\sigma L/(1-\sigma L)} \cdot (LaborDemand/\alpha L)$$

$$(3.9)\ LaborLDemand = (1 - \gamma L)^{\sigma L} \cdot PLaborL^{-\sigma L} \cdot (\gamma L^{\sigma L} \cdot PLaborH^{(1-\sigma L)} + (1 - \gamma L) \cdot PLaborL^{(1-\sigma L)})^{\sigma L/(1-\sigma L)} \cdot (LaborDemand/\alpha L)$$

Where *LaborHDemand* represents high skilled labor demand, *LaborLDemand* is low skilled labor demand, *PLaborH* is the price of high skilled labor and, *PLaborL* is the price of low skilled labor. The Greek parameters are labor aggregator versions of the parameters given in the value added equation (3.2).

Intermediate Goods Demand

Intermediate goods are purchased from local and imported sources. Imports are considered imperfect substitutes for local goods for producers, consumers, and investors. As such, producers, consumers, and investors choose between imported and locally produced goods using a common Armington (1969) function. The Armington function is specified later in this chapter.

Given import and local goods choices as determined by the Armington function, firms choose composite intermediate goods for input into the production process based on an input-output fixed coefficient matrix:

$$(3.10)\ InputOutput_{ij} = Intermediate_{ij} / TotalOutput_{i}$$

Here, $InputOutput_{ij}$ represents the dollar input of intermediate good j for every dollar output of good i. InputOutput is determined by benchmark values and serves as an exogenous parameter in the model.

Exports and Zero Profits

Each firm has the choice of selling its commodities on local or extra-regional markets. As stated above, international firms typically produce different goods for local and foreign use for a variety of reasons such as differing quality or environmental standards or perhaps just different preferences. Because regional exports are produced largely for consumption within the U.S., standards and preferences are chiefly the same and thus local firms typically don't differentiate between export and local production. Therefore, production (TotalOutput) is used for both local and extra-regional consumption without the need for a separate Constant Elasticity of Transformation (CET) function. Export demand is determined by changes to relative prices and export demand elasticity. The export demand equation is:

$$(3.11)\ ExportDemand = exportdemand0 \cdot (PWorld\ /\ POutput)^{\sigma exp}$$

Where ExportDemand represents export demand, exportdemand0 represents the benchmark value of exports, PWorld is the exogenous world price of the particular good, POutput is the endogenous price of the particular good and σexp is the elasticity of export demand.

Finally, as is typical in CGE models, constant returns to scale for firms is assumed and thus each earns zero economic profits. The firm's zero profit function is:

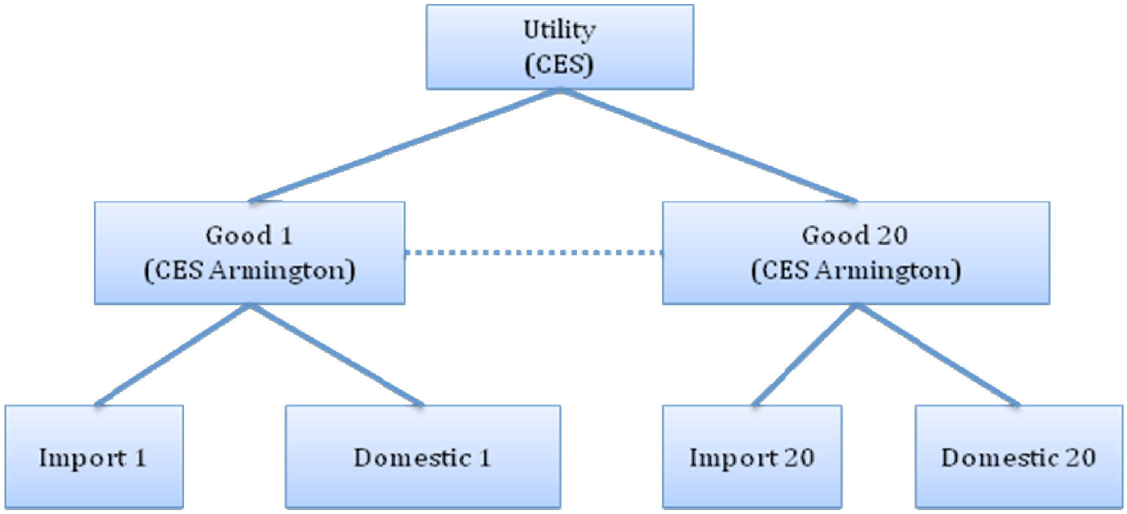
$$(3.12)\ POutput \cdot TotalOutput = PCapital \cdot CapitalDemand + PLaborH \cdot LaborHDemand + PLaborL \cdot LaborLDemand + \Sigma_j\, InputOuput_{ji} \cdot TotalOuput \cdot PComposite + misccost0$$

Households maximize utility through the consumption of goods, services and leisure. The household nest is three-tiered. At the top of the household nest, households maximize utility by choosing between consumption goods using a CES utility function. The total of all income net of taxes, transfers, and savings is spent on composite goods as aggregated by the Armington aggregator function. Household savings shares are calculated as fixed proportions of disposable income from base year data. The local household nest is given in Figure 3.4.

There are nine household classifications based on household income as given by IMPLAN. Each household maximizes utility based on total consumption of goods. Each chooses the optimal goods/leisure bundle subject to their budget and time constraints.[10] Each household is made up of workers of one (in one case two) skill type based on income. The breakdown of labor by skill type is covered in Chapter 4.

[10] For elasticity estimates see Berck, Golan and Smith (1997)

Figure 3.4: Local Household Nest



Household consumption expenditure is equal to total household income less taxes, transfers, and saving. Total household income is:

(3.13) HHDIncome = PCapital · HHDCapitalSupply + PLaborH · HHDLaborHSupply

+ PLaborL · HHDLaborLSupply

Where *HHDIncome* is total household income, *HHDCapitalSupply* is capital owned by the household, *HHDLaborHSupply* is high skilled labor supplied by the household and *HHDLaborLSupply* is low skilled labor supplied by the household. Consumption expenditure is given by disposable income net of taxes, transfers and saving:

(3.14) CBUD = (1 – mps) · HHDIncome

Where *CBUD* is disposable income and *mps* represents the fixed share of income that goes to taxes, transfers and savings.

Households spend their entire consumption budget on the 20 goods and services. The expenditure mix is determined by a CES utility function as defined in Shoven and Whalley (1992):

$$\textbf{(3.15) } HHDConsumption_i = \alpha cons_i^{\sigma cons} \cdot CBUD$$

$$/PComposite_i^{\sigma cons} \cdot \Sigma_j \alpha cons_j \cdot PComposite_j^{(1-\sigma cons)}$$

Where $\alpha cons$ is a consumption share parameter and $\sigma cons$ is an elasticity of substitution parameter.

Government

IMPLAN gives federal and state and local government expenditure data. The federal data is used to set the exogenous level of federal government expenditure that is used to clear the goods market. The federal expenditures are fixed, as they are not dependent upon regional changes. Benchmark state and local government expenditures are used to set initial expenditure levels. Changes in government expenditure depend directly upon changes in regional income as the state has a balanced budget requirement. Government participation is relegated to local consumption of final demand composite goods. Federal expenditure is given by:

$$\textbf{(3.16) } FederalGovtDemand = fedgovtdemand0$$

State and local expenditures are given by:

$$\textbf{(3.17) } StateLocalGovtDemand = statelocalgovtdemand0 \cdot (TotalOutput \,/\, totaloutput0)$$

Saving and Investment

Within the U.S., capital is assumed to be perfectly mobile. This assumption implies that local saving and local investment are unrelated. Capital moves freely from region to region to equilibrate investment returns. Thus, local saving is unimportant with regard to model results and is therefore not specifically modeled. Investment is determined by capital requirements relative to initial investment levels and capital requirements.

$$\textbf{(3.18)}\ Investment = investment0 \cdot (CapitalDemand / capitaldemand0)$$

Likewise, investment demand for local goods is proportional to total investment:

$$\textbf{(3.19)}\ InvestmentDemandLocal = investmentdemandlocal0 \cdot (Investment / investment0)$$

Armington Function

There is one primary Armington function that aggregates local and imported goods into composite goods. These composite goods become the supply of local goods used for intermediate inputs, household consumption, government demand, and investment demand. According to the Armington assumption, there is an "aggregator" firm that minimizes its total cost:

$$\textbf{(3.20)}\ PWorld \cdot ImportDemand + PLocal \cdot LocalDemandForLocal$$

Subject to the constant elasticity of substitution production function:

$$\textbf{(3.21)}\ CompositeGood = \alpha A \cdot (\gamma A \cdot ImportDemand^{-\rho A} + (1 - \gamma A) \cdot LocalDemandForLocal^{-\rho A})^{-1/\rho A}$$

Minimizing (3.20) subject to (3.21) leads to the following supply equations for imported and local goods:

$$\textbf{(3.22)}\ ImportDemand = \gamma A^{\sigma A} \cdot PWorld^{-\sigma A} \cdot (\gamma A^{\sigma A} \cdot PWorld^{(1 - \sigma A)} + (1 - \gamma A)^{\sigma A} \cdot PLocal^{(1 - \sigma A)})^{\sigma A / (1 - \sigma A)} \cdot (CompositeGood / \alpha A)$$

$$(3.23)\ LocalDemandForLocal = (1 - \gamma A)^{\sigma A} \cdot PLocal^{-\sigma A} \cdot (\gamma A^{\sigma A} \cdot PWorld^{(1 - \sigma A)} + (1 - \gamma A)^{\sigma A} \cdot PLocal^{(1 - \sigma A)})^{\sigma A / (1 - \sigma A)} \cdot (CompositeGood / \alpha A)$$

The following zero profit function completes the Armington aggregation:

$$(3.24)\ PComposite \cdot CompositeGood = PWorld \cdot ImportDemand + PLocal \cdot LocalDemandForLocal$$

Market Equilibria

There are three factor markets and one commodity market for each commodity in the model. In general, equilibrium is attained by price adjustment. In the case of the goods markets, the composite commodity prices adjust to clear the markets. In the capital market, the capital supply is perfectly elastic due to the perfect mobility of capital outlined in the investment section. Therefore, the supply of capital is equal to the sum of capital demanded by all firms and the price of capital is fixed at one.

$$(3.25)\ CapitalDemand = CapitalSupply$$

$$(3.26)\ PCapital = 1$$

Each labor market clears similarly:

$$(3.27)\ LaborHDemand = LaborHSupply$$

$$(3.28)\ LaborLDemand = LaborLSupply$$

Goods market clearance requires that demand for composite goods equal the supply of composite goods as given by the Armington equations above and that demand for locally only produced goods equals the supply. The Armington composite good clearance condition is given in equation (3.29) and the total local production clearance is given in equation (3.30).

$$\textbf{\textit{(3.29) CompositeGood}} = \Sigma_j \,(\textit{InputOutput}_{ij} \cdot \textit{TotalOutput}) + \textit{StateLocalGovtDemand} + \textit{HHDConsumption} + \textit{InvestmentDemandLocal} + \textit{MigrantLConsumption} + \textit{MigrantHConsumption} + \textit{fedgovtdemand0}$$

$$\textit{(3.30) TotalOutput} = \textit{ExportDemand} + \textit{LocalDemandForLocal}$$

Price Deflator

The price deflator is used to estimate regional cost of living. Regional cost of living estimates provide information necessary for calculating real regional wages relative to the rest of the U.S. To calculate the regional cost of living, a standard Consumer Price Index (CPI) is used.

$$\textit{(3.31) CPI} = (\Sigma_i \, \textit{PComposite}_i \cdot \textit{compositegood0}_i) \,/\, (\Sigma_i \, \textit{pcomposite0}_i \cdot \textit{compositegood0}_i)$$

Labor Supplies

Total labor supplied for each skill type is the sum of local and commuter labor. Local labor is supplied by households who reside within the study region. It is dynamic in that participation rates increase as opportunities increase and local households change as migration occurs. Commuter labor belongs to households who reside in the nearby region and is a source of income for that region.

Labor Force Participation

Labor force participation depends on the consumption/leisure decision that individuals weigh. As real wages increase, labor force participation increases relative to initial participation rates and the elasticity of participation. This is true for both labor skills as outlined in equations (3.32) and (3.33).

$$(3.32)\ LocalHLabor = localhlabor0 \cdot ((PLaborH / CPI) / (plaborh0 / cpi0))^{\sigma laborh}$$

$$(3.33)\ LocalLLabor = locallabor0 \cdot ((PLaborL / CPI) / (plaborl0 / cpi0))^{\sigma laborl}$$

Labor Migration

Migrants respond to regional amenity adjusted real wage differentials. Assuming world real wages are constant relative to the study region implies that regional in-migration would occur as regional real wages increase. The amount of migration depends on the wage differential and the labor migration elasticity. The labor migration equations are similar to those in Schreiner (1999):

$$(3.34)\ MigrantLaborHSupply = laborHsupply0 \cdot sigmaLaborH \cdot \log((PLaborH / CPI) / (plaborh0 / cpi0))$$

$$(3.35)\ MigrantLaborLSupply = laborLsupply0 \cdot sigmaLaborL \cdot \log((PLaborL / CPI) / (plaborl0 / cpi0))$$

Commuters

While local participants and migrants respond to real wage changes, commuters are unconcerned about local cost of living conditions as their primary residence and thus the majority of their consumption decisions occur within their “commute from” region. Therefore, commuters are responsive to regional changes in nominal wages only.

$$(3.36)\ CommuterHLabor = commuterhlabor0 \cdot (PLaborH / plaborh0)^{\sigma comlaborh}$$

$$(3.37)\ CommuterLLabor = commuterllabor0 \cdot (PLaborL / plaborl0)^{\sigma comlaborl}$$

The regional labor supply is then the sum of participants, migrants and commuters:

$$(3.38)\ LaborHSupply = HHDLaborHSupply + MigrantLaborHSupply + CommuterHLabor$$

$$(3.39)\ LaborLSupply = HHDLaborLSupply + MigrantLaborLSupply + CommuterLLabor$$

Migrant and Commuter Consumption

The model does not incorporate direct commuter consumption due to difficulty assessing their local consumption patterns and the fact that their primary residence exists outside the local region. Migrants become local consumers once they arrive in the local region. The model incorporates two migrant households to capture the consumption activities of low and high skilled workers. It is assumed that migrant consumption patterns mirror those of the original low and high-income household residents. For simplicity, low skilled migrant consumption behavior mirrors household 4 and high skilled migrant consumption behavior mirrors household 7. The two migrant household consumption equations are:

$$(3.40)\ MigrantHConsumption_i = \alpha cons_i^{\sigma cons} \cdot (MigrantLaborHSupply / HHDLaborHSupply) \cdot CBUD / PComposite_i^{\sigma cons} \cdot \Sigma_j \alpha cons_j \cdot PComposite_j^{(1-\sigma cons)}$$

$$(3.41)\ MigrantLConsumption_i = \alpha cons_i^{\sigma cons} \cdot (MigrantLaborLSupply / HHDLaborLSupply) \cdot CBUD / PComposite_i^{\sigma cons} \cdot \Sigma_j \alpha cons_j \cdot PComposite_j^{(1-\sigma cons)}$$

CHAPTER IV

DATA DEVELOPMENT AND STRUCTURE

This chapter details the data sources used in developing the data and the creation of the micro-consistent data set. It also explains the calibration procedures for all parameters.

Data Sources

The primary source of data is the 2004 micro IMpact Analysis for PLANning (IMPLAN)[11] database for Oklahoma County Oklahoma. IMPLAN was developed by the US Forestry Service and is currently maintained by Minnesota IMPLAN Group, Inc. The IMPLAN data was chosen because it is the most comprehensive source of data and data linkages for countywide regions available.

Other sources were used to augment the IMPLAN data in creating the initial OKCGE database. IMPLAN does not provide sufficient information to complete the model in two specific areas. First, IMPLAN provides no information concerning the breakdown of labor skills on either the producer or supplier (households, commuters, etc.) sides of the market. Second, it provides limited information concerning the number and residence of commuters. To address both of these deficiencies, the author used

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[11] Minnesota IMPLAN Group (MIG), Inc., Stillwater, MN.

external data to impute model values consistent with the actual Oklahoma County economy and that provide data set balance. Labor by skill input use was imputed from national shares derived from dollar payments to labor skills provided by the Bureau of Labor Statistics[12]. Commuter by residence and work location data was derived using IMPLAN household payment shares and actual commuter data provided by the Oklahoma Department of Commerce[13]. The details concerning actual data creation are outlined in the paragraphs that follow.

Micro-Consistent Database

CGE models use two primary methods of data input. The most widely used is the Social Accounting Matrix (SAM). SAMs provide a snapshot of the economy at a given point in time. They track all economic flows and are used to recreate the structural linkages within the economy. A SAM was created from the IMPLAN database for the given region under consideration. In this case, a SAM for Oklahoma County, OK was created using 2004 IMPLAN data.

Many times, models don't need every piece of data that a SAM contains. Depending on the desired economic structure, many of the SAM features such as exports for a closed economy or, say, federal government taxes/services, etc. aren't important for the project under study. In these cases, a micro-consistent data set can be used. The micro-consistent data set is a snapshot of the economic flows necessary to create the

[12] 2003 National NAICS Three Digit Wage Information, Bureau of Labor Statistics.
[13] "2006 Demographic State of the State, A Report to the Governor and Legislature on Commuting Patterns and Daytime Population," Oklahoma Department of Commerce, June 2006.

conditions under study. The OKCGE uses a micro-consistent data set derived by the author from the IMPLAN SAM data[14] and the other sources listed above.

Production Data

Production data for Oklahoma County is calculated by summing total payments to each sector as extracted from IMPLAN industry-by-industry detail. Figure 4.1 illustrates the size of each local sector.

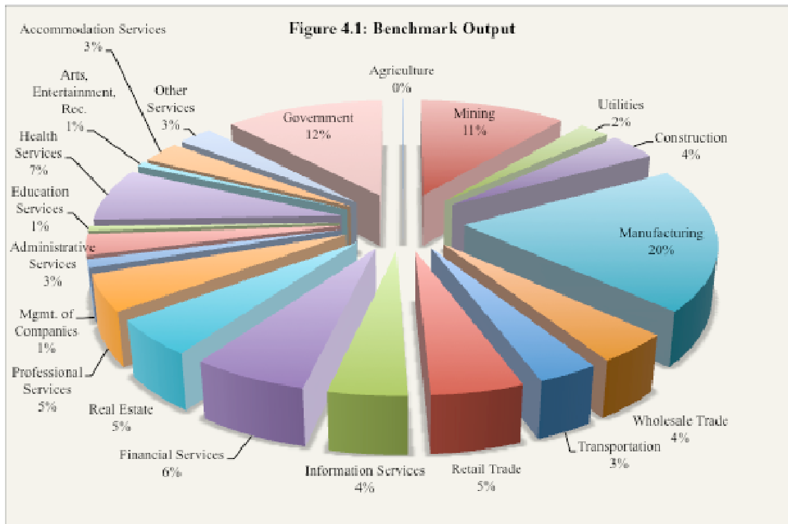

Figure 4.1: Benchmark Output

IMPLAN provides the data in different formats for different uses. These include industry-by-commodity detail as well as industry-by-industry detail. When specific commodity detail is required, the modeler should consider using the industry-by-commodity detail to ensure that all appropriate linkages for commodity production are incorporated. Many firms produce multiple commodities for sale in different markets. For example, Nike produces shoes and golf equipment. Industry-by-commodity detail would provide specific links between the sports equipment manufacturers and golf and shoe retailers.

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[14] For detailed information on the IMPLAN SAM, see "Elements of the Social Accounting Matrix," MIG IMPLAN Technical Report, TR-98002, Minnesota IM

Table 4.1: GAMS Sector Codes

This level of detail would be handy for reporting information about the impacts that a specific firm or firms who produce multiple goods from disparate sectors on a given locale. However, in a study such as the current undertaking, the higher level, dollar input per dollar output linkages are required. For intermediate inputs, only dollar input for dollar output by industry is required. This is readily available in the industry-by-industry detail. The industry data in the OKCGE is aggregated to 20 producing sectors at the 2-digit NAICS level. GAMS sector codes for each industry are listed in Table 4.1.

Sector	Description
AGRI	Agriculture, Fishing, Hunting
MINE	Mining
UTIL	Utilities
CONS	Construction
MFTG	Manufacturing
WHOL	Wholesale Trade
TRAN	Transportation & Warehousing
RETA	Retail Trade
INFO	Information
FINC	Finance & Insurance
REAL	Real Estate & Rental
PROF	Professional, Scientific & Tech Services
MGMT	Management of Companies
ADMI	Administrative & Waste Services
EDUC	Educational Services
HEAL	Health & Social Services
ARTS	Arts, Entertainment & Recreation
ACCO	Accommodation & Food Services
OTHR	Other Services
GNNC	Government Services

Each sector produces goods for local consumption (10001 – 10009)[15], local investment (14001, 14002), local (12001 – 12003) and federal government (11001 – 11003) consumption, export consumption (25001 – 28001) and intermediate input use. Each of these is determined by payments to the producing sector as outlined in the paragraphs that follow.

[15] Codes listed in parentheses indicate IMPLAN reference numbers. For example, Household 1 is represented by the number 10001, household 9 by 10009, etc. For a complete list of IMPLAN codes, see "IMPLAN Pro, User's Guide, Analysis Guide, Data Guide," MIG Inc., February 2004.

Intermediate Demand

Sectors require intermediate goods to create the final products they produce. Intermediate goods come from a variety of sectors and locations. Some goods are produced locally and some are imported. Local intermediates are given in IMPLAN as payments from the producing sector to the intermediate goods sector. For instance, a transportation input into agriculture is listed as a payment from AGRI to TRAN.

Local producers require some inputs that aren't produced locally and thus must import these from outside Oklahoma County. Aggregation of these inputs is listed in the IMPLAN SAM in a format that provides insufficient detail to determine the specific intermediate input requirement of each sectoral input. For instance, total imported intermediate inputs for agriculture (AGRI) show up in the IMPLAN SAM as payments from AGRI to the rest of the world (ROW). However, the model requires specific information on each input industry. To model the economy, one must know how much of TRAN is required by AGRI. This includes both TRAN inputs produced locally and those imported into the region. The industry-by-industry import matrix details the specific industry inputs that are imported and, when added to intermediate inputs produced locally, provide the total intermediate input requirement for each sector. Intermediate input requirements are given in Tables 4.2 and 4.3. The production sector is given by column as the "payee" and the input sector is given by row.

Table 4.2: Intermediate Input Requirements – Local Inputs
(Millions of U.S. Dollars)

Producing Sector (Receipt)	Purchasing Sector (Payment)									
	AGRI	MINE	UTIL	CONS	MFTG	WHOL	TRAN	RETA	INFO	FINC
AGRI	0.666	0.035	0.000	0.243	29.671	0.005	0.001	0.013	0.007	0.001
MINE	0.067	218.184	71.986	7.611	174.351	0.908	3.361	0.837	1.660	0.222
UTIL	0.367	70.033	1.129	6.061	148.635	16.617	7.680	42.195	11.626	10.735
CONS	0.106	0.410	19.708	1.609	20.984	5.628	5.509	12.259	11.760	10.255
MFTG	1.856	181.835	13.069	152.909	1161.511	29.142	65.342	27.624	53.216	9.103
WHOL	1.005	71.875	6.147	59.808	707.258	63.695	39.417	15.241	38.134	4.741
TRAN	0.489	73.974	74.970	30.390	284.991	46.964	156.061	55.848	31.238	38.945
RETA	0.047	13.567	0.924	196.435	36.162	22.014	16.500	45.915	7.879	4.848
INFO	0.090	18.863	3.913	18.088	93.647	29.306	16.214	37.495	294.138	39.071
FINC	0.405	60.312	8.945	24.302	124.168	34.688	33.759	55.486	31.707	704.619
REAL	1.242	212.210	4.647	23.198	104.262	58.866	44.685	148.635	60.314	106.536
PROF	0.489	132.705	25.476	95.026	354.594	96.521	52.102	137.097	173.585	148.996
MGMT	0.016	145.957	0.523	1.974	252.418	45.351	9.645	122.819	11.012	22.139
ADMI	0.037	12.331	4.763	19.359	55.968	59.541	53.707	60.530	43.565	37.892
EDUC		1.464	3.101	0.233	7.927	2.618	0.980	2.097	4.839	1.431
HEAL							0.478	0.009		0.006
ARTS	0.012	39.559	0.272	0.908	9.017	2.685	0.483	2.531	18.532	3.981
ACCO	0.017	4.383	6.531	3.055	53.437	13.324	19.857	18.831	12.792	29.604
OTHR	0.271	7.823	1.737	19.480	133.658	22.316	19.757	21.736	32.470	14.078
GNNC	0.121	25.620	2.528	4.407	78.295	11.074	14.333	16.918	17.508	20.911

Producing Sector (Receipt)	Purchasing Sector (Payment)									
	REAL	PROF	MGMT	ADMI	EDUC	HEAL	ARTS	ACCO	OTHR	GNNC
AGRI	0.365	0.022		1.154	0.002	0.139	0.054	1.887	0.060	0.039
MINE	0.727	1.107	0.172	0.803	0.146	4.350	0.154	3.662	2.033	4.516
UTIL	72.914	14.522	12.061	11.988	2.107	30.503	5.924	34.364	16.680	9.307
CONS	40.797	8.648	7.363	2.799	7.699	15.381	3.279	10.972	11.626	43.912
MFTG	20.174	35.553	6.557	25.377	4.595	134.142	4.940	111.572	62.325	24.440
WHOL	8.819	15.851	2.435	18.281	3.574	61.304	2.571	65.547	27.694	11.927
TRAN	27.347	50.629	1.463	25.425	4.022	59.632	3.944	23.300	20.619	9.412
RETA	37.274	19.842	0.026	47.937	0.682	24.135	2.293	20.215	27.355	29.507
INFO	30.427	77.830	27.846	24.555	7.046	52.930	5.669	21.027	21.902	5.018
FINC	83.758	46.373	2.183	21.296	6.235	73.374	6.719	27.155	17.996	60.311
REAL	202.389	127.654	41.402	37.763	42.422	211.513	19.383	70.831	97.072	33.809
PROF	113.239	230.040	82.918	60.484	10.365	130.832	16.357	44.564	44.436	35.746
MGMT	6.105	9.352		21.589	0.614	33.152	3.453	5.188	9.029	0.097
ADMI	141.330	125.974	0.865	64.650	10.055	135.682	8.813	19.763	38.201	20.200
EDUC	1.150	3.548		0.767	2.226	5.690	0.700	0.339	1.223	0.135
HEAL		0.403		0.228	0.212	42.081	0.168	0.006	0.329	
ARTS	3.801	11.667	0.148	2.972	0.916	3.556	26.858	7.563	3.976	0.152
ACCO	23.495	45.799	0.102	17.111	1.436	64.204	1.589	15.168	7.985	0.654
OTHR	26.319	24.157	12.651	24.083	3.639	27.177	5.466	14.650	17.395	19.389
GNNC	31.507	11.993	4.877	6.430	1.544	16.563	2.343	13.497	8.184	6.234

Table 4.3: Intermediate Input Requirements – Imported Inputs
(Millions of U.S. Dollars)

Producing Sector (Receipt)	Purchasing Sector (Payment)									
	AGRI	MINE	UTIL	CONS	MFTG	WHOL	TRAN	RETA	INFO	FINC
AGRI	8.523	0.273	0.004	3.113	379.915	0.046	0.016	0.162	0.008	0.001
MINE	0.220	852.233	282.236	26.445	658.111	2.940	11.731	2.710	5.374	0.718
UTIL	0.014	3.062	0.144	0.243	6.061	0.656	0.305	1.667	0.459	0.424
CONS	0.003	0.012	0.561	0.046	0.597	0.160	0.157	0.349	0.335	0.292
MFTG	5.984	582.403	41.127	490.492	3743.058	89.787	209.047	82.971	164.109	22.433
WHOL	0.072	5.120	0.438	4.261	50.383	4.537	2.808	1.086	2.717	0.338
TRAN	0.142	21.450	21.739	8.812	82.639	13.618	45.253	16.194	9.058	11.293
RETA	0.003	0.755	0.051	10.937	2.013	1.226	0.919	2.556	0.439	0.270
INFO	0.077	12.028	2.719	15.775	99.734	33.005	18.453	40.456	435.917	41.356
FINC	0.255	37.422	6.097	16.349	83.820	22.810	22.456	35.377	20.717	485.544
REAL	0.380	64.851	1.420	7.089	31.862	17.989	13.656	45.423	18.432	32.557
PROF	0.141	38.118	7.321	27.331	102.193	27.847	15.035	39.521	51.971	42.938
MGMT	0.007	69.332	0.248	0.938	119.903	21.543	4.582	58.341	5.231	10.516
ADMI	0.017	5.836	2.252	8.863	25.717	27.312	24.647	27.755	19.949	17.350
EDUC		0.544	1.152	0.086	2.945	0.973	0.364	0.779	1.798	0.532
HEAL							0.038	0.001		0.000
ARTS	0.003	10.318	0.072	0.241	2.367	0.705	0.128	0.666	4.839	1.045
ACCO	0.003	0.624	0.788	0.378	6.477	1.630	2.410	2.334	1.567	3.611
OTHR	0.047	1.366	0.303	3.391	23.252	3.884	3.437	3.785	5.653	2.455
GNNC	0.015	2.774	0.655	0.580	6.932	1.261	2.155	1.962	1.736	2.591

Producing Sector (Receipt)	Purchasing Sector (Payment)									
	REAL	PROF	MGMT	ADMI	EDUC	HEAL	ARTS	ACCO	OTHR	GNNC
AGRI	4.664	0.229		14.765	0.016	1.764	0.574	24.131	0.747	0.503
MINE	2.438	3.624	0.558	2.601	0.472	14.082	0.498	11.862	6.585	17.185
UTIL	2.880	0.574	0.476	0.474	0.083	1.205	0.234	1.357	0.659	0.373
CONS	1.161	0.246	0.209	0.080	0.219	0.438	0.093	0.312	0.331	1.249
MFTG	59.960	104.270	17.327	79.301	14.386	428.061	15.222	359.053	199.653	77.425
WHOL	0.628	1.129	0.173	1.302	0.255	4.367	0.183	4.669	1.973	0.850
TRAN	7.930	14.681	0.424	7.373	1.166	17.291	1.144	6.756	5.979	2.729
RETA	2.075	1.105	0.001	2.669	0.038	1.344	0.128	1.126	1.523	1.643
INFO	32.576	91.142	32.543	30.352	9.599	65.335	6.685	26.972	28.326	3.137
FINC	53.850	29.497	0.667	13.971	3.451	46.477	4.256	17.352	10.478	41.056
REAL	61.850	39.011	12.652	11.540	12.964	64.638	5.923	21.646	29.665	10.332
PROF	32.639	66.431	23.943	17.499	3.022	37.851	4.725	12.915	12.886	10.267
MGMT	2.900	4.442		10.255	0.292	15.748	1.640	2.464	4.289	0.046
ADMI	64.867	57.781	0.371	29.671	4.615	62.271	4.042	9.061	17.529	9.268
EDUC	0.427	1.318		0.285	0.827	2.114	0.260	0.126	0.454	0.050
HEAL		0.032		0.018	0.017	3.339	0.013	0.001	0.026	
ARTS	0.996	3.052	0.043	0.778	0.239	0.933	7.002	1.974	1.039	0.041
ACCO	2.919	5.569	0.031	2.076	0.192	7.822	0.200	1.857	1.005	0.094
OTHR	4.581	4.211	2.203	4.190	0.633	4.731	0.951	2.549	3.026	3.372
GNNC	2.884	1.689	0.468	0.727	0.315	2.346	0.243	1.211	1.047	0.634

Value Added Demand

Value Added (VA) includes only capital and labor inputs. Capital inputs are derived from the IMPLAN SAM as payments from each sector to Other Property Income (7001). Labor inputs are determined by payments to Employee Compensation (5001) and Proprietor Income (6001). Labor is divided into skilled and unskilled labor based on national labor payments by industry[16]. Total VA requirements are given in Table 4.4.

Table 4.4: Value Added Requirements
(Millions of U.S. Dollars)

	Total Labor	High Skilled Labor	Low Skilled Labor	Capital
AGRI	14.0494	0.4159	13.6335	5.5139
MINE	1517.9547	338.6557	1179.2990	2232.5640
UTIL	277.0536	209.2586	67.7950	423.8078
CONS	921.8353	159.2931	762.5422	155.9931
MFTG	2385.1638	639.9394	1745.2244	910.1260
WHOL	993.9951	369.7662	624.2289	404.8234
TRAN	974.1135	167.8398	806.2737	172.0872
RETA	1297.4367	79.0139	1218.4228	325.5238
INFO	614.5794	420.1879	194.3915	460.6338
FINC	1126.4551	738.3913	388.0638	977.6404
REAL	596.5538	133.3894	463.1644	1124.9280
PROF	1664.8895	1046.3831	618.5064	205.4951
MGMT	333.0403	182.1730	150.8673	114.6357
ADMI	1015.5708	113.4393	902.1315	162.7832
EDUC	179.9020	116.2707	63.6313	29.8541
HEAL	2346.1216	893.8723	1452.2493	345.9371
ARTS	154.0085	14.4614	139.5471	46.2229
ACCO	603.5754	15.7533	587.8221	174.1708
OTHR	700.5389	64.9400	635.5989	143.2437
GNNC	5353.3060	2316.3755	3036.9305	1685.7330

[16] Local industry labor by skill shares were derived from national industry wage payment data. Workers earning less than $35,000/year are considered low skilled. Remaining workers are high skilled. Local wage by skill payments were estimated by multiplying national skill shares by local industry labor bills. National wage payment data source: BLS, 2003 National NAICS 3-digit wage information, www.bls.gov.

Miscellaneous Input

In addition to value added and intermediate inputs, producing sectors make payments to other IMPLAN accounts that aren't individually modeled in the OKCGE. These payments are treated as miscellaneous payments by producers. They are included in order to balance the value of production with production income. They include direct payments to households, State and Local Government, Federal Government, and indirect business taxes. Payments to households (other than factor payments) typically represent household production. Household production is minor relative to industry production, is complex to model, and provides little insight into the primary objective of this study. Government activity is modeled relative to the size of regional income alleviating the need to specifically model tax or other government payments.

Table 4.5: Miscellaneous Producer Payments
(Millions of U.S. Dollars)

Sector	Miscellaneous Payment
AGRI	1.9330
MINE	391.0994
UTIL	141.2532
CONS	15.5113
MFTG	147.8410
WHOL	413.1466
TRAN	56.5018
RETA	455.0218
INFO	122.7390
FINC	107.0352
REAL	243.9794
PROF	41.6059
MGMT	7.2216
ADMI	27.7796
EDUC	7.9552
HEAL	45.2948
ARTS	28.7351
ACCO	105.7323
OTHR	84.5586
GNNC	252.2883

Household Aggregation

IMPLAN provides data for 9 distinct households. All nine households are used in the model to provide a rich range of income distribution analysis. The 9 households are categorized in IMPLAN by household income as detailed in Table 4.6.

Table 4.6: Household Categories

Household	Income Range
HHD1	< $10,000
HHD2	$10,000 - $15,000
HHD3	$15,000 - $25,000
HHD4	$25,000 - $35,000
HHD5	$35,000 - $50,000
HHD6	$50,000 - $75,000
HHD7	$75,000 - $100,000
HHD8	$100,000 - $150,000
HHD9	≥ $150,000

Labor Supply

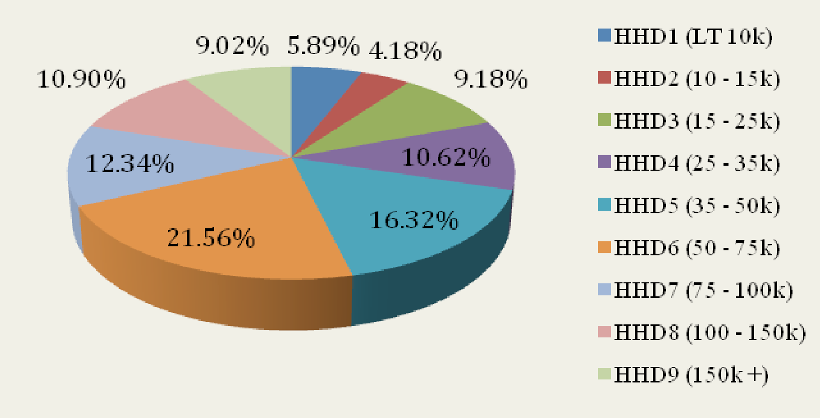
The IMPLAN SAM contains income inconsistencies that make determining actual labor income by skill determination for each household impossible without using external data and imputation techniques. IMPLAN uses household income data given by the Consumer Expenditure Survey[17] and notes that problems exist with the fact that many households in lower income classes spend more than they earn. They attribute this to underreporting of income. IMPLAN acknowledges the deficiency and accounts for it in payments to capital as saving (or in this case dissaving). Coupled with the lack of labor

[17] The U.S. Census Bureau collects the Consumer Expenditure Survey quarterly for the Bureau of Labor Statistics. See www.bls.gov for more information.

skill breakout, this problem requires that the household data be somewhat imputed. A description of the process is given in the following paragraphs.

Household labor supply was divided into high and low skilled categories based on the income of the household and the total local supply used by local producers. Labor by skill demanded is met by local households and commuters. The share of local labor requirements met by each was determined by the share of workers from each group who work in Oklahoma County. According to the Oklahoma Department of Commerce (2006), 72.4% of Oklahoma County labor requirements are met by households residing within the county. Thus, of the total labor expenditure by county producers, roughly $16,709 billion is paid to local workers. This amount is divided among the 9 local households in shares equal to their IMPLAN labor income shares. Starting with the lowest income household (HHD1), low skilled labor income is allocated until all low skilled payments are exhausted. This implies that Households 1 through 6 are assumed to supply only low skilled labor. Households 8 through 9 are assumed to supply only high skilled labor. Household 7 supplies both low and high skilled labor. High and low skilled labor determination is discussed in the Value Added

Figure 4.2: Benchmark Income Distribution



Demand section earlier in this chapter. Table 4.7 details the allocation of high and low skilled labor income by household. Figure 4.2 shows the initial income distribution.

Table 4.7: Labor Income by Household and Skill
(Millions of U.S. Dollars)

Household	Share of Local Labor Income	Calculated Labor Income	Low Skilled Income	High Skilled Income
HHD1	0.0126	210.8127	210.8127	0.0000
HHD2	0.0211	353.3550	353.3550	0.0000
HHD3	0.0704	1176.9281	1176.9281	0.0000
HHD4	0.0989	1652.7628	1652.7628	0.0000
HHD5	0.1582	2642.7952	2642.7952	0.0000
HHD6	0.2558	4273.8233	4273.8233	0.0000
HHD7	0.1464	2445.7362	589.0515	1856.6846
HHD8	0.1293	2159.8053	0.0000	2159.8053
HHD9	0.1072	1791.5084	0.0000	1791.5084

Income, Saving, and Consumption Demand

Traditionally, total household income is the sum of factor incomes plus miscellaneous income from interest, transfers, household production, etc. In this model, miscellaneous income is imputed to balance total income and consumption. Miscellaneous income is calculated as the (negative) difference between consumption expenditure and factor income. For lower income households, this yields a consumption budget exactly equal to factor income plus miscellaneous income (Marginal Propensity to Save (MPS) equal to zero). For Higher income households, factor income alone is greater than their consumption expenditures yielding a positive saving differential. Their MPS is calculated as their positive saving differential divided by their total income. As stated in Chapter 3 and outlined in the Saving and Investment section below, household saving is not important in the regional model, as local saving does not equal local investment. Household income and consumption are detailed in tables 4.8 and 4.9 respectively.

Table 4.8: Income by Household
(Millions of U.S. Dollars)

Household	Low Skilled Income	High Skilled Income	Capital Income	Misc Income	Total Income
HHD1	210.8402	0.0000	18.9758	1044.0992	1273.9151
HHD2	353.4011	0.0000	31.4129	519.7302	904.5441
HHD3	1177.0815	0.0000	104.4347	705.0759	1986.5921
HHD4	1652.9782	0.0000	148.0241	498.4743	2299.4766
HHD5	2643.1397	0.0000	238.5636	650.8201	3532.5234
HHD6	4274.3804	0.0000	392.1888	0.0000	4666.5692
HHD7	589.1283	1856.9267	225.5672	0.0000	2671.6222
HHD8	0.0000	2160.0868	198.4497	0.0000	2358.5365
HHD9	0.0000	1791.7420	160.3901	0.0000	1952.1321

Initial payments to local and import producers determine consumption demand. These payments are combined to yield total consumption demand. The consumption budget (CBUD) is equal to total income multiplied by (1 – MPS) which happens to equal total initial consumption.

Table 4.9: Consumption Demand by Household
(Millions of U.S. Dollars)

Household	Local Consumption	Import Consumption	Total Consumption (and CBUD)	Income less Consumption	MPS
HHD1	921.3048	352.6103	1273.9151	0.0000	0.0000
HHD2	643.0572	261.4869	904.5441	0.0000	0.0000
HHD3	1440.7089	545.8832	1986.5921	0.0000	0.0000
HHD4	1634.8767	664.5999	2299.4766	0.0000	0.0000
HHD5	2518.8900	1013.6334	3532.5234	0.0000	0.0000
HHD6	2893.8500	1119.5942	4013.4442	653.1249	0.1400
HHD7	1836.2287	669.3715	2505.6003	166.0219	0.0621
HHD8	1436.2518	523.5656	1959.8174	398.7191	0.1691
HHD9	1036.2261	377.7417	1413.9678	538.1643	0.2757

Saving Dollars and Local Investment

Typical national CGE models link saving and investment to some degree. Limitations to capital mobility require that local saving provide a significant portion of loanable funds required for capital expenditures. At a regional level in the United States, the high degree of capital mobility allows loanable funds to flow in and out of the region seamlessly. This mobility provides for little relationship between local saving and capital investment. Therefore, local investment decisions are made based largely on national interest rates yielding no link between local saving and investment.

Benchmark investment by producers is determined by initial payments to capital (IMPLAN code 14001) and inventory (14002). Benchmark investment in capital goods is detailed in Table 4.10.

Table 4.10: Capital Investment by Local Producers
(Millions of U.S. Dollars)

Investment Sector	Sectoral Investment Expenditure
AGRI	5.5139
MINE	2232.5640
UTIL	423.8078
CONS	155.9931
MFTG	910.1260
WHOL	404.8234
TRAN	172.0872
RETA	325.5238
INFO	460.6338
FINC	977.6404
REAL	1124.928
PROF	205.4951
MGMT	114.6357
ADMI	162.7832
EDUC	29.8541
HEAL	345.9371
ARTS	46.2229
ACCO	174.1708
OTHR	143.2437
GNNC	1685.7330

Investment Demand for Local Goods

Investment demand for local goods is determined by payments from capital (14001) and inventory (14002) to local sectors. Investment demand is detailed in Table 4.11.

Table 4.11: Capital Demand for Local Production
(Millions of U.S. Dollars)

Sector	Demand for Sector Production
AGRI	0.024
MINE	281.384
UTIL	0.123
CONS	1518.111
MFTG	561.246
WHOL	216.490
TRAN	18.087
RETA	79.684
INFO	56.173
FINC	3.918
REAL	74.327
PROF	233.034
MGMT	
ADMI	0.512
EDUC	
HEAL	
ARTS	0.418
ACCO	0.183
OTHR	0.287
GNNC	16.233

Government

Government expenditure is determined by payments from state and local (12001, 12002, 12003) and federal (11001, 11002, 11003) government to local production sectors. Other government activities are not specifically modeled in the OKCGE. Government demand is detailed in Table 4.12.

Table 4.12: Government Demand for Local Production
(Millions of U.S. Dollars)

Sector	State & Local Gov't Demand	Federal Gov't Demand
AGRI	0.484188	0.000021
MINE	4.074497	3.201743
UTIL	90.591618	94.954879
CONS	622.378160	2.429542
MFTG	105.722650	104.508327
WHOL	63.442078	0.384841
TRAN	44.279659	0.399966
RETA	0.376602	6.710979
INFO	45.952435	36.326786
FINC	60.619661	3.590565
REAL	71.450091	0.957406
PROF	111.267450	332.105754
MGMT		
ADMI	60.803704	22.664710
EDUC	7.996143	22.924770
HEAL	15.868410	1.928122
ARTS	1.132114	0.655354
ACCO	44.512622	0.008594
OTHR	48.404536	50.493882
GNNC	2211.752048	2707.560763

Exports

The IMPLAN SAM provides export information on U.S. and extra-regional demand for local production. Extra-regional exports are given as payments from IMPLAN code 25001 and local (U.S.) exports are given as payments from IMPLAN code 28001. These two categories are aggregated into one export demand payment for each producing sector. Exports for each sector are given in Table 4.13.

Table 4.13: Export Demand for Local Production (Millions of U.S. Dollars)

Producing Sector	Total Export Demand
AGRI	1.673
MINE	6326.859
UTIL	324.412
CONS	0.182
MFTG	8924.067
WHOL	355.201
TRAN	721.355
RETA	557.421
INFO	1549.479
FINC	1638.984
REAL	709.698
PROF	308.055
MGMT	49.626
ADMI	783.331
EDUC	80.151
HEAL	1556.395
ARTS	0.730
ACCO	491.585
OTHR	296.130
GNNC	354.630

Commuting

Like many U.S. regions, Oklahoma County relies on a significant number of commuters to augment the labor force. In 2006, roughly 26.9% of Oklahoma County workers came from outside the county. 25.1% of workers came from the surrounding counties of Canadian, Cleveland, Grady, Lincoln, Logan, McClain and Pottawatomie for roughly 91% of the total commuter work force. For Oklahoma workforce data, see Table 4.14.

Table 4.14: County of Residence for Oklahoma County Workers[18]

County of Residence	Number Commuters	Shares
Adair	21	0.00537%
Alfalfa	4	0.00102%
Atoka	16	0.00409%
Beaver	5	0.00128%
Beckham	42	0.01074%
Blaine	106	0.02712%
Bryan	41	0.01049%
Caddo	489	0.12509%
Canadian	25,060	6.41055%
Carter	98	0.02507%
Cherokee	44	0.01126%
Choctaw	22	0.00563%
Cimarron		0.00000%
Cleveland	46,421	11.87487%
Coal	26	0.00665%
Comanche	303	0.07751%
Cotton	14	0.00358%
Craig	2	0.00051%
Creek	79	0.02021%
Custer	177	0.04528%
Delaware	70	0.01791%
Dewey	11	0.00281%
Ellis	4	0.00102%
Garfield	170	0.04349%
Garvin	553	0.14146%
Grady	4,797	1.22711%
Grant	9	0.00230%
Greer	13	0.00333%
Harmon		0.00000%
Harper	13	0.00333%
Haskell	19	0.00486%
Hughes	90	0.02302%
Jackson	22	0.00563%
Jefferson	13	0.00333%
Johnston	20	0.00512%
Kay	95	0.02430%
Kingfisher	759	0.19416%
Kiowa	19	0.00486%
Latimer	9	0.00230%
LeFlore	32	0.00819%
Lincoln	3,677	0.94061%
Logan	8,367	2.14035%

[18] Source: "2006 Demographic State of the State, A Report to the Governor and Legislature on Commuting Patterns and Daytime Population," Oklahoma Department of Commerce, June 2006.

Love	17	0.00435%
McClain	3,850	0.98486%
McCurtain	24	0.00614%
McIntosh	147	0.03760%
Major	23	0.00588%
Marshall	60	0.01535%
Mayes	4	0.00102%
Murray	85	0.02174%
Muskogee	54	0.01381%
Noble	109	0.02788%
Nowata	11	0.00281%
Okfuskee	179	0.04579%
Oklahoma	283,105	72.42056%
Okmulgee	32	0.00819%
Osage	31	0.00793%
Ottawa	3	0.00077%
Pawnee	26	0.00665%
Payne	693	0.17728%
Pittsburg	106	0.02712%
Pontotoc	171	0.04374%
Pottawatomie	5,937	1.51873%
Pushmataha	27	0.00691%
Roger Mills	3	0.00077%
Rogers	65	0.01663%
Seminole	507	0.12969%
Sequoyah	41	0.01049%
Stephens	289	0.07393%
Texas	8	0.00205%
Tillman	7	0.00179%
Tulsa	636	0.16269%
Wagoner	16	0.00409%
Washington	27	0.00691%
Washita	78	0.01995%
Woods	2	0.00051%
Woodward	32	0.00819%
Resident Workers	283,105	72.42056%
In State Commuters	105,032	26.86804%
Out of State Commuters	2,781	0.71140%
Total Workers	390,918	

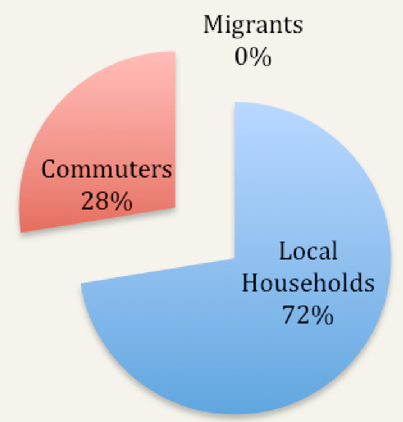
Because of data inconsistencies, these numbers do not match the employment numbers given by IMPLAN. However, the percentages can be used to impute commuter employment and income. According to IMPLAN, total labor payments by Oklahoma County producers were $23,070.143 million. Multiplying the various sector payments by the national industry labor skill share matrix outlined in the Value Added section above yields total high and low skilled labor payments of $8,019.820 million and $15,050.324 million respectively. Because there is little information available on high versus low skilled labor commuting patterns in Oklahoma, it is assumed that high and low skilled labor have equal commuter shares for simplicity. Using the commuter/local worker percentages given by the department of commerce would yield $6,362.617 million attributed to commuter labor of which $5,789.932 million was imported from the counties directly neighboring Oklahoma County.

Table 4.15: Labor Dollars by Region
(Millions of U.S. Dollars)

Residence of Workers	High Skilled	Low Skilled	Aggregate Labor
Oklahoma County	5,807.998	10,899.528	16,707.527
Surrounding Region	2,012.740	3,777.192	5,789.932
Rest of Oklahoma	142.027	266.535	408.563
Out of State	57.053	107.068	164.122
Total Commuter Labor	2,211.820	4,150.795	6,362.617
Total Labor Dollars for Oklahoma County	8,019.820	15,050.324	23,070.143

Location shares of benchmark high and low skilled labor participants are illustrated in Figure 4.3. Of course, migration occurs post policy, so initial migrant shares are zero.

Figure 4.3: Benchmark Worker Shares



Parameter Calibration

Within the OKCGE model, parameters are either input directly from IMPLAN data or they are calculated based on the model's underlying equations. The calculated, or endogenous parameters are said to be calibrated in that they are the calculated values that will yield the benchmark solution given the exogenous parameters and model equations. This section details the methodology used to calibrate each of the endogenous parameters. All calibration parameters and their equations are listed in Table 4.16.

Leontief Share Parameters

The top of the production nest uses Leontief input technology to scale aggregate intermediate input and aggregate value added requirements. The parameter *InputOutput* represents the amount of intermediate good '*i*' required for the production of one unit of good '*j*'. I*nputOutput* is calculated by dividing sectoral demand for each intermediate input by own sectoral output.

$$InputOutput_{i,j} = \frac{Intermediate_{i,j}}{TotalOutput_{j}}$$

CES Production Parameters

The value added nest aggregates capital and labor using a CES production function. A similar CES function is used to aggregate labor skill types and as an Armington (1969) aggregator for local and imported intermediate inputs, investment goods, and consumption goods. Each CES function has three calibrated parameters – share, shift, and elasticity of substitution transformation. Calibration of each is detailed below.

Elasticity of Substitution Transformation

For each CES function an exogenous elasticity of substitution σ is given by literature estimates. CES derivations often call for a transformation of this parameter for simplification. All transformations in the OKCGE model are given by the parameter ρ and are calculated as:

$$\sigma = \frac{1}{1+\rho}$$

CES Share Parameters

To demonstrate the calibration of the CES share parameters, consider a CES equation of the standard form:

$$Q = a \cdot \left(\gamma \cdot X1^{-\rho} + \left(1-\gamma\right) \cdot X2^{-\rho_i}\right)^{-1/\rho}$$

We would like to calibrate the share parameter γ. Recall, the firm's dual problem is to minimize cost subject to their expenditure constraint. Solving the dual problem, the first order conditions for this equation subject to its expenditure constraint $PX1 \cdot X1 + PX2 \cdot X2 = PQ \cdot Q$ gives the standard share parameter calibration function:

$$\gamma = \frac{1}{1 + \frac{PX2}{PX1}\left(\frac{X1}{X2}\right)^{1+\rho}}$$

The variables X1 and X2 represent two substituted inputs. For instance, in the case of labor and capital substitution, let X1 be capital and X2 be labor. A typical labor/capital share calibration equation looks like:

$$\gamma = \frac{1}{1 + \frac{PLabor}{PCapital}\left(\frac{Capital}{Labor}\right)^{-1}}$$

For the OKCGE, the benchmark values of capital and labor demanded for each sector and the corresponding benchmark prices are used to calibrate the capital/aggregate labor CES share parameter[19]:

$$\gamma F = \frac{1}{1 + \frac{plabor0}{pcapital0}\left(\frac{capitaldemand0}{labordemand0}\right)^{\frac{1}{\sigma}}}$$

The above calibration equation is derived from equation (3.2). The share parameters for all the other CES functions are calculated in the same manner.

CES Shift Parameters

The shift parameters for each CES function are easily calculated once the share and elasticity transformation parameters are calculated. To calibrate the shift parameter, the CES function is solved for the shift parameter. Using the generic language of the original CES share parameter calibration example above, the equation for calibrating the shift parameter is simply:

---

[19] All OKCGE benchmark variables are indicated by a lowercase version of their variable name followed by the number ‘0’.

$$a = \frac{Q}{\left[\delta X_1^{-\rho} + (1-\delta) X_2^{-\rho}\right]^{-\frac{1}{\rho}}}$$

In the OKCGE example above, the production shift parameter of the OKCGE is:

$$\alpha F = \frac{totaloutput\,0}{\left(\gamma F \cdot capitaldemand\,0^{-\rho F} + (1-\gamma F)\cdot labordemand\,0^{-\rho F}\right)^{-\frac{1}{\rho F}}}$$

The above calibration procedures are used for the top of the value added nest and all CES production and Armington equations. The remaining CES production and Armington calibration equations are given in Table 4.15.

Household CES Parameters

The household CES utility parameters are somewhat different to calibrate than the traditional CES production parameters due to the differences in the CES functions. The elasticity of substitution in consumption parameter σC is determined by literature estimates. The share parameter αC is calibrated for each household and good as[20]:

$$\alpha C_{h,i} = \frac{hhdconsumption\,0_{h,i}^{\,1/\sigma C_h}}{\sum_i hhdconsumption\,0_{h,i}^{\,1/\sigma C_h}}$$

[20] For a more detailed derivation of the utility calibration equation, see Shoven and Whalley (1992).

Table 4.16: Input (Calculated) Parameters

Parameter	Parameter Calibration/Calculation Equation
Armington Shift Parameter	
αA_i	$\alpha A_i = \dfrac{compositegood0_i}{\left(\gamma A_i \cdot importdemand0_i^{-\rho A_i} + (1-\gamma A_i) \cdot domesticdemandfordomestic0_i^{-\rho A_i}\right.}$
Household Consumption Share Parameter	
$\alpha C_{h,i}$	$\alpha C_{h,i} = \dfrac{hhdconsumption\ 0_{h,i}^{1/\sigma C_h}}{\sum_i hhdconsumption\ 0_{h,i}^{1/\sigma C_h}}$
Value Added (Factor) Shift Parameter	
αF_i	$\alpha F_i = \dfrac{totaloutput0_i}{\left(\gamma F_i \cdot capitaldemand0_i^{-\rho F_i} + (1-\gamma F_i) \cdot labordemand0_i^{-\rho F_i}\right)^{-\frac{1}{\rho F_i}}}$
Labor Skill Shift Parameter	
αL_i	$\alpha L_i = \dfrac{labordemand0_i}{\left(\gamma L_i \cdot laborhdemand0_i^{-\rho L_i} + (1-\gamma L_i) \cdot laborldemand0_i^{-\rho L_i}\right)^{-\frac{1}{\rho L_i}}}$
Armington Share Parameter	
γA_i	$\gamma A_i = \dfrac{1}{1 + \dfrac{pdomestic0_i}{pworld0_i} \cdot \left(\dfrac{importdemand0_i}{domesticdemandfordomestic0_i}\right)^{-\frac{1}{\sigma A_i}}}$
Value Added (Factor) Share Parameter	
γF_i	$\gamma F_i = \dfrac{1}{1 + \dfrac{plabor0_i}{pcapital0_i} \cdot \left(\dfrac{capitaldemand0_i}{labordemand0_i}\right)^{-\frac{1}{\sigma F_i}}}$
Labor Skill Share Parameter	
γL_i	$\gamma L_i = \dfrac{1}{1 + \dfrac{plaborl0_i}{plaborh0_i} \cdot \left(\dfrac{laborhdemand0_i}{laborldemand0_i}\right)^{-\frac{1}{\sigma L_i}}}$
Household Expenditure Budget	
$cbud0_h$	$cbud\,0_h = (1-mps) \cdot hhdincome\ 0_h$

Initial Prices	
pcapital0	pcapital0=1
pcomposite0	pcomposite0=1
plocal0	plocal0=1
plabor0	plabor0=1
plaborh0	plaborh0=1
plaborl0	plaborl0=1
pworld0	pworld0=1

Model Parameterization

The choices of elasticities certainly influence the results of any model. The variety of estimates for all elasticities is vast. While many elasticity decisions provide ample fodder for controversy, care was taken to pick the most appropriate elasticities from the literature to provide the most palatable results. The elasticity estimates for each of the required functions are listed in the remaining sections of Chapter 4.

Trade

Trade incorporates local and export production as well as local and import consumption. Many trade elasticity estimates are given for exports as well as imports in the international trade literature. As Berck et al. (1997) point out, regional economies are much more open to trade than national economies and thus higher trade elasticities are appropriate for use. Most studies estimate elasticity ranges between low, medium and high values. The "high" values are typically used in this model to reflect the openness of the regional economy. Table 4.17 gives the elasticity of substitution between imported and locally produced goods and services.

Table 4.17: Elasticity of Substitution: Armington Local/Import

Sector	Elasticity	Source
Agriculture	1.5	Berck, Golan and Smith 1997
Mining	1.062	Berck, Golan and Smith 1997
Utilities	1.5	Berck, Golan and Smith 1997
Construction	1.5	Berck, Golan and Smith 1997
Manufacturing	0.55	Berck, Golan and Smith 1997
Wholesale Trade	0.5	Rickman and Snead, 2007
Transportation	1.5	Berck, Golan and Smith 1997
Retail Trade	0.5	Rickman and Snead, 2007
Information	1.5	Rickman and Snead, 2007
Finance and Insurance	1.5	Berck, Golan and Smith 1997
Real Estate	1.5	Rickman and Snead, 2007
Professional Services	1.5	Oregon Tax Incidence Model, 2001
Management of Companies	0.5	Oregon Tax Incidence Model, 2001
Administrative Services	1.5	Berck, Golan and Smith 1997
Education Services	0.5	Rickman and Snead, 2007
Health Services	0.5	Oregon Tax Incidence Model, 2001
Arts & Entertainment	0.5	Oregon Tax Incidence Model, 2001
Accommodation Services	0.5	Rickman and Snead, 2007
Other Services	1.5	Berck, Golan and Smith 1997
Government	0.5	Rickman and Snead, 2007

Production

Production elasticities involve substitution between value added factors labor and capital and at a lower level high and low skilled labor. Capital and Labor substitutability taken from de Melo and Tarr (1992) is mostly consistent with Rickman and Snead (2007) who vacillate between 0.8 and 0.9. Specific capital and labor substitution elasticities are given in Table 4.18.

Table 4.18: Capital-Labor Substitution Elasticities

Sector	Elasticity	Source
Agriculture	0.61	de Melo and Tarr, 1992
Mining	0.8	de Melo and Tarr, 1992
Utilities	0.8	de Melo and Tarr, 1992
Construction	0.8	de Melo and Tarr, 1992
Manufacturing	0.8	de Melo and Tarr, 1992
Wholesale Trade	0.8	de Melo and Tarr, 1992
Transportation	0.8	de Melo and Tarr, 1992
Retail Trade	0.8	de Melo and Tarr, 1992
Information	0.8	de Melo and Tarr, 1992
Finance and Insurance	0.8	de Melo and Tarr, 1992
Real Estate	0.8	de Melo and Tarr, 1992
Professional Services	0.8	de Melo and Tarr, 1992
Management of Companies	0.8	de Melo and Tarr, 1992
Administrative Services	0.8	de Melo and Tarr, 1992
Education Services	0.8	de Melo and Tarr, 1992
Health Services	0.8	de Melo and Tarr, 1992
Arts & Entertainment	0.8	de Melo and Tarr, 1992
Accommodation Services	0.8	de Melo and Tarr, 1992
Other Services	0.8	de Melo and Tarr, 1992
Government	0.8	de Melo and Tarr, 1992

As Rickman and Snead (2007) point out, labor skills tend to be relatively inelastic in substitution. A low value would be most appropriate for implementation. The literature provides little guidance for this so the author chose an elasticity of 0.15.

Table 4.19: Labor Skill Substitution Elasticities

Sector	Elasticity	Source
All	0.15	Author

Labor Migration

Migration elasticities are taken from Berck et al. (1997). Higher skilled labor is assumed to be more mobile than lower skilled labor as is reflected in their elasticities in Table 4.20.

Table 4.20: Labor Migration Elasticities

Labor Skill	Elasticity	Source
High-Skilled	2.3	Berck, Golan, and Smith, 1997
Low-Skilled	1.3	Berck, Golan, and Smith, 1997

Commuting

Commuting elasticities measure the percentage change in commuters given a 1% change in nominal wages. Commuters are less impacted by real wages because they merely spend their workday in the commute-to county. Commuting elasticities can be impacted by any number of factors including the quantity and quality of transportation options, commute distance and congestion. Additionally, Mills and Hamilton (1994) point out that income has a significant impact on the decision to commute as the value of time increases with income, longer commutes become more expensive. However, commuters are willing to trade some income (lost time) to live in a more desirable location. These factors vary significantly around the country making one specific commuting elasticity estimate untenable. This is particularly troubling for county-to-county commutes considering that each county exhibits a large number of unique characteristics such as area (size), location of commuter, type of roads available, etc.

Having no commuter elasticity estimates, the author has chosen a variety of elasticities related to distance and skill level. Nearby locations and higher skill levels are attributed higher commuter elasticities. Clearly, locations closer to the central county exhibit lower commute costs. Higher skilled workers are more likely to have access to reliable transportation. The commuting elasticities used for Oklahoma County are given in Table 4.21.

Table 4.21: Commuter Elasticities

Location	High Skilled	Low Skilled
Nearby Counties	1.5	1.0
Other Oklahoma Counties	0.15	0.1
Out of State	0.015	0.01

Household Consumption

The elasticity of substitution between consumable goods and services by households is 0.75. This estimate was taken from Rickman and Snead (2007). This estimate is large enough to account for the variety of goods and services included in each of the 20 sectors while still maintaining some degree of inelasticity.

CHAPTER V

SIMULATIONS AND RESULTS

The primary objective of the OKCGE is to provide insight about the final beneficiaries of local development initiatives. Specifically, the model attempts to determine the magnitude of the benefits that accrue to the residents who originally voted for a specific initiative. A second objective of the study is to decompose the development effects into income distribution cohorts. Finally, some measure of the broader regional impacts needs to be addressed to provide a minimal measure of needed regional cooperation. To address each of the stated objectives, a number of model simulations are performed to provide counterfactual analysis.

Economic development is a somewhat nebulous term. Referenced here, it implies policies that aim to increase the economic activity of the region. Increasing export demand for one or more of the region's production sectors can simulate the transmission of such policies. For example, suppose a policy is enacted to spur increased manufacturing. The increased manufacturing can be simulated by exogenously increasing world demand (export) for local manufacturing production. The simulations addressed below each include a 50% increase in export demand for local manufacturing production. Each simulation provides insight about the impacts on local residents by allowing changes to commuter nominal wage rates elasticities and migration elasticities. The specifics are described below.

Simulation Short Descriptions

The following simulations are performed:

- Simulation 1: Realistic Labor Supply, Commuter and Migration Elasticities
- Simulation 2: Low Commuter Elasticities
- Simulation 3: High Commuter Elasticities
- Simulation 4: Low Migration Elasticities
- Simulation 5: High Migration Elasticities

Simulation Results

The results from all simulations are reported in the following paragraphs. For comparison, Tables 5.1 – 5.9 present the values of key model variables for all five simulations.

Simulation 1

Simulation 1 provides an estimate of development impacts for Oklahoma County given the baseline parameter specifications described in Chapter 4. The benchmark model is shocked by increasing export demand for locally manufactured goods to provide estimated impacts on the labor market, output, income and consumption.

Labor Impacts – Local Residents, Commuters and Migrants

The results from Simulation 1 provide some interesting evidence concerning the primary and secondary objectives of the study. First, the increased economic activity has a direct impact on real wages for both low and high skilled workers. While there is a 1.39% increase in local consumer prices, nominal wage increases lead to increased real wages of 2.54% and 2.98% for low and high skilled workers (see Table 5.8). This increase in real earning power induces increased labor force participation of 7.82% and 2.38% for low and high skilled workers (Table 5.1). Migrants stole labor force share from both commuters and local households. Local workers' share of the low skilled labor declined slightly by 0.47% points while migrants became 2.30% of the low skilled labor force. Local high skilled workers witnessed an even greater decline

Figure 5.1: Low Skilled Workers - Simulation 1

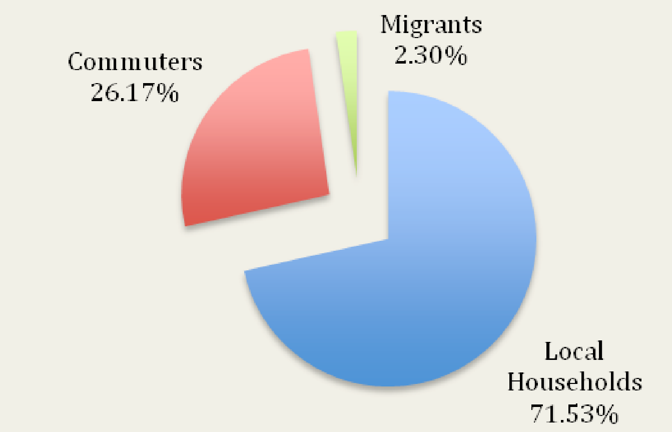
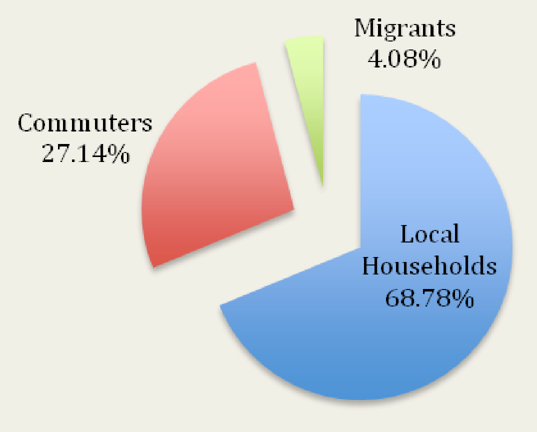
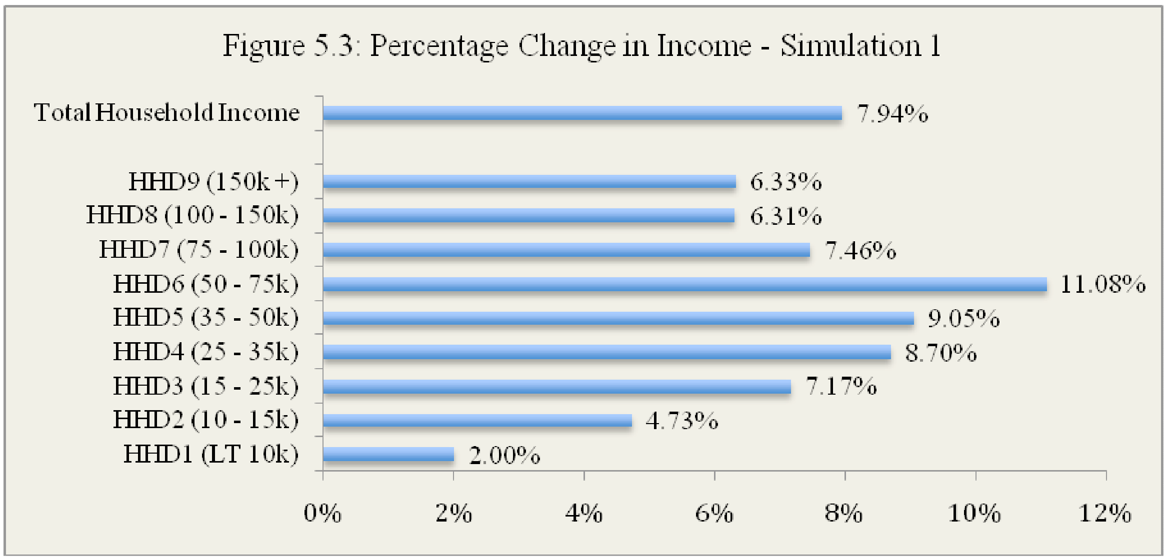


Figure 5.2: High Skilled Workers - Simulation 1



in labor share to 68.78% of the high skilled workforce. While their share of labor force declined, actual labor force participation by all local households increased. The increases in real wages and participation rates lead to increases in household income and consumption. Income is increased on average by 7.83% leading to an average increase in consumption of 6.45% (Table 5.7).

The model also predicts some interesting distributional effects. The distributional effects are greatest among the middle four income cohorts (HHD3 – HHD7). The greatest income impact occurs among the cohort earning $50,000 to $75,000 (HHD6) as



their nominal household income increases by 11.08%. Households 1 (Less than $10,000) and 2 ($10,000 to $15,000) are the least impacted as their nominal incomes increase by 2.0% and 4.73% respectively. The top income households (100 – 150k, 150k+) experience modest 6.3% increases in income. Based on these results, there appears to be some unequal distributional effects of local growth policy. The data provides some clues to this inequality. First, while high skilled labor experiences a greater increase in real wages than low skilled labor, the difference is relatively small. Second, low skilled labor experiences a larger increase in labor force participation. The significant participation differential between high and low skilled workers is going to cause households who supply low skilled labor to receive the greater proportion of the development benefits given that the real wage change differences are small. Households 1 – 7 supply low skilled labor while households 7 – 9 supply high skilled labor. To get the full picture, we must also analyze labor income shares for each household. Households 1 and 2 receive only 16.6% and 39.1% of their income from low skilled labor services initially.[21] Households 4, 5 and 6 receive 71.9%, 74.8% and 91.6% of their income from low skilled labor services providing a more substantial income boost from increased low skilled wages. Household 7 receives only 22.1% of income from low skilled labor and 69.5% from high skilled labor. Households 8 and 9 receive no income from low skilled labor services and 91.6% and 91.8% of household income from high skilled labor services.

The simulation does indicate that local households are not the only beneficiaries of the local development. Both low and high skilled migrants matriculated and account for 2.3% of low skilled labor and 4.1% of high skilled labor post simulation. Both of these are up from the initial 0% benchmark.

Low and high skilled commuting also increases by 3.64% and 6.13% respectively. Nearby counties experience a 9.24% increase in income from commuters. Other counties in Oklahoma receive an additional 4.62% in commuter income and other states receive an increase of 4.17%. Total commuter income increases by 8.81%.

[21] As stated in Chapter 4, labor income for lower income households is likely underreported. This may cause labor income increases to also be underreported by the model.

Demand

Total output for Oklahoma County increased by 12.5% as a result of the manufacturing stimulus. While the counterfactual experiment was initiated by a 50% increase in manufacturing export demand, rising input and therefore output prices led to an equilibrium increase in manufacturing exports of only 48.66%. Total manufacturing output increased by 39.93%. The increase in manufacturing led to increased demand and competition for regional resources causing all sectoral prices to increase above world prices leading to a drop in production of exports in every sector but manufacturing. However, higher regional income increased local consumption of all sectors by an average of 10.2%. The increase in local use caused total production increases in every local sector. The biggest beneficiary of the regional expansion is the agricultural sector whose output increased 28.61% due primarily to a 29.75% increase in local consumption. The mining sector showed the least impact (0.33%) likely because of the export nature of mining.

The local expansion also had a positive impact on regional imports as import demand increased by an average of 16.35%. Again the largest increase occurred in Agriculture (30.32%) while the smallest occurred in health services (6.57%).

Regional Prices

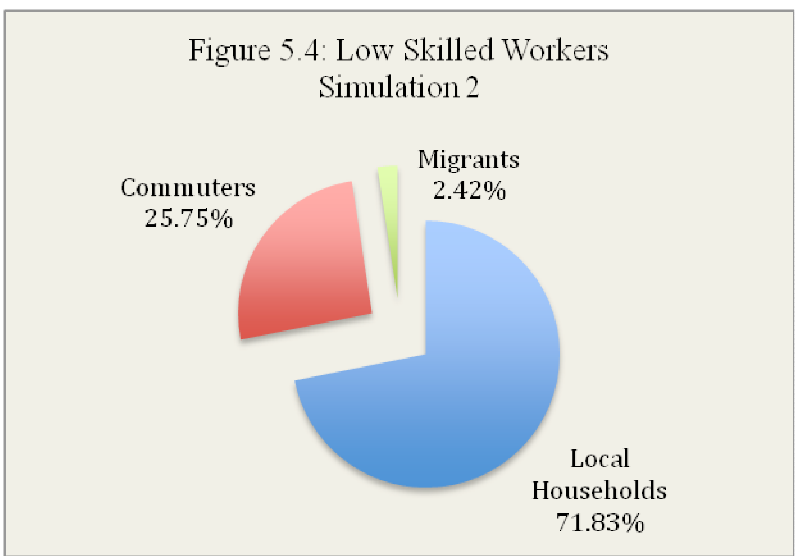
Overall, regional prices were up. The price index (CPI) used to calculate real wages was up 1.39%. Nominal Low (3.97%) and High (4.41%) Skilled wages increased sufficiently to cause real wage increases of 2.54% and 2.98% respectively. These wage increases are to be expected as factor markets tightened due to the initial increase in export demand.

Simulation 2

This simulation demonstrates the impact of development with less response from commuters. Specifically, commuter elasticities are halved for all commuters. With lesser commuting one would expect greater impacts accruing to the primary county residents as well as migrants.

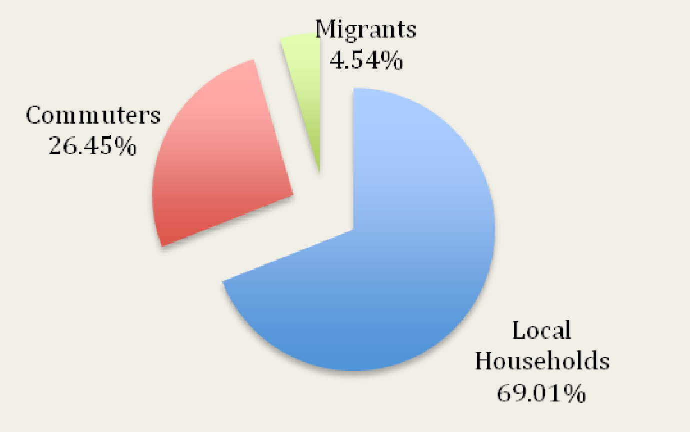
Simulation 2 Impacts

As expected, decreased commuter availability forced firms to increase wages even more to satisfy labor demand requirements. Low and high skilled nominal wages increased by 4.25 and 4.90% respectively while real wages increased by 2.68 and 3.31% respectively. These increases in wages led to greater increases in participation (8.24% for low skilled and 2.64% for high skilled) and increased incomes of local residents by 7.97% on average. This is a 0.14 percentage point increase over Simulation 1. The distributional effects witnessed in Simulation 1 are present and magnified slightly in Simulation 2.



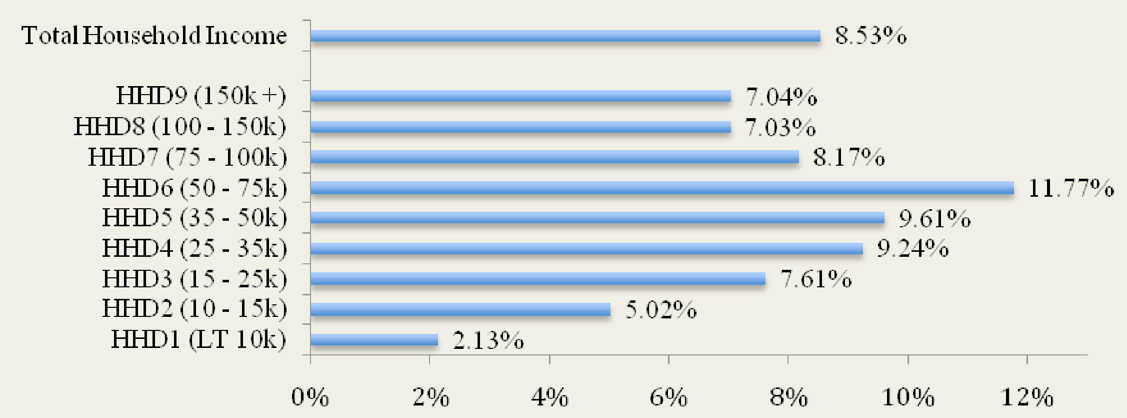
Commuter participation increases were less than those experienced in Simulation 1 leading to lower increases in commuter income. Migrants supplied more labor in both low and high skilled pools although their share of the low and high skilled total decreased from Simulation 1 to 1.77% and 3.77% respectively. Total low skilled labor is up slightly over Simulation 1 while high skilled labor is off slightly indicating that some substitution between high and low skilled labor is likely occurring.

Figure 5.5: High Skilled Workers Simulation 2



Overall production impacts are nearly equal to those experienced under Simulation 1 although some export production was shifted to local production to supply increased local goods to local residents and migrants. Local consumption increased as

Figure 5.6: Percentage Change in Income - Simulation 2



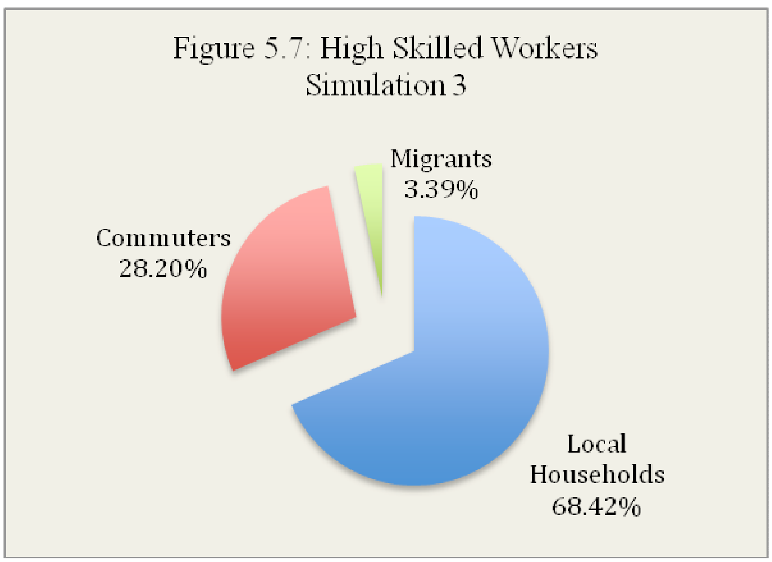
local residents experienced increases in income and migrant consumption demand increased.

Simulation 3

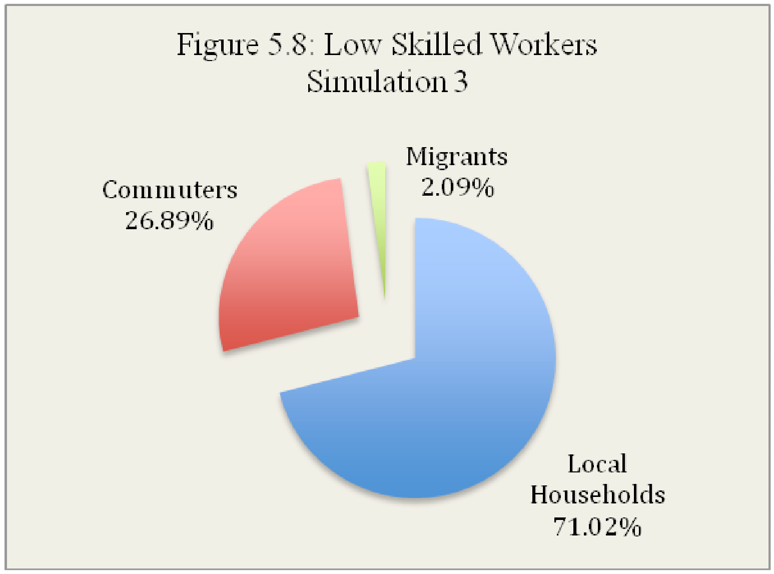
This simulation demonstrates the impact of development with greater response from commuters. Specifically, commuter elasticities are doubled for all commuters. With increased commuting one would expect lesser impacts accruing to the primary county residents as well as migrants.

Simulation 3 Impacts

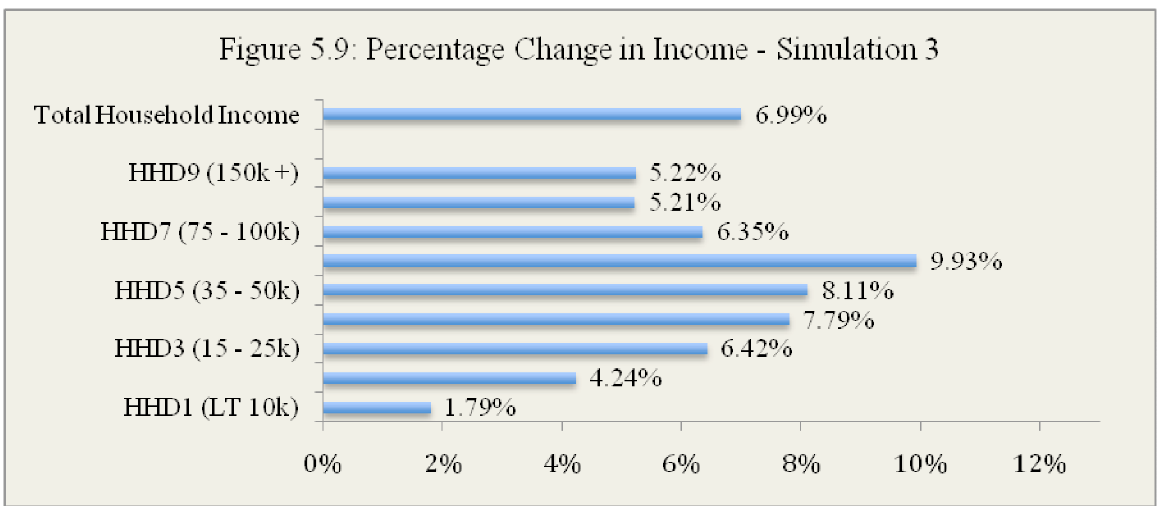
Increasing commuter elasticities has the opposite effect of the decreased elasticities from Simulation 2. More commuters provide a larger labor pool in the nearby area. This increased supply (when compared with Simulation 2) relieves wage pressure experienced in Simulations 1 and 2. Low and high skilled nominal wages increased by 3.49% and 3.65% respectively while real wages increased by 2.31% and 2.47% respectively. When compared to Simulations 1 and 2, these wage gains are modest and lead to a lower increase in participation and migration responses. Lower participation and migration responses led to smaller increases in resident income (7.59% on average) and migrant income. The



distributional effects witnessed in Simulations 1 and 2 are present, but slightly weakened in Simulation 3. Commuter participation increases were considerable at 6.52% and 10.41% for low and high skilled labor. Total low and high skilled labor increased relative to simulations 1 and 2.



All simulations yield similar overall production increases of 12.50%. In Simulation 3, the increase in production for export is greater than Simulations 1 and 2 as local households consume less due to smaller local household

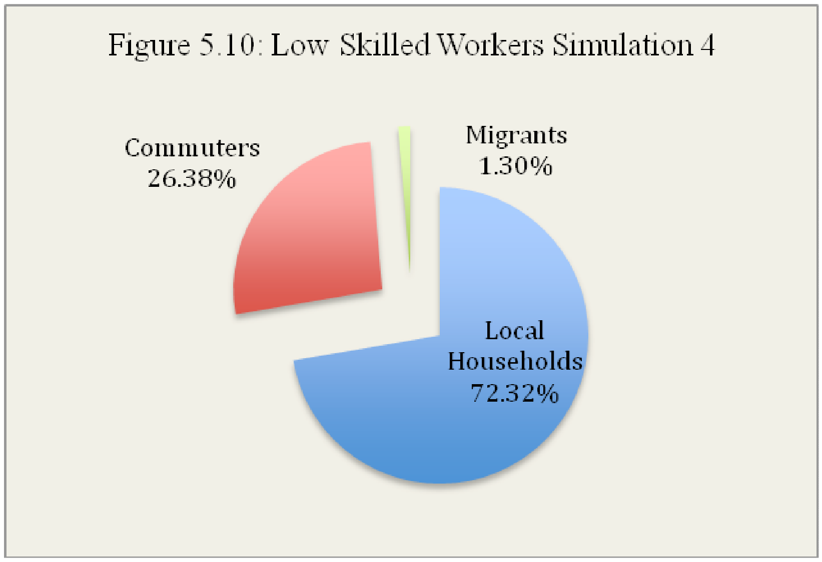


income increases due to a larger share of income leaving the county with commuters. The production shift to exports is also due to smaller migration responses as increased commuting suppressed real wages.

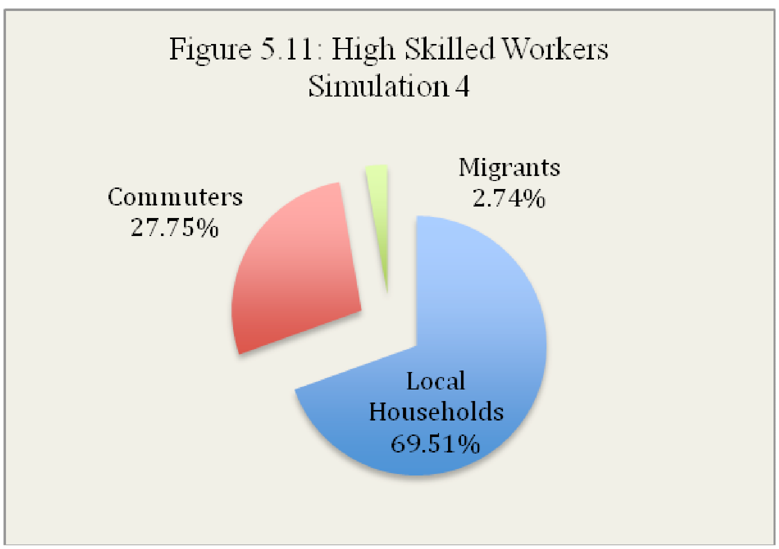
Simulation 4

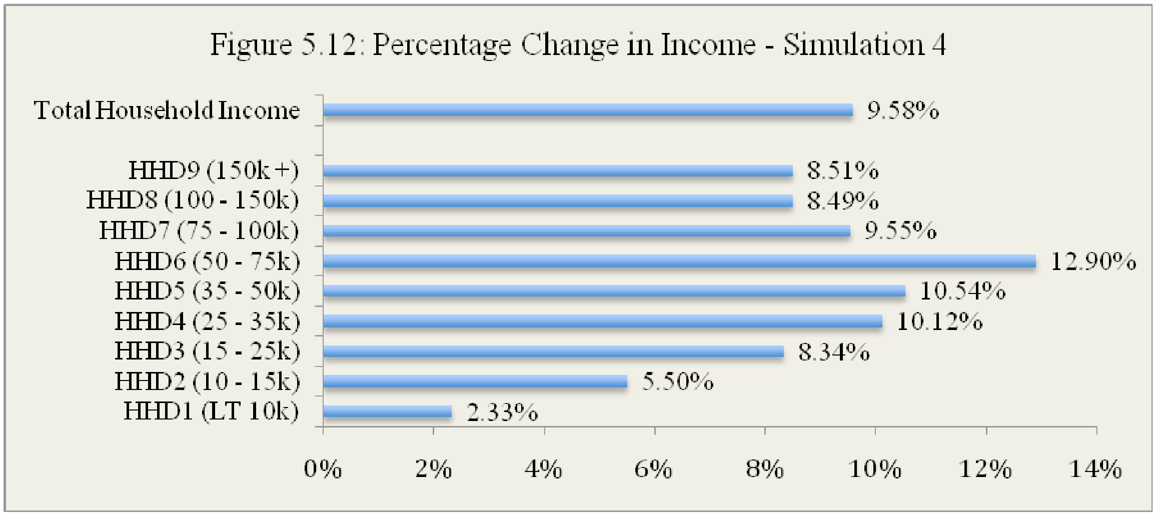
In this simulation, migration elasticities are halved for both low and high skilled workers. Migrants choose locations based on a combination of amenities and real wages. In some locales, increased real wages induce lower migration responses than others largely due to the desirability of the area (Roback 1982, Treyz et al 1993).

Simulation 4 Impacts



With locals, commuters and migrants all competing for local jobs, one would expect a lower migration elasticity to result in higher participation rates for commuters and locals. In Simulation 4, such a result occurs. Local high skilled workers are more affected due to higher mobility for both high skilled migrants and commuters. Local household low skilled worker shares actually increase when compared to





benchmark values. Local household high skilled worker shares decrease relative to the benchmark, but increase relative to the previous two simulations.

As seen in previous simulations, higher participation rates yield increases in local income. Income distribution effects are minimal although as Figure 5.12 indicates, households 3, 4 and 5 all increased their shares.

Simulation 5

In Simulation 5, migration elasticities were doubled for both labor skills. This simulated increased worker mobility. As pointed out earlier, increased amenities enhance the desirability of an area leading to greater migration (Roback 1982, Treyz et al 1993).

Simulation 5 Impacts

Like the commuter simulations, increasing the migration elasticities had the opposite effect of decreasing the same elasticities. Increased mobility made migrants much more responsive to real wage differentials. As a result, migrant workers comprise a larger share of the workforce than in any previous simulation (Figure 5.13, Figure 5.14). Additionally, Simulation 5 resulted in the largest total labor force for both low and high skilled workers. The low skilled labor force increased by 9.28% and the high skilled labor force increased by 8.07%. The quick response of migrants alleviated wage pressure resulting in the smallest nominal (2.95% low, 2.88% high) and real (2.03% low, 1.96% high) wage increases for both skills. Lower real wages led to the smallest local household response of all the simulations. The commuter response to the nominal wage change was also tepid. Only in Simulation 2, when commuter elasticities were halved

Figure 5.13: Low Skilled Workers Simulation 5

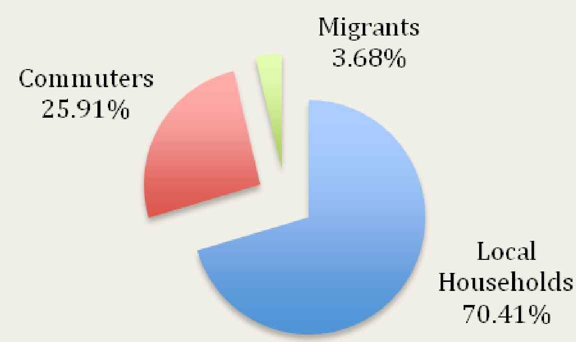
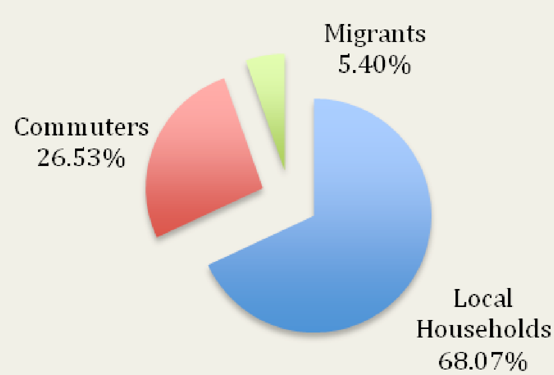


Figure 5.14: High Skilled Workers Simulation 5



was the response smaller.

When coupled with lower wages, local participation rates led to the smallest increase in local household income and consumption. Lower local prices induced by lower local demand caused the largest shift in average export production of all the simulations as firms sought to take advantage of relatively higher export prices.

Figure 5.15: Percentage Change in Income - Simulation 5

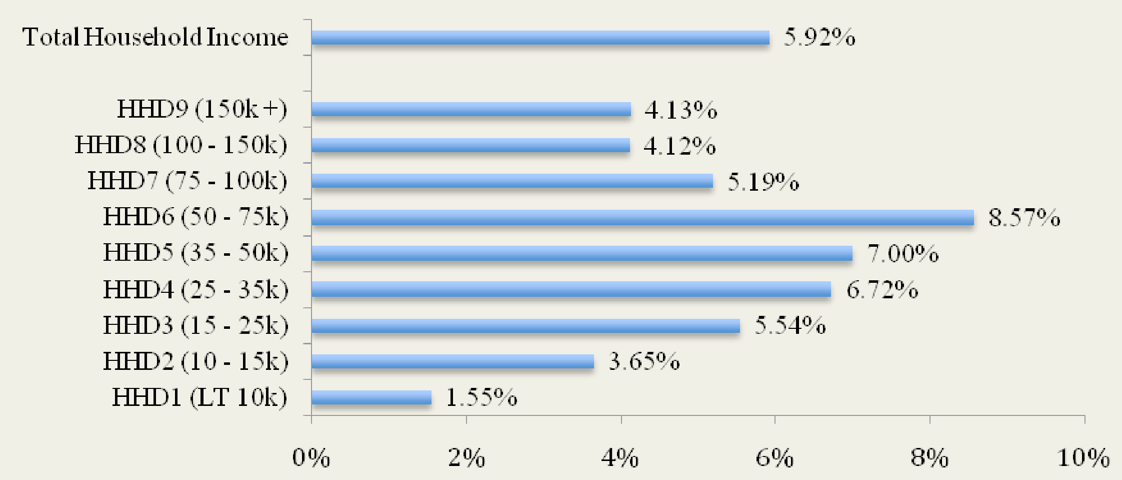


Table 5.1: Regional Development Impacts on Local, Commuter and Migrant Labor Supplies

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Low Skilled Labor											
Local Households	10,900.95	11,753.39	7.82%	11,799.69	8.24%	11,674.93	7.10%	11,872.23	8.91%	11,579.14	6.22%
Commuters											
Nearby Counties	3,776.13	3,925.95	3.97%	3,855.62	2.11%	4,044.69	7.11%	3,955.41	4.75%	3,887.48	2.95%
Other Oklahoma	266.39	267.43	0.39%	266.95	0.21%	268.23	0.69%	267.63	0.46%	267.17	0.29%
Out of State	106.86	106.90	0.04%	106.88	0.02%	106.93	0.07%	106.91	0.05%	106.89	0.03%
Total Commuters	4,149.37	4,300.28	3.64%	4,229.44	1.93%	4,419.85	6.52%	4,329.95	4.35%	4,261.54	2.70%
Migrants	0.00	377.72	*n/a*	397.44	*n/a*	344.12	*n/a*	214.10	*n/a*	605.58	*n/a*
Total Low Skilled Labor	15,050.32	16,431.39	9.18%	16,426.57	9.14%	16,438.89	9.23%	16,416.28	9.08%	16,446.26	9.28%
High Skilled Labor											
Local Households	5,808.76	5,946.77	2.38%	5,962.16	2.64%	5,923.10	1.97%	5,994.19	3.19%	5,899.89	1.57%
Commuters											
Nearby Counties	2,012.17	2,146.76	6.69%	2,085.68	3.65%	2,240.68	11.36%	2,192.49	8.96%	2,099.75	4.35%
Other Oklahoma	141.95	142.87	0.65%	142.46	0.36%	143.49	1.08%	143.17	0.86%	142.56	0.43%
Out of State	56.94	56.98	0.06%	56.96	0.04%	57.00	0.11%	56.99	0.09%	56.96	0.04%
Total Commuters	2,211.06	2,346.61	6.13%	2,285.10	3.35%	2,441.17	10.41%	2,392.65	8.21%	2,299.27	3.99%
Migrants	0.00	353.10	*n/a*	391.97	*n/a*	293.12	*n/a*	236.26	*n/a*	468.16	*n/a*
Total High Skilled Labor	*8,019.82*	*8,646.48*	*7.81%*	*8,639.24*	*7.72%*	*8,657.39*	*7.95%*	*8,623.10*	*7.52%*	*8,667.33*	*8.07%*

Table 5.2: Regional Development Impacts on Local Production
(Millions U.S. Dollars)

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Total Production											
Agriculture	44.70	57.50	28.61%	57.43	28.46%	57.61	28.87%	57.30	28.18%	57.74	29.16%
Mining	7,141.28	7,164.57	0.33%	7,154.83	0.19%	7,180.38	0.55%	7,137.13	-0.06%	7,197.99	0.79%
Utilities	1,461.81	1,583.96	8.36%	1,584.93	8.42%	1,582.25	8.24%	1,586.19	8.51%	1,579.99	8.08%
Construction	2,383.81	2,785.77	16.86%	2,788.56	16.98%	2,781.18	16.67%	2,793.33	17.18%	2,775.87	16.45%
Manufacturing	12,702.06	17,773.64	39.93%	17,759.16	39.81%	17,796.92	40.11%	17,732.01	39.60%	17,822.24	40.31%
Wholesale Trade	2,645.16	3,084.31	16.60%	3,086.65	16.69%	3,080.38	16.45%	3,090.32	16.83%	3,075.61	16.27%
Transportation	2,140.17	2,288.58	6.93%	2,286.00	6.81%	2,292.76	7.13%	2,281.20	6.59%	2,297.36	7.34%
Retail Trade	3,266.20	3,482.94	6.64%	3,491.83	6.91%	3,468.42	6.19%	3,507.36	7.38%	3,451.87	5.68%
Information Services	2,804.24	2,870.06	2.35%	2,866.65	2.23%	2,875.32	2.53%	2,859.48	1.97%	2,880.45	2.72%
Financial Services	4,095.51	4,212.75	2.86%	4,210.49	2.81%	4,215.95	2.94%	4,204.75	2.67%	4,218.30	3.00%
Real Estate	3,179.62	3,363.10	5.77%	3,364.96	5.83%	3,359.89	5.67%	3,367.60	5.91%	3,355.80	5.54%
Professional Services	3,202.99	3,488.40	8.91%	3,485.00	8.80%	3,493.62	9.07%	3,477.79	8.58%	3,498.66	9.23%
Mgmt. of Companies	750.06	867.63	15.67%	867.02	15.59%	868.57	15.80%	865.81	15.43%	869.54	15.93%
Administrative Services	1,851.75	1,889.17	2.02%	1,885.83	1.84%	1,894.62	2.31%	1,879.76	1.51%	1,900.71	2.64%
Education Services	380.05	397.22	4.52%	397.91	4.70%	396.08	4.22%	399.06	5.00%	394.75	3.87%
Health Services	4,645.85	4,762.60	2.51%	4,768.82	2.65%	4,752.18	2.29%	4,778.76	2.86%	4,739.63	2.02%
Arts, Entertainment, Rec.	403.66	429.00	6.28%	430.13	6.56%	427.15	5.82%	432.15	7.06%	425.08	5.31%
Accommodation Services	1,902.14	2,003.49	5.33%	2,007.44	5.54%	1,997.07	4.99%	2,014.42	5.90%	1,989.81	4.61%
Other Services	1,691.68	1,813.31	7.19%	1,815.76	7.34%	1,809.33	6.95%	1,820.10	7.59%	1,804.83	6.69%
Government	7,786.39	8,221.73	5.59%	8,228.77	5.68%	8,210.01	5.44%	8,240.33	5.83%	8,196.11	5.26%
Total County Output	*64,479.13*	*72,539.74*	*12.50%*	*72,538.17*	*12.50%*	*72,539.69*	*12.50%*	*72,524.85*	*12.48%*	*72,532.35*	*12.49%*

Table 5.3: Regional Development Impacts on Export Production
(Millions U.S. Dollars)

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Export Production											
Agriculture	1.67	1.67	-0.49%	1.66	-0.65%	1.67	-0.22%	1.66	-0.93%	1.67	0.09%
Mining	6,326.86	6,228.50	-1.55%	6,219.64	-1.69%	6,242.90	-1.33%	6,203.61	-1.95%	6,258.99	-1.07%
Utilities	324.41	323.85	-0.17%	323.16	-0.39%	324.93	0.16%	321.79	-0.81%	326.03	0.50%
Construction	0.18	0.17	-5.04%	0.17	-5.45%	0.17	-4.38%	0.17	-6.17%	0.18	-3.63%
Manufacturing	8,924.07	13,266.94	48.66%	13,249.39	48.47%	13,295.33	48.98%	13,217.31	48.11%	13,326.78	49.34%
Wholesale Trade	355.20	357.45	0.63%	357.03	0.51%	358.11	0.82%	356.25	0.29%	358.83	1.02%
Transportation	721.35	692.23	-4.04%	689.73	-4.38%	696.33	-3.47%	685.28	-5.00%	700.96	-2.83%
Retail Trade	557.42	553.50	-0.70%	553.04	-0.79%	554.26	-0.57%	552.24	-0.93%	555.12	-0.41%
Information Services	1,549.48	1,521.08	-1.83%	1,517.82	-2.04%	1,526.24	-1.50%	1,511.47	-2.45%	1,531.65	-1.15%
Financial Services	1,638.98	1,599.04	-2.44%	1,594.92	-2.69%	1,605.56	-2.04%	1,586.95	-3.18%	1,612.44	-1.62%
Real Estate	709.70	704.13	-0.78%	703.20	-0.92%	705.65	-0.57%	701.48	-1.16%	707.32	-0.34%
Professional Services	308.05	292.82	-4.95%	291.32	-5.43%	295.20	-4.17%	288.46	-6.36%	297.75	-3.35%
Mgmt. of Companies	49.63	47.75	-3.77%	47.57	-4.14%	48.05	-3.18%	47.22	-4.85%	48.36	-2.55%
Administrative Services	783.33	747.63	-4.56%	744.93	-4.90%	752.09	-3.99%	740.17	-5.51%	757.18	-3.34%
Education Services	80.15	78.72	-1.79%	78.57	-1.97%	78.94	-1.51%	78.30	-2.31%	79.17	-1.22%
Health Services	1,556.39	1,523.64	-2.10%	1,520.83	-2.28%	1,528.15	-1.81%	1,515.62	-2.62%	1,533.09	-1.50%
Arts, Entertainment, Rec.	0.73	0.72	-1.08%	0.72	-1.17%	0.72	-0.92%	0.72	-1.34%	0.72	-0.75%
Accommodation Services	491.58	485.68	-1.20%	485.20	-1.30%	486.48	-1.04%	484.36	-1.47%	487.41	-0.85%
Other Services	296.13	292.05	-1.38%	291.69	-1.50%	292.65	-1.18%	291.06	-1.71%	293.32	-0.95%
Government	354.63	348.20	-1.81%	347.61	-1.98%	349.15	-1.54%	346.50	-2.29%	350.18	-1.25%
Total County Exports	*25,029.96*	*29,065.78*	*16.12%*	*29,018.22*	*15.93%*	*29,142.58*	*16.43%*	*28,930.60*	*15.58%*	*29,227.15*	*16.77%*

Table 5.4: Regional Development Impacts on Production for Local Use
(Millions U.S. Dollars)

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Production for Local Use											
Agriculture	43.03	55.83	29.75%	55.76	29.59%	55.94	30.00%	55.64	29.31%	56.06	30.29%
Mining	814.42	936.07	14.94%	935.19	14.83%	937.48	15.11%	933.52	14.62%	939.00	15.30%
Utilities	1,137.40	1,260.11	10.79%	1,261.77	10.93%	1,257.32	10.54%	1,264.40	11.17%	1,253.97	10.25%
Construction	2,383.62	2,785.60	16.86%	2,788.39	16.98%	2,781.01	16.67%	2,793.16	17.18%	2,775.70	16.45%
Manufacturing	3,778.00	4,506.70	19.29%	4,509.77	19.37%	4,501.59	19.15%	4,514.70	19.50%	4,495.47	18.99%
Wholesale Trade	2,289.96	2,726.87	19.08%	2,729.62	19.20%	2,722.27	18.88%	2,734.07	19.39%	2,716.78	18.64%
Transportation	1,418.82	1,596.35	12.51%	1,596.27	12.51%	1,596.44	12.52%	1,595.92	12.48%	1,596.41	12.52%
Retail Trade	2,708.77	2,929.44	8.15%	2,938.79	8.49%	2,914.16	7.58%	2,955.12	9.09%	2,896.75	6.94%
Information Services	1,254.76	1,348.98	7.51%	1,348.83	7.50%	1,349.08	7.52%	1,348.01	7.43%	1,348.80	7.49%
Financial Services	2,456.52	2,613.72	6.40%	2,615.57	6.47%	2,610.39	6.26%	2,617.81	6.57%	2,605.86	6.08%
Real Estate	2,469.93	2,658.96	7.65%	2,661.76	7.77%	2,654.24	7.46%	2,666.12	7.94%	2,648.48	7.23%
Professional Services	2,894.93	3,195.58	10.39%	3,193.68	10.32%	3,198.41	10.48%	3,189.33	10.17%	3,200.91	10.57%
Mgmt. of Companies	700.43	819.87	17.05%	819.45	16.99%	820.53	17.15%	818.59	16.87%	821.18	17.24%
Administrative Services	1,068.42	1,141.54	6.84%	1,140.90	6.78%	1,142.53	6.94%	1,139.59	6.66%	1,143.54	7.03%
Education Services	299.90	318.51	6.21%	319.34	6.48%	317.15	5.75%	320.76	6.96%	315.57	5.23%
Health Services	3,089.45	3,238.96	4.84%	3,247.98	5.13%	3,224.02	4.36%	3,263.14	5.62%	3,206.54	3.79%
Arts, Entertainment, Rec.	402.93	428.28	6.29%	429.41	6.57%	426.43	5.83%	431.43	7.07%	424.36	5.32%
Accommodation Services	1,410.56	1,517.81	7.60%	1,522.24	7.92%	1,510.58	7.09%	1,530.06	8.47%	1,502.40	6.51%
Other Services	1,395.55	1,521.26	9.01%	1,524.07	9.21%	1,516.68	8.68%	1,529.05	9.57%	1,511.51	8.31%
Government	7,431.76	7,873.53	5.94%	7,881.16	6.05%	7,860.86	5.77%	7,893.83	6.22%	7,845.93	5.57%
Total County Local Use	*39,449.16*	*43,473.97*	*10.20%*	*43,519.96*	*10.32%*	*43,397.11*	*10.01%*	*43,594.26*	*10.51%*	*43,305.20*	*9.77%*

Table 5.5: Regional Development Impacts on Imports
(Millions U.S. Dollars)

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Import Goods											
Agriculture	542.74	707.32	30.32%	707.52	30.36%	706.97	30.26%	707.82	30.42%	706.54	30.18%
Mining	1,996.22	2,317.64	16.10%	2,317.59	16.10%	2,317.69	16.10%	2,317.30	16.08%	2,317.60	16.10%
Utilities	38.23	42.42	10.96%	42.56	11.32%	42.20	10.38%	42.81	11.99%	41.95	9.75%
Construction	6.85	8.39	22.49%	8.43	23.09%	8.32	21.52%	8.50	24.17%	8.25	20.43%
Manufacturing	9,623.02	11,513.39	19.64%	11,526.32	19.78%	11,492.13	19.42%	11,548.24	20.01%	11,467.47	19.17%
Wholesale Trade	143.16	169.65	18.50%	169.98	18.73%	169.12	18.14%	170.54	19.12%	168.52	17.72%
Transportation	393.22	459.30	16.81%	460.79	17.19%	456.88	16.19%	463.42	17.85%	454.12	15.49%
Retail Trade	145.99	158.74	8.74%	159.35	9.15%	157.75	8.05%	160.41	9.88%	156.62	7.28%
Information Services	1,446.97	1,582.00	9.33%	1,584.91	9.53%	1,577.26	9.00%	1,590.00	9.89%	1,571.86	8.63%
Financial Services	1,605.83	1,747.34	8.81%	1,752.69	9.15%	1,738.67	8.27%	1,762.20	9.74%	1,728.92	7.67%
Real Estate	709.96	769.79	8.43%	771.53	8.67%	766.92	8.02%	774.51	9.09%	763.62	7.56%
Professional Services	643.62	743.99	15.59%	747.01	16.06%	739.18	14.85%	752.73	16.95%	734.01	14.04%
Mgmt. of Companies	332.72	394.02	18.43%	394.28	18.50%	393.60	18.30%	394.74	18.64%	393.14	18.16%
Administrative Services	450.90	502.63	11.47%	504.00	11.78%	500.36	10.97%	506.37	12.30%	497.73	10.39%
Education Services	99.94	107.63	7.69%	108.06	8.12%	106.93	7.00%	108.83	8.89%	106.16	6.22%
Health Services	243.71	259.72	6.57%	260.81	7.02%	257.93	5.84%	262.72	7.80%	255.90	5.00%
Arts, Entertainment, Rec.	104.56	112.07	7.18%	112.45	7.54%	111.45	6.59%	113.12	8.19%	110.76	5.93%
Accommodation Services	165.41	179.65	8.61%	180.31	9.01%	178.56	7.95%	181.47	9.71%	177.34	7.21%
Other Services	225.46	253.76	12.55%	254.96	13.08%	251.82	11.69%	257.08	14.02%	249.62	10.71%
Government	195.41	209.96	7.45%	210.44	7.69%	209.18	7.05%	211.29	8.13%	208.31	6.60%
Total County Imports	*19,113.90*	*22,239.40*	*16.35%*	*22,273.97*	*16.53%*	*22,182.91*	*16.06%*	*22,334.11*	*16.85%*	*22,118.43*	*15.72%*

Table 5.6: Regional Development Impacts on Composite Good Demand
(Millions U.S. Dollars)

	Benchmark	Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
		Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Local C.G. Demand											
Agriculture	0.48	0.54	12.50%	0.54	12.50%	0.54	12.50%	0.54	12.48%	0.54	12.49%
Mining	4.07	4.58	12.50%	4.58	12.50%	4.58	12.50%	4.58	12.48%	4.58	12.49%
Utilities	90.59	101.92	12.50%	101.91	12.50%	101.92	12.50%	101.90	12.48%	101.91	12.49%
Construction	622.38	700.18	12.50%	700.17	12.50%	700.18	12.50%	700.04	12.48%	700.11	12.49%
Manufacturing	105.72	118.94	12.50%	118.94	12.50%	118.94	12.50%	118.91	12.48%	118.93	12.49%
Wholesale Trade	63.44	71.37	12.50%	71.37	12.50%	71.37	12.50%	71.36	12.48%	71.37	12.49%
Transportation	44.28	49.82	12.50%	49.81	12.50%	49.82	12.50%	49.80	12.48%	49.81	12.49%
Retail Trade	0.38	0.42	12.50%	0.42	12.50%	0.42	12.50%	0.42	12.48%	0.42	12.49%
Information Services	45.95	51.70	12.50%	51.70	12.50%	51.70	12.50%	51.69	12.48%	51.69	12.49%
Financial Services	60.62	68.20	12.50%	68.20	12.50%	68.20	12.50%	68.18	12.48%	68.19	12.49%
Real Estate	71.45	80.38	12.50%	80.38	12.50%	80.38	12.50%	80.37	12.48%	80.37	12.49%
Professional Services	111.27	125.18	12.50%	125.17	12.50%	125.18	12.50%	125.15	12.48%	125.16	12.49%
Mgmt. of Companies	0.00	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Administrative Services	60.80	68.40	12.50%	68.40	12.50%	68.40	12.50%	68.39	12.48%	68.40	12.49%
Education Services	8.00	9.00	12.50%	9.00	12.50%	9.00	12.50%	8.99	12.48%	8.99	12.49%
Health Services	15.87	17.85	12.50%	17.85	12.50%	17.85	12.50%	17.85	12.48%	17.85	12.49%
Arts, Entertainment, Rec.	1.13	1.27	12.50%	1.27	12.50%	1.27	12.50%	1.27	12.48%	1.27	12.49%
Accommodation Services	44.51	50.08	12.50%	50.08	12.50%	50.08	12.50%	50.07	12.48%	50.07	12.49%
Other Services	48.40	54.46	12.50%	54.45	12.50%	54.46	12.50%	54.44	12.48%	54.45	12.49%
Government	2,211.75	2,488.25	12.50%	2,488.19	12.50%	2,488.24	12.50%	2,487.74	12.48%	2,487.99	12.49%
Total Composite Good Demand	*3,611.11*	*4,062.54*	*12.50%*	*4,062.45*	*12.50%*	*4,062.53*	*12.50%*	*4,061.70*	*12.48%*	*4,062.12*	*12.49%*

Table 5.7: Regional Development Impacts on Household Income and Consumption
(Millions U.S. Dollars)

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Household Income											
HHD1 (LT 10k)	1,273.92	1,299.42	2.00%	1,301.01	2.13%	1,296.78	1.79%	1,303.60	2.33%	1,293.64	1.55%
HHD2 (10 - 15k)	904.54	947.30	4.73%	949.96	5.02%	942.86	4.24%	954.31	5.50%	937.60	3.65%
HHD3 (15 - 25k)	1,986.59	2,128.99	7.17%	2,137.85	7.61%	2,114.23	6.42%	2,152.34	8.34%	2,096.69	5.54%
HHD4 (25 - 35k)	2,299.48	2,499.45	8.70%	2,511.88	9.24%	2,478.71	7.79%	2,532.23	10.12%	2,454.09	6.72%
HHD5 (35 - 50k)	3,532.52	3,852.28	9.05%	3,872.16	9.61%	3,819.12	8.11%	3,904.70	10.54%	3,779.76	7.00%
HHD6 (50 - 75k)	4,666.57	5,183.67	11.08%	5,215.82	11.77%	5,130.05	9.93%	5,268.44	12.90%	5,066.39	8.57%
HHD7 (75 - 100k)	2,671.62	2,870.87	7.46%	2,889.76	8.17%	2,841.18	6.35%	2,926.69	9.55%	2,810.20	5.19%
HHD8 (100 - 150k)	2,358.54	2,507.40	6.31%	2,524.23	7.03%	2,481.46	5.21%	2,558.75	8.49%	2,455.63	4.12%
HHD9 (150k +)	1,952.13	2,075.61	6.33%	2,089.57	7.04%	2,054.10	5.22%	2,118.20	8.51%	2,032.67	4.13%
Total Household Income	21,645.91	23,365.00	7.94%	23,492.24	8.53%	23,158.49	6.99%	23,719.26	9.58%	22,926.68	5.92%
HHD Consumption Demand											
Agriculture	111.45	119.80	7.50%	120.38	8.02%	118.86	6.65%	121.40	8.93%	117.78	5.68%
Mining	122.50	131.50	7.35%	132.12	7.86%	130.48	6.52%	133.22	8.75%	129.32	5.57%
Utilities	443.15	475.58	7.32%	477.37	7.72%	472.59	6.64%	480.35	8.39%	469.08	5.85%
Construction	0.00	0.00	*n/a*	0.00	*n/a*	0.00	*n/a*	0.00	*n/a*	0.00	*n/a*
Manufacturing	3,718.19	3,995.12	7.45%	4,014.18	7.96%	3,963.97	6.61%	4,047.57	8.86%	3,928.54	5.66%
Wholesale Trade	840.19	910.15	8.33%	913.48	8.72%	904.66	7.67%	919.12	9.39%	898.26	6.91%
Transportation	433.93	459.60	5.92%	461.32	6.31%	456.78	5.27%	464.38	7.02%	453.60	4.53%
Retail Trade	2,183.61	2,331.16	6.76%	2,340.61	7.19%	2,315.73	6.05%	2,357.17	7.95%	2,298.18	5.25%
Information Services	712.01	762.87	7.14%	766.33	7.63%	757.22	6.35%	772.33	8.47%	750.76	5.44%
Financial Services	1,618.53	1,732.18	7.02%	1,739.77	7.49%	1,719.72	6.25%	1,752.89	8.30%	1,705.40	5.37%
Real Estate	880.44	941.58	6.94%	945.33	7.37%	935.38	6.24%	951.65	8.09%	928.15	5.42%
Professional Services	301.98	318.78	5.56%	319.76	5.89%	317.15	5.02%	321.38	6.42%	315.20	4.38%
Mgmt. of Companies	0.00	0.00	*n/a*	0.00	*n/a*	0.00	*n/a*	0.00	*n/a*	0.00	*n/a*
Administrative Services	102.94	109.05	5.93%	109.47	6.35%	108.35	5.26%	110.23	7.08%	107.57	4.50%
Education Services	313.41	331.75	5.85%	333.00	6.25%	329.71	5.20%	335.19	6.95%	327.39	4.46%
Health Services	3,267.96	3,430.16	4.96%	3,440.20	5.27%	3,413.55	4.46%	3,457.16	5.79%	3,394.18	3.86%
Arts, Entertainment, Rec.	329.22	350.53	6.47%	352.03	6.93%	348.09	5.73%	354.72	7.75%	345.37	4.91%
Accommodation Services	1,150.30	1,224.22	6.43%	1,229.29	6.87%	1,215.97	5.71%	1,238.33	7.65%	1,206.69	4.90%
Other Services	995.55	1,055.30	6.00%	1,059.37	6.41%	1,048.69	5.34%	1,066.67	7.14%	1,041.29	4.59%
Government	2,364.51	2,493.48	5.45%	2,501.65	5.80%	2,480.03	4.89%	2,515.71	6.39%	2,464.51	4.23%
Ttal Houshold Consumption	*19,889.88*	*21,172.82*	*6.45%*	*21,255.69*	*6.87%*	*21,036.94*	*5.77%*	*21,399.48*	*7.59%*	*20,881.28*	*4.98%*

Table 5.8: Price Index and Wages

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Price Index (Laspeyres)	1.00	1.01	1.39%	1.02	1.54%	1.01	1.16%	1.02	1.81%	1.01	0.90%
Low Skilled Wages											
Nominal Wage	1.00	1.04	3.97%	1.04	4.25%	1.03	3.49%	1.05	4.75%	1.03	2.95%
Real Wage	1.00	1.03	2.54%	1.03	2.68%	1.02	2.31%	1.03	2.89%	1.02	2.03%
High Skilled Wages											
Nominal Wage	1.00	1.04	4.41%	1.05	4.90%	1.04	3.65%	1.06	5.89%	1.03	2.88%
Real Wage	1.00	1.03	2.98%	1.03	3.31%	1.02	2.47%	1.04	4.01%	1.02	1.96%

Table 5.9: Commuter Income
(Millions U.S. Dollars)

		Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5	
	Benchmark	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change	Sim	% Change
Nearby Counties											
Canadian	1,478.80	1,615.45	9.24%	1,585.90	7.24%	1,662.80	12.44%	1,651.63	11.69%	1,574.36	6.46%
Cleveland	2,738.43	2,991.47	9.24%	2,936.77	7.24%	3,079.16	12.44%	3,058.47	11.69%	2,915.40	6.46%
Grady	283.76	309.98	9.24%	304.32	7.24%	319.07	12.44%	316.93	11.69%	302.10	6.46%
Lincoln	216.86	236.90	9.24%	232.57	7.24%	243.84	12.44%	242.20	11.69%	230.87	6.46%
Logan	493.70	539.32	9.24%	529.46	7.24%	555.13	12.44%	551.40	11.69%	525.61	6.46%
McClain	226.09	246.98	9.24%	242.46	7.24%	254.22	12.44%	252.51	11.69%	240.70	6.46%
Pottawatomie	350.67	383.07	9.24%	376.06	7.24%	394.30	12.44%	391.65	11.69%	373.33	6.46%
Total Nearby Counties	*5,788.30*	*6,323.17*	9.24%	*6,207.54*	7.24%	*6,508.53*	12.44%	*6,464.79*	11.69%	*6,162.37*	6.46%
All Other Oklahoma Counties	408.34	427.21	4.62%	427.75	4.75%	426.33	4.40%	431.94	5.78%	421.71	3.27%
Other States	163.80	170.63	4.17%	171.18	4.51%	169.75	3.63%	172.33	5.21%	168.65	2.96%
Total Commuter Income	*6,360.44*	*6,921.02*	8.81%	*6,806.47*	7.01%	*7,104.60*	11.70%	*7,069.06*	11.14%	*6,752.72*	6.17%

CHAPTER VI

STUDY CONCLUSIONS AND AREAS FOR FURTHER RESEARCH

Summary

Local development initiatives have enjoyed wide support in Oklahoma, and in particular the Oklahoma City Metropolitan Statistical Area (MSA) since the early 1990s. Many native residents were skeptical when the Metropolitan Area Projects (MAPS) initiative was proposed by then mayor Ron Norrick. Perhaps the best indicator of the success of the MAPS projects is the results from the MAPS for Kids ballot initiative and the existing interest in a potential MAPS3 proposal by current Mayor Mick Cornett.[22] The sense of pride in a vibrant, developing local area is undeniable. The city has recently received a National Basketball Association (NBA) team – a testament to the success of the MAPS initiatives.

While the voters of Oklahoma County believe that development initiatives are beneficial to growth and prospects of local residents, regional economists have mixed opinions. Certainly, the goal of any initiative should be to provide benefits to the local voters who approved such an initiative. Whether local unemployment rates are high or labor force participation is low, development initiatives are often implemented to benefit

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[22] For information about all MAPS initiatives, see the MAPS3 website www.maps3.org.

local workers. Winnick (1966) decried, however, that the primary beneficiaries were the real estate agents, bankers and migrants with little or no benefit accruing to the local target population. Marston (1985) found evidence that local labor force shocks are eliminated by mobility within a year. Blanchard and Katz (1992) found mixed results for labor force participation rates due to different model specifications. Bartik (1991) found evidence that local development does increase local labor force participation rates. While focusing on the migrant versus local resident discussion, these studies rarely address commuters as competitors for local jobs and thus the benefits they provide. Bartik (1993) discussed the need to specify a model that delineated labor groups by skill (and thus migration propensities) to estimate the effects of policies on different income groups without mention of commuters. The OKCGE addresses the local beneficiary question by incorporating two skill groups, nine local representative households, migrants and commuters from multiple regions. This design provides a more complete specification of the local labor market, as it is sensitive to commuter and labor skill issues not addressed in previous studies.

Study Objectives and Methodology

The objectives of the study are to estimate the effects of local development on local residents, migrants and commuters. The primary question addressed is whether the local residents who approve development projects receive pecuniary benefits that result. A secondary question concerns the distribution of local benefits between local households of disparate income classes. Lastly, the study addresses the impact of commuters who, like migrants, respond to wage differentials and enter the local labor market to take advantage of nominal wage disparities between the study area labor market and their primary location of residence.

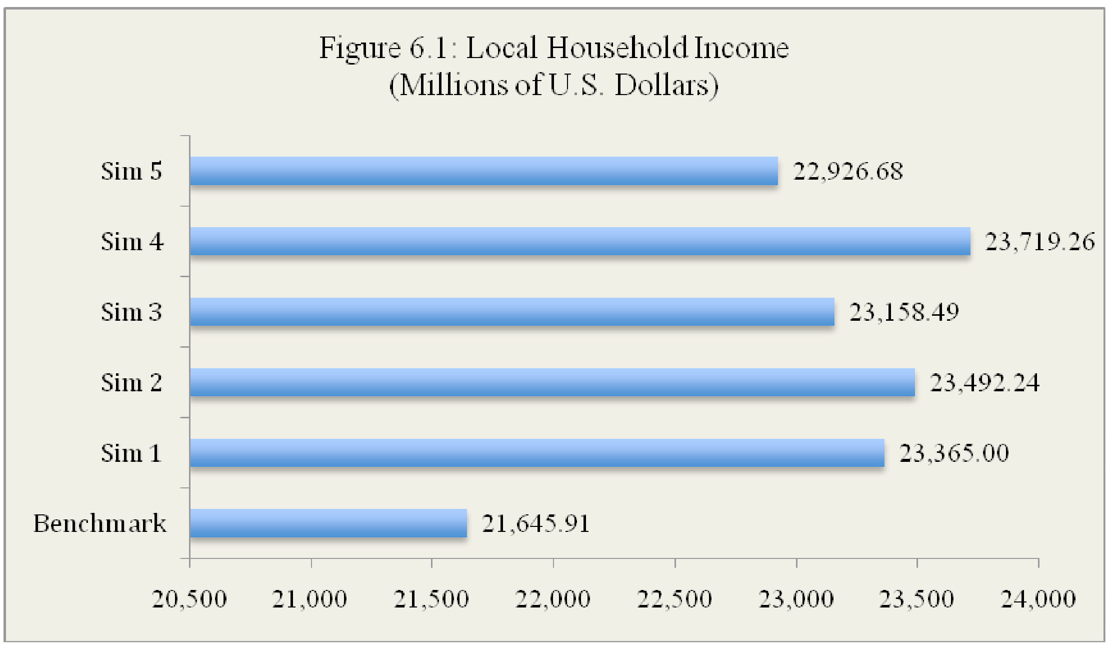
A Computable General Equilibrium (CGE) model is used to incorporate the necessary economic linkages to represent the Oklahoma County region. The modeled labor market includes Oklahoma County residents as well as commuters from the surrounding counties within the Oklahoma City MSA, commuters from the remaining Oklahoma counties and commuters from out of state based on current commuter patterns. The model segregates local households, commuters and migrants to provide a long run analysis of the impacts of local development on each.

The data for this research was compiled primarily from the IMPLAN 2004 data set for Oklahoma. Using IMPLAN, labor demand by skill estimated from national labor data and local IMPLAN labor payments, and commuter data estimated from Oklahoma commuter patterns, a micro-consistent database was created and read into the model. The model is created using the General Algebraic Modeling System (GAMS) programming language and solved with a CONOPT nonlinear solver.

Local development is simulated by incorporating an export demand shock to the manufacturing sector consistent with a 50% increase in final demand. Five separate simulations incorporating ranges of commuting and migration propensities are run to estimate the development effects on the local residents. Income changes for nine local households are reported to provide clarity to the primary study objective.

Study Conclusions

Five simulations were run to demonstrate the impacts of local development policy. The first simulation used reasonable commuter and migration elasticity estimates to demonstrate the impact local development has on local residents who are the target of the development. The simulation reported that local residents, commuters and migrants all benefited from development. Local household income increased by 7.83% on average with positive income increases for all nine household groups. While the increases were not distributed uniformly, they were significant for most cohorts. The middle to mid-



high income groups benefited the most, while the two poorest income groups benefited the least. Indeed, the lowest income group only received a 2% increase in income. However, this increase is likely understated due to unreported income in benchmark data. Local income effects from all simulations are illustrated in Figure 6.1.

Commuter and migrant benefits are evidenced in the fact that they chose to increase their participation in the regional workforce as a result of the development policy. The tangible benefits measured by this model are increased income by commuters and migrants. Nearby counties received a 9.24% increase in income flowing from the study region due to increased commuting from nearby residents. Commuter income effects were distributed to other Oklahoma counties and other states also.

Simulations 2 and 3 measured the development impacts with variable commuter rates to provide a range of possible outcomes. In Simulation 2, low commuter elasticities led to lower commuter participation and higher local and migrant participation. Local resident income increased by 0.59% points over aggregate income from Simulation 1 as local participation increased by 0.42% and 0.26% points over rates reported from Simulation 1 for low and high skilled residents respectively. Increasing commuter elasticities in Simulation 3 served to increase commuter income while decreasing resident income and migration.

Simulations 4 and 5 measured the development impacts with variable migration elasticities to estimate a range of local outcomes in the face of changing migration. Migration decreased in Simulation 4 and increased in Simulation 5. Fewer migrants led to increased local participation rates and income and increased commuter participation and income when compared to Simulation 1. Increased migration led to decreased local and commuter participation and income.

Migration had the greatest impact on local income as changing migration elasticities provided the largest variation, however, all simulations provided local residents with increased income. All local households benefited the most from decreased migration as demonstrated by Simulation 4 with middle-income households (HHD4 – HHD6) receiving the greatest boost. Indeed the middle-income households increased their aggregate share of household income from 48.5% to 49.3%. This increase in middle-income shares derived mostly from the three lowest income households. Their share of total household income declined from 19.2% to 18.6% leaving the highest-income households (HHD7 – HHD9) losing only 0.2% points of the aggregate distribution from 32.26% to 32.06%.

The OKCGE demonstrates that regardless of whether commuter or migration elasticities are high or low, local residents do indeed benefit from local development as all households experienced income increases in all simulations. Additionally, these results provide some insight into the equity vs. efficiency tradeoff for development policy. In this particular case, development increased income for all households, but at unequal distributional rates.

Study Limitations

This study is limited by several factors including the accuracy and availability of local data including, but not limited to the supply and demand of specific labor skills and commuter and migrant elasticities. Labor by skill was attributed to local households and commuters based on ad-hoc assumptions that may not represent the actual distribution. Labor demand by skill was based on total labor payments by sector as given by IMPLAN and a national labor demand by skill matrix developed from data reported by the Bureau of Labor Statistics. Local firms may require different skill shares as industries may differ across regions.

Migration elasticities were taken from a model developed for the California economy. These elasticities are specific to California and the wage/amenity mix that is unique to that region. As such, it is not likely that they represent Oklahoma migration rates. The study attempted to account for possible discrepancies by running simulations with increased and decreased elasticities to provide sensitivity analysis.

The commuter elasticities are particularly problematic because they are based on conjecture alone. As stated in Chapter 4, actual elasticities are not available, and difficult if not impossible to estimate. As in the migration elasticity case, a range of commuter elasticities was used to provide sensitivity analysis.

Areas for Further Research

This study provides the long run impacts of development on local residents, commuters and migrants. It addresses these impacts through changes in income. Another study should address tax implications for the study and commuter regions. A sophisticated tax model that might report changes to income, property, sales and other taxes would be of particular interest to policymakers. Simulations could provide information about the optimality of the local tax mix and provide guidance concerning possible tax changes available due to increased development. Such a model would require specific linkages between actual government services and tax receipts at the city and county level. Unfortunately, difficulty may arise when compiling such data.

Other benefits and costs could also be studied. Agglomeration effects could lead to exponential growth not accounted for in the current model. These effects would require extensive knowledge of the study area as it relates to the optimal city size literature. Such a study would also need to include congestion and environmental impacts.

Regional cooperation impacts could be more specifically modeled using a multi-region model that incorporated all of the distinct features of the OKCGE as well as those not included but addressed in the preceding paragraphs. There may be a multitude of benefits and costs that accrue to nearby and distant regions due to increased commuting such as increased road use and congestion, decreased (or increased) local development in the commuter region, increased quality of life effects due to increased amenities, etc. Such a study might provide policymakers with a more accurate estimate of the costs and benefits of regional cooperation leading to the appropriate coordination of regional governments.

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APPENDIX A

VARIABLES, PARAMETERS, EQUATIONS

APPENDIX A.1

CGE PRIMARY MODEL EQUATIONS

Firms

Capital Demand

(3.5) $$CapitalDemand = \gamma F^{\sigma F} \cdot PCapital^{-\sigma F} \cdot (\gamma F^{\sigma F} \cdot PCapital^{(1-\sigma F)} + (1 - \gamma F) \cdot PLabor^{(1-\sigma F)})^{\sigma F/(1-\sigma F)} \cdot (TotalOuput/\alpha F)$$

Aggregate Labor Demand

(3.6) $$LaborDemand = (1 - \gamma F)^{\sigma F} \cdot PLabor^{-\sigma F} \cdot (\gamma F^{\sigma F} \cdot PCapital^{(1-\sigma F)} + (1 - \gamma F) \cdot PLabor^{(1-\sigma F)})^{\sigma F/(1-\sigma F)} \cdot (TotalOuput/\alpha F)$$

High Skilled Labor Demand

(3.8) $$LaborHDemand = \gamma L^{\sigma L} \cdot PLaborH^{-\sigma L} \cdot (\gamma L^{\sigma L} \cdot PLaborH^{(1-\sigma L)} + (1 - \gamma L) \cdot PLaborL^{(1-\sigma L)})^{\sigma L/(1-\sigma L)} \cdot (LaborDemand/\alpha L)$$

Low Skilled Labor Demand

(3.9) $$LaborLDemand = (1 - \gamma L)^{\sigma L} \cdot PLaborL^{-\sigma L} \cdot (\gamma L^{\sigma L} \cdot PLaborH^{(1-\sigma L)} + (1 - \gamma L) \cdot PLaborL^{(1-\sigma L)})^{\sigma L/(1-\sigma L)} \cdot (LaborDemand/\alpha L)$$

Aggregate Labor Demand Zero Profit

(3.7) $$PLabor \cdot LaborDemand = PLaborH \cdot LaborHDemand + PLaborL \cdot LaborLDemand$$

Zero Profit

(3.12) $$POutput \cdot TotalOutput = PCapital \cdot CapitalDemand + PLaborH \cdot LaborHDemand + PLaborL \cdot LaborLDemand + \Sigma_j InputOuput_{ji} \cdot TotalOuput \cdot PComposite + misccost0$$

Extra-regional Sector

Export Demand

(3.11) $$ExportDemand = exportdemand0 \cdot (PWorld / POutput)^{\sigma exp}$$

Armington Import Demand

(3.22) $$ImportDemand = \gamma A^{\sigma A} \cdot PWorld^{-\sigma A} \cdot (\gamma A^{\sigma A} \cdot PWorld^{(1 - \sigma A)} + (1 - \gamma A)^{\sigma A} \cdot PLocal^{(1 - \sigma A)})^{\sigma A / (1 - \sigma A)} \cdot (CompositeGood / \alpha A)$$

Armington Local Demand

(3.23) $$LocalDemandForLocal = (1 - \gamma A)^{\sigma A} \cdot PLocal^{-\sigma A} \cdot (\gamma A^{\sigma A} \cdot PWorld^{(1 - \sigma A)} + (1 - \gamma A)^{\sigma A} \cdot PLocal^{(1 - \sigma A)})^{\sigma A / (1 - \sigma A)} \cdot (CompositeGood / \alpha A)$$

Armington Zero Profit

(3.24) $$PComposite \cdot CompositeGood = PWorld \cdot ImportDemand + PLocal \cdot LocalDemandForLocal$$

Households, Migrants and Commuters

Consumption (CES)

(3.15) $$HHDConsumption_i = \alpha cons_i^{\sigma cons} \cdot CBUD / PComposite_i^{\sigma cons} \cdot \Sigma_j \alpha cons_j \cdot PComposite_j^{(1-\sigma cons)}$$

(3.40) $$MigrantHConsumption_i = \alpha cons_i^{\sigma cons} \cdot (MigrantLaborHSupply / HHDLaborHSupply) \cdot CBUD / PComposite_i^{\sigma cons} \cdot \Sigma_j \alpha cons_j \cdot PComposite_j^{(1-\sigma cons)}$$

(3.41) $$MigrantLConsumption_i = \alpha cons_i^{\sigma cons} \cdot (MigrantLaborLSupply / HHDLaborLSupply) \cdot CBUD / PComposite_i^{\sigma cons} \cdot \Sigma_j \alpha cons_j \cdot PComposite_j^{(1-\sigma cons)}$$

Income

(3.13) $$HHDIncome = PCapital \cdot HHDCapitalSupply + PLaborH \cdot HHDLaborHSupply + PLaborL \cdot HHDLaborLSupply + hhdmiscincome0$$

(3.14) $$CBUD = (1 - mps) \cdot HHDIncome$$

Labor Supplies

(3.32) $$LocalHLabor = localhlabor0 \cdot ((PLaborH / CPI) / (plaborh0 / cpi0))^{\sigma laborh}$$

(3.33) $$LocalLLabor = localllabor0 \cdot ((PLaborL / CPI) / (plaborl0 / cpi0))^{\sigma laborl}$$

(3.34) $$MigrantLaborHSupply = laborHsupply0 \cdot sigmaLaborH \cdot \log((PLaborH / CPI) / (plaborh0 / cpi0))$$

(3.35) $$MigrantLaborLSupply = laborLsupply0 \cdot sigmaLaborL \cdot \log((PLaborL / CPI) / (plaborl0 / cpi0))$$

(3.36) $$CommuterHLabor = commuterhlabor0 \cdot (PLaborH / plaborh0)^{\sigma comlaborh}$$

(3.37) $$CommuterLLabor = commuterllabor0 \cdot (PLaborL / plaborl0)^{\sigma comlaborl}$$

(3.38) $$LaborHSupply = HHDLaborHSupply + MigrantLaborHSupply + CommuterHLabor$$

(3.39) $$LaborLSupply = HHDLaborLSupply + MigrantLaborLSupply + CommuterLLabor$$

<u>Government</u>

(3.17) $$StateLocalGovtDemand = statelocalgovtdemand0 \cdot (TotalOutput / totaloutput0)$$

<u>Market Clearing</u>

(3.25) $$CapitalDemand = CapitalSupply$$

(3.27) $$LaborHDemand = LaborHSupply$$

(3.28) $$LaborLDemand = LaborLSupply$$

(3.29) $$CompositeGood = \Sigma j\ (InputOutputij \cdot TotalOutput) + StateLocalGovtDemand + HHDConsumption + InvestmentDemandLocal + MigrantLConsumption + MigrantHConsumption + fedgovtdemand0$$

(3.30) $$TotalOutput = ExportDemand + LocalDemandForLocal$$

<u>Investment</u>

(3.18) $$Investment = investment0 \cdot (CapitalDemand / capitaldemand0)$$

(3.19) $$InvestmentDemandLocal = investmentdemandlocal0 \cdot (Investment / investment0)$$

APPENDIX A.2

VARIABLE AND PARAMETER DEFINITIONS

Variables

Variable	*Description*
misccost	Miscellaneous costs included for zero profit balance (U.S. Dollars / year)
CapitalDemand	Aggregate capital demand (U.S. Dollars / year)
CompositeGood	Aggregated import and local good for local consumption (U.S. Dollars / year)
LocalDemandForLocal	Local demand for local production (U.S. Dollars / year)
ExportDemand	Export demand for local production (U.S. Dollars / year)
HHDCapitalSupply	Local household capital ownership (U.S. Dollars / year)
HHDConsumption	Local household consumption demand (U.S. Dollars / year)
CBUD	Local household disposable income used for consumption (U.S. Dollars / year)
HHDIncome	Local household total income (U.S. Dollars / year)
HHDLaborSupply	Local household labor supply (U.S. Dollars / year)
ImportDemand	Local demand for imported goods (U.S. Dollars / year)
InputOutput	Input output coefficients matrix (U.S. Dollars / year)
LaborDemand	Aggregate labor demand (U.S. Dollars / year)
LaborHDemand	High skilled labor demand (U.S. Dollars / year)
LaborLDemand	Low skilled labor demand (U.S. Dollars / year)
PCapital	Price of aggregate capital (U.S. Dollars)
PComposite	Price of composite Armington good (U.S. Dollars)
PLocal	Price of local production in local market (U.S. Dollars)
PLabor	Price of aggregate labor (U.S. Dollars)
PLaborH	Price of high skilled labor (U.S. Dollars)
PLaborL	Price of low skilled labor (U.S. Dollars)
POutput	Price of total output produced by local firms (U.S. Dollars)
PWorld	World price of sectoral production – exogenously fixed (U.S. Dollars)

StateLocalGovtDemand	Local government demand for local production (U.S. Dollars / year)
TotalOutput	Total production by local producers (U.S. Dollars / year)

Parameters

Parameter	*Description*
αA	Technology shift parameter – Armington aggregator function
αcons	Household CES consumption share parameter
αF	Technology shift parameter – Value added aggregator function
αL	Technology shift parameter – Labor aggregator function
γA	Share parameter – Armington aggregator function
γF	Share parameter – Value added aggregator function
γL	Share parameter – Labor aggregator function
σA	Elasticity of substitution – Armington aggregator function
σcons	Elasticity of substitution in consumption
σexp	Export demand elasticity
σF	Elasticity of substitution – Value added aggregator function
σL	Elasticity of substitution – Labor aggregator function
σMigLaborH	High Skilled Labor Migration Elasticity
σMigLaborL	Low Skilled Labor Migration Elasticity

APPENDIX B

GAMS CODE

APPENDIX B.1

GAMS CODE LISTING

```
$Title OK County Regional Cooperation CGE
$Stitle 2008 Dissertation Model
$Stitle Kyle Dean
$Stitle Oklahoma State University

********************************************************************************
*                                                                              *
* The OKCGE uses Oklahoma County data to determine the impact of local         *
* development policies on local residents, commuters and migrants.  It also    *
* decomposes local impacts by income distribution.  Five simulations are       *
* performed using various labor force participation, commuter and migration    *
* scenarios.                                                                   *
*                                                                              *
* The OKCGE was created by Kyle Dean for the purpose of fulfilling             *
* dissertation requirements for Oklahoma State University, Department of       *
* Economics, Fall 2008.                                                        *
*                                                                              *
* The OKCGE is comprised of 6 modules to perform the following functions:      *
*                                                                              *
* - OKCGE Master.gms - Master Control Module used to call all other modules    *
* - OKCGE Microdata.gms - Input Microdata Set                                  *
* - OKCGE Calibration.gms - Calibrate Model Parameters                         *
* - OKCGE Calibration Check.gms - Check Calibration of Model Parameters        *
* - OKCGE Model.gms - Set Model Variables and Equations and Run Simulations    *
* - OKCGE Report Writer.gms - Report Simulation Results                        *
* - OKCGE Excel.gms - Place Results into Parameter and Unload to Excel         *
*                                                                              *
********************************************************************************


*######################### Master Control Module ###############################


********************************************************************************
*                                                                              *
* PROGPATH is the folder where the primary gams program files are located.     *
*                                                                              *
********************************************************************************

$setglobal PROGPATH C:\gamsdat\Diss08\OKCGE\

********************************************************************************
*                                                                              *
* DATAPATH is the folder where the IMPLAN data files are located.              *
*                                                                              *
********************************************************************************

$setglobal DATAPATH C:\gamsdat\Diss08\OKCGE\

* Declare Parameters and Set Benchmark Values

$include '%PROGPATH%OKCGE Microdata.gms'

hhdconsumption0(sec,h) = hhddomesticconsumption0(sec,h)
         + hhdimportconsumption0(sec,h);
cbud0(h) = sum(sec, hhdconsumption0(sec,h));
totaloutput0(sec) = sum(sec2, intermeddomestic0(sec,sec2))
         + sum(h, hhddomesticconsumption0(sec,h))
         + exportdemand0(sec) + statelocalgovtdemand0(sec) + fedgovtdemand0(sec)
         + investdemand0(sec);
```

```
inputoutput(sec,sec2) =  (intermeddomestic0(sec,sec2)
         + intermedimport0(sec,sec2)) / totaloutput0(sec2);
domesticdemandfordomestic0(sec) = totaloutput0(sec) - exportdemand0(sec);
importdemand0(sec) = sum(h, hhdimportconsumption0(sec,h))
         + sum(sec2, intermedimport0(sec,sec2));
compositegood0(sec) = domesticdemandfordomestic0(sec) + importdemand0(sec);
capitalsupply0 = sum(sec, capitaldemand0(sec));
laborhsupply0 = sum(h, hhdlaborhsupply0(h))
         + sum(location, commuterlaborhsupply0(location));
laborlsupply0 = sum(h, hhdlaborlsupply0(h))
         + sum(location, commuterlaborlsupply0(location));
hhdincome0(h) = hhdlaborlsupply0(h) + hhdlaborhsupply0(h) + hhdcapitalsupply0(h)
         + hhdmiscincome0(h);
migranthconsumption0(sec) = 0;
migrantlconsumption0(sec) = 0;
pcapital0 = 1;
pcomposite0(sec) = 1;
pdomestic0(sec) = 1;
plabor0(sec) = 1;
plaborh0 = 1;
plaborl0 = 1;
poutput0(sec) = 1;
pworld0(sec) = 1;
cpi0=1;

* Calibrate Model Parameters

$include '%PROGPATH%OKCGE Calibration.gms'

* Check Parameter Calibration

$include '%PROGPATH%OKCGE Calibration Check.gms'

*********************************************** Run the Benchmark Model

$include '%PROGPATH%OKCGE Model.gms'

* Unload the Solution into an Excel Spreadsheet

parameter solution(*,*)              Parameter to store results;

$include '%PROGPATH%OKCGE Excel.gms'
execute_unload 'OKCGESOL.gdx',solution;
execute 'gdxxrw OKCGESOL.gdx par=solution Rng=Benchmark!a1';


*********************************************** Run the Model for Simulation 1

* Increase Manufacturing Export Demand to Simulate Development

exportdemand0('MFTG') = exportdemand0('MFTG') * 1.5;
SOLVE OKCGE using NLP Maximizing TRICK;

* Unload the Solution into an Excel Spreadsheet

$include '%PROGPATH%OKCGE Excel.gms'
execute_unload 'OKCGESOL.gdx',solution;
execute 'gdxxrw OKCGESOL.gdx par=solution Rng=Sim1!a1';

******************************** Simulation 2: Decreased Commuter Elasticities

* Cut Commuter Elasticities in Half

SigmaComLaborH(location) = SigmaComLaborH(location) * 0.5;
SigmaComLaborL(location) = SigmaComLaborL(location) * 0.5;

SOLVE OKCGE using NLP Maximizing TRICK;
display exportdemand0;

* Unload the Solution into an Excel Spreadsheet
```

```
$include '%PROGPATH%OKCGE Excel.gms'
execute_unload 'OKCGESOL.gdx',solution;
execute 'gdxxrw OKCGESOL.gdx par=solution Rng=Sim2!a1';

********************************** Simulation 3: Increased Commuter Elasticities

* Increase Commuter Elasticities to Twice their Benchmark Values
SigmaComLaborH(location) = SigmaComLaborH(location) * 4;
SigmaComLaborL(location) = SigmaComLaborL(location) * 4;

SOLVE OKCGE using NLP Maximizing TRICK;
display exportdemand0;

* Unload the Solution into an Excel Spreadsheet

$include '%PROGPATH%OKCGE Excel.gms'
execute_unload 'OKCGESOL.gdx',solution;
execute 'gdxxrw OKCGESOL.gdx par=solution Rng=Sim3!a1';

*************************************** Simulation 4: Low Migration Elasticities

* Return Commuter Elasticities to their Benchmark Values

SigmaComLaborH(location) = SigmaComLaborH(location) * 0.5;
SigmaComLaborL(location) = SigmaComLaborL(location) * 0.5;

* Cut Migration Elasticities in Half

SigmaMigLaborH = SigmaMigLaborH * 0.5;
SigmaMigLaborL = SigmaMigLaborL * 0.5;

SOLVE OKCGE using NLP Maximizing TRICK;
display exportdemand0;

* Unload the Solution into an Excel Spreadsheet

$include '%PROGPATH%OKCGE Excel.gms'
execute_unload 'OKCGESOL.gdx',solution;
execute 'gdxxrw OKCGESOL.gdx par=solution Rng=Sim4!a1';

************************************** Simulation 5: High Migration Elasticities

* Increase Migration Elasticities to Twice their Benchmark Values

SigmaMigLaborH = SigmaMigLaborH * 4;
SigmaMigLaborL = SigmaMigLaborL * 4;

SOLVE OKCGE using NLP Maximizing TRICK;
display exportdemand0;

* Unload the Solution into an Excel Spreadsheet

$include '%PROGPATH%OKCGE Excel.gms'
execute_unload 'OKCGESOL.gdx',solution;
execute 'gdxxrw OKCGESOL.gdx par=solution Rng=Sim5!a1';

*######################### Micro Data Set Module ###############################


sets

        sec                                Production Sectors
                                           /
                                           AGRI
                                           MINE
                                           UTIL
                                           CONS
                                           MFTG
                                           WHOL
                                           TRAN
                                           RETA
```

```
                                INFO
                                FINC
                                REAL
                                PROF
                                MGMT
                                ADMI
                                EDUC
                                HEAL
                                ARTS
                                ACCO
                                OTHR
                                GNNC
                                /

        h                       Households
                                /
                                HHD1
                                HHD2
                                HHD3
                                HHD4
                                HHD5
                                HHD6
                                HHD7
                                HHD8
                                HHD9
                                /
        location                Commuter origination location
                                /
                                canadian
                                cleveland
                                grady
                                lincoln
                                logan
                                mcclain
                                pottawatomie
                                otherokla
                                outofstate
                                /
        nearloc(location)       Counties Surrounding Oklahoma County
                                /
                                canadian
                                cleveland
                                grady
                                lincoln
                                logan
                                mcclain
                                pottawatomie
                                /
;

alias (sec,sec2), (h,h2);

scalar

        almostzero              A Value that approaches zero for zero items
                                /0.00000000000000000000000001/
;

parameters

* Benchmark Parameters

        capitaldemand0(sec)     Capital Demand
                                /
                                AGRI 5.513865
                                MINE 2232.564000
                                UTIL 423.807800
                                CONS 155.993100
                                MFTG 910.126000
                                WHOL 404.823400
                                TRAN 172.087200
```

```
                                RETA 325.523800
                                INFO 460.633800
                                FINC 977.640400
                                REAL 1124.928000
                                PROF 205.495100
                                MGMT 114.635700
                                ADMI 162.783200
                                EDUC 29.854050
                                HEAL 345.937100
                                ARTS 46.222890
                                ACCO 174.170800
                                OTHR 143.243700
                                GNNC 1685.733000
                                /
capitalsupply0                  Regional Capital Supply
cbud0(h)                        Household Consumption Budget
compositegood0(sec)             Aggregate Goods for Local Use
commuterlaborhsupply0(location) Commuter High Skilled Labor Supply
                                /
                                canadian       514.070445
                                cleveland      951.952602
                                grady          98.643783
                                lincoln        75.386305
                                logan          171.624142
                                mcclain        78.594233
                                pottawatomie   121.901260
                                otherokla      141.950809
                                outofstate     56.940720
                                /
commuterlaborlsupply0(location) Commuter Low Skilled Labor Supply
                                /
                                canadian       964.725741
                                cleveland      1786.473409
                                grady          185.118980
                                lincoln        141.473042
                                logan          322.076925
                                mcclain        147.493171
                                pottawatomie   228.764918
                                otherokla      266.390727
                                outofstate     106.857297
                                /
cpi0                            Regional Price Index
domesticdemandfordomestic0(sec) Local Demand for Local Production
                                /
                                AGRI 43.030749
                                MINE 814.420074
                                UTIL 1137.398846
                                CONS 2383.623111
                                MFTG 3777.997045
                                WHOL 2289.958294
                                TRAN 1418.817289
                                RETA 2708.774732
                                INFO 1254.763896
                                FINC 2456.521806
                                REAL 2469.926518
                                PROF 2894.931829
                                MGMT 700.433064
                                ADMI 1068.419711
                                EDUC 299.897352
                                HEAL 3089.454651
                                ARTS 402.931069
                                ACCO 1410.556671
                                OTHR 1395.548493
                                GNNC 7431.757281
                                /
exportdemand0(sec)              Export Demand
                                /
                                AGRI 1.673366
                                MINE 6326.859000
                                UTIL 324.412484
                                CONS 0.182296
```

```
                                MFTG 8924.067000
                                WHOL 355.201400
                                TRAN 721.354500
                                RETA 557.420612
                                INFO 1549.478990
                                FINC 1638.984100
                                REAL 709.697500
                                PROF 308.054840
                                MGMT 49.625880
                                ADMI 783.331122
                                EDUC 80.151129
                                HEAL 1556.394977
                                ARTS 0.729726
                                ACCO 491.584682
                                OTHR 296.129510
                                GNNC 354.629600
                                /
fedgovtdemand0(sec)             Federal Government Demand for Production
                                /
                                AGRI 0.000021
                                MINE 3.201743
                                UTIL 94.954879
                                CONS 2.429542
                                MFTG 104.508327
                                WHOL 0.384841
                                TRAN 0.399966
                                RETA 6.710979
                                INFO 36.326786
                                FINC 3.590565
                                REAL 0.957406
                                PROF 332.105754
                                MGMT 0.000000
                                ADMI 22.664710
                                EDUC 22.924770
                                HEAL 1.928122
                                ARTS 0.655354
                                ACCO 0.008594
                                OTHR 50.493882
                                GNNC 2707.560763
                                /
hhdcapitalsupply0(h)            Capital Supplied by Local Households
                                /
                                HHD1 18.975802
                                HHD2 31.412902
                                HHD3 104.434669
                                HHD4 148.024105
                                HHD5 238.563587
                                HHD6 392.188790
                                HHD7 225.567216
                                HHD8 198.449686
                                HHD9 160.390137
                                /
hhdconsumption0(sec,h)          HHD Consumption Demand
hhddomesticconsumption0(sec,h)  HHD Consumption of Domestic Production
                                /
                                AGRI.HHD1 0.542112
                                AGRI.HHD2 0.428877
                                AGRI.HHD3 0.918002
                                AGRI.HHD4 1.031506
                                AGRI.HHD5 1.447971
                                AGRI.HHD6 1.583495
                                AGRI.HHD7 0.939856
                                AGRI.HHD8 0.735132
                                AGRI.HHD9 0.530383
                                MINE.HHD1 1.917397
                                MINE.HHD2 1.418925
                                MINE.HHD3 2.840977
                                MINE.HHD4 3.563672
                                MINE.HHD5 5.402823
                                MINE.HHD6 5.861974
                                MINE.HHD7 3.364300
```

MINE.HHD8	2.631471
MINE.HHD9	1.898552
UTIL.HHD1	36.156410
UTIL.HHD2	27.374540
UTIL.HHD3	57.410210
UTIL.HHD4	57.078740
UTIL.HHD5	72.644350
UTIL.HHD6	81.333550
UTIL.HHD7	40.180150
UTIL.HHD8	31.427900
UTIL.HHD9	22.674580
CONS.HHD1	0.000000
CONS.HHD2	0.000000
CONS.HHD3	0.000000
CONS.HHD4	0.000000
CONS.HHD5	0.000000
CONS.HHD6	0.000000
CONS.HHD7	0.000000
CONS.HHD8	0.000000
CONS.HHD9	0.000000
MFTG.HHD1	58.372810
MFTG.HHD2	43.222200
MFTG.HHD3	86.551360
MFTG.HHD4	108.601200
MFTG.HHD5	164.673200
MFTG.HHD6	178.818700
MFTG.HHD7	102.705200
MFTG.HHD8	80.333400
MFTG.HHD9	57.958890
WHOL.HHD1	52.006370
WHOL.HHD2	39.373950
WHOL.HHD3	82.573780
WHOL.HHD4	94.559500
WHOL.HHD5	146.733900
WHOL.HHD6	163.208100
WHOL.HHD7	87.731860
WHOL.HHD8	68.621670
WHOL.HHD9	49.509120
TRAN.HHD1	21.344080
TRAN.HHD2	14.849220
TRAN.HHD3	31.059230
TRAN.HHD4	37.780910
TRAN.HHD5	54.408740
TRAN.HHD6	65.460530
TRAN.HHD7	47.511120
TRAN.HHD8	37.162000
TRAN.HHD9	26.811620
RETA.HHD1	137.780300
RETA.HHD2	95.624310
RETA.HHD3	200.540200
RETA.HHD4	235.360600
RETA.HHD5	388.574500
RETA.HHD6	432.547100
RETA.HHD7	246.333100
RETA.HHD8	192.675500
RETA.HHD9	139.011400
INFO.HHD1	18.299170
INFO.HHD2	14.165680
INFO.HHD3	28.983560
INFO.HHD4	34.420560
INFO.HHD5	51.606530
INFO.HHD6	59.422510
INFO.HHD7	35.942600
INFO.HHD8	28.113400
INFO.HHD9	20.283230
FINC.HHD1	45.637630
FINC.HHD2	39.928020
FINC.HHD3	84.823010
FINC.HHD4	110.964400
FINC.HHD5	190.829400
FINC.HHD6	209.957700

```
FINC.HHD7 120.376100
FINC.HHD8 94.155160
FINC.HHD9 67.931020
REAL.HHD1 72.597250
REAL.HHD2 48.156540
REAL.HHD3 100.992400
REAL.HHD4 109.924900
REAL.HHD5 135.940000
REAL.HHD6 102.415100
REAL.HHD7 44.463890
REAL.HHD8 34.778540
REAL.HHD9 25.092000
PROF.HHD1 13.777830
PROF.HHD2 11.791750
PROF.HHD3 24.758450
PROF.HHD4 28.928180
PROF.HHD5 38.255270
PROF.HHD6 48.149410
PROF.HHD7 28.678620
PROF.HHD8 22.431690
PROF.HHD9 16.184000
MGMT.HHD1 0.000000
MGMT.HHD2 0.000000
MGMT.HHD3 0.000000
MGMT.HHD4 0.000000
MGMT.HHD5 0.000000
MGMT.HHD6 0.000000
MGMT.HHD7 0.000000
MGMT.HHD8 0.000000
MGMT.HHD9 0.000000
ADMI.HHD1 4.208035
ADMI.HHD2 3.098941
ADMI.HHD3 6.795226
ADMI.HHD4 7.487379
ADMI.HHD5 11.768500
ADMI.HHD6 14.279770
ADMI.HHD7 10.047190
ADMI.HHD8 7.858656
ADMI.HHD9 5.669858
EDUC.HHD1 9.768647
EDUC.HHD2 6.379629
EDUC.HHD3 19.128560
EDUC.HHD4 19.328210
EDUC.HHD5 28.973780
EDUC.HHD6 47.242270
EDUC.HHD7 41.631640
EDUC.HHD8 32.563220
EDUC.HHD9 23.493690
HEAL.HHD1 234.453800
HEAL.HHD2 138.811200
HEAL.HHD3 349.810500
HEAL.HHD4 359.748100
HEAL.HHD5 487.638500
HEAL.HHD6 555.149300
HEAL.HHD7 384.457000
HEAL.HHD8 300.712600
HEAL.HHD9 216.957900
ARTS.HHD1 12.885420
ARTS.HHD2 9.038076
ARTS.HHD3 25.208430
ARTS.HHD4 27.941530
ARTS.HHD5 40.937870
ARTS.HHD6 50.375180
ARTS.HHD7 40.378920
ARTS.HHD8 31.583360
ARTS.HHD9 22.786750
ACCO.HHD1 47.162660
ACCO.HHD2 29.208710
ACCO.HHD3 83.923230
ACCO.HHD4 108.293600
ACCO.HHD5 195.054500
```

```
                              ACCO.HHD6 229.198900
                              ACCO.HHD7 142.185500
                              ACCO.HHD8 111.213900
                              ACCO.HHD9 80.238560
                              OTHR.HHD1 47.232910
                              OTHR.HHD2 38.059210
                              OTHR.HHD3 79.816520
                              OTHR.HHD4 97.070310
                              OTHR.HHD5 129.322100
                              OTHR.HHD6 159.855400
                              OTHR.HHD7 126.466300
                              OTHR.HHD8 98.918740
                              OTHR.HHD9 71.367830
                              GNNC.HHD1 107.162000
                              GNNC.HHD2 82.127460
                              GNNC.HHD3 174.575300
                              GNNC.HHD4 192.793400
                              GNNC.HHD5 374.678100
                              GNNC.HHD6 488.991000
                              GNNC.HHD7 332.835400
                              GNNC.HHD8 260.335500
                              GNNC.HHD9 187.826700
                              /
hhdlaborhsupply0(h)           Household High Skilled Labor Supply
                              /
                              HHD1 0.000000
                              HHD2 0.000000
                              HHD3 0.000000
                              HHD4 0.000000
                              HHD5 0.000000
                              HHD6 0.000000
                              HHD7 1856.926663
                              HHD8 2160.086814
                              HHD9 1791.741953
                              /
hhdlaborlsupply0(h)           Household Low Skilled Labor Supply
                              /
                              HHD1 210.840176
                              HHD2 353.401057
                              HHD3 1177.081531
                              HHD4 1652.978200
                              HHD5 2643.139725
                              HHD6 4274.380364
                              HHD7 589.128312
                              HHD8 0.000000
                              HHD9 0.000000
                              /
hhdimportconsumption0(sec,h)  HHD Consumption of Imports
                              /
                              AGRI.HHD1 6.884396
                              AGRI.HHD2 5.451597
                              AGRI.HHD3 11.642720
                              AGRI.HHD4 13.083970
                              AGRI.HHD5 18.358850
                              AGRI.HHD6 20.052060
                              AGRI.HHD7 11.854530
                              AGRI.HHD8 9.272319
                              AGRI.HHD9 6.689787
                              MINE.HHD1 6.210516
                              MINE.HHD2 4.596014
                              MINE.HHD3 9.202439
                              MINE.HHD4 11.541520
                              MINE.HHD5 17.496720
                              MINE.HHD6 18.983930
                              MINE.HHD7 10.894710
                              MINE.HHD8 8.521567
                              MINE.HHD9 6.148135
                              UTIL.HHD1 1.429858
                              UTIL.HHD2 1.082587
                              UTIL.HHD3 2.270453
                              UTIL.HHD4 2.257672
```

UTIL.HHD5	2.875613
UTIL.HHD6	3.220809
UTIL.HHD7	1.592728
UTIL.HHD8	1.245792
UTIL.HHD9	0.898813
CONS.HHD1	0.000000
CONS.HHD2	0.000000
CONS.HHD3	0.000000
CONS.HHD4	0.000000
CONS.HHD5	0.000000
CONS.HHD6	0.000000
CONS.HHD7	0.000000
CONS.HHD8	0.000000
CONS.HHD9	0.000000
MFTG.HHD1	188.087600
MFTG.HHD2	139.188400
MFTG.HHD3	278.648000
MFTG.HHD4	349.786700
MFTG.HHD5	530.453400
MFTG.HHD6	575.527200
MFTG.HHD7	330.391000
MFTG.HHD8	258.423500
MFTG.HHD9	186.447200
WHOL.HHD1	3.704792
WHOL.HHD2	2.804894
WHOL.HHD3	5.882332
WHOL.HHD4	6.736162
WHOL.HHD5	10.452920
WHOL.HHD6	11.626500
WHOL.HHD7	6.249780
WHOL.HHD8	4.888422
WHOL.HHD9	3.526895
TRAN.HHD1	6.189160
TRAN.HHD2	4.305841
TRAN.HHD3	9.006270
TRAN.HHD4	10.955360
TRAN.HHD5	15.776950
TRAN.HHD6	18.981640
TRAN.HHD7	13.776840
TRAN.HHD8	10.775900
TRAN.HHD9	7.774587
RETA.HHD1	7.671303
RETA.HHD2	5.324152
RETA.HHD3	11.165640
RETA.HHD4	13.104360
RETA.HHD5	21.634980
RETA.HHD6	24.083270
RETA.HHD7	13.715290
RETA.HHD8	10.727750
RETA.HHD9	7.739852
INFO.HHD1	26.615210
INFO.HHD2	20.470990
INFO.HHD3	41.717600
INFO.HHD4	49.653930
INFO.HHD5	75.118360
INFO.HHD6	85.763230
INFO.HHD7	51.752980
INFO.HHD8	40.479880
INFO.HHD9	29.205390
FINC.HHD1	30.109440
FINC.HHD2	26.655520
FINC.HHD3	56.653650
FINC.HHD4	74.565860
FINC.HHD5	129.315800
FINC.HHD6	143.239000
FINC.HHD7	82.414450
FINC.HHD8	64.462510
FINC.HHD9	46.508380
REAL.HHD1	22.185540
REAL.HHD2	14.716520
REAL.HHD3	30.863020

REAL.HHD4	33.592790
REAL.HHD5	41.542940
REAL.HHD6	31.297820
REAL.HHD7	13.588060
REAL.HHD8	10.628240
REAL.HHD9	7.668053
PROF.HHD1	4.089327
PROF.HHD2	3.487341
PROF.HHD3	7.318583
PROF.HHD4	8.554251
PROF.HHD5	11.361350
PROF.HHD6	14.260960
PROF.HHD7	8.503919
PROF.HHD8	6.651552
PROF.HHD9	4.798957
MGMT.HHD1	0.000000
MGMT.HHD2	0.000000
MGMT.HHD3	0.000000
MGMT.HHD4	0.000000
MGMT.HHD5	0.000000
MGMT.HHD6	0.000000
MGMT.HHD7	0.000000
MGMT.HHD8	0.000000
MGMT.HHD9	0.000000
ADMI.HHD1	1.886155
ADMI.HHD2	1.387129
ADMI.HHD3	3.044100
ADMI.HHD4	3.352966
ADMI.HHD5	5.239096
ADMI.HHD6	6.340314
ADMI.HHD7	4.465622
ADMI.HHD8	3.492897
ADMI.HHD9	2.520053
EDUC.HHD1	3.629580
EDUC.HHD2	2.370377
EDUC.HHD3	7.107295
EDUC.HHD4	7.181475
EDUC.HHD5	10.765320
EDUC.HHD6	17.553050
EDUC.HHD7	15.468400
EDUC.HHD8	12.099000
EDUC.HHD9	8.729176
HEAL.HHD1	18.601700
HEAL.HHD2	11.013360
HEAL.HHD3	27.754170
HEAL.HHD4	28.542620
HEAL.HHD5	38.689520
HEAL.HHD6	44.045870
HEAL.HHD7	30.503040
HEAL.HHD8	23.858710
HEAL.HHD9	17.213570
ARTS.HHD1	3.359423
ARTS.HHD2	2.356462
ARTS.HHD3	6.572117
ARTS.HHD4	7.284734
ARTS.HHD5	10.672860
ARTS.HHD6	13.133300
ARTS.HHD7	10.526710
ARTS.HHD8	8.233727
ARTS.HHD9	5.940465
ACCO.HHD1	5.708008
ACCO.HHD2	3.536529
ACCO.HHD3	10.144240
ACCO.HHD4	13.080730
ACCO.HHD5	23.532290
ACCO.HHD6	27.625530
ACCO.HHD7	17.129060
ACCO.HHD8	13.397920
ACCO.HHD9	9.666322
OTHR.HHD1	8.211442
OTHR.HHD2	6.616629

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                              OTHR.HHD3 13.876170
                              OTHR.HHD4 16.875710
                              OTHR.HHD5 22.482680
                              OTHR.HHD6 27.790930
                              OTHR.HHD7 21.985760
                              OTHR.HHD8 17.196700
                              OTHR.HHD9 12.407070
                              GNNC.HHD1 8.036864
                              GNNC.HHD2 6.122560
                              GNNC.HHD3 13.014380
                              GNNC.HHD4 14.449110
                              GNNC.HHD5 27.863740
                              GNNC.HHD6 36.068810
                              GNNC.HHD7 24.558670
                              GNNC.HHD8 19.209180
                              GNNC.HHD9 13.859020
                              /
hhdincome0(h)                 Total Household Income
hhdmiscincome0(h)             Miscellaneous Household Income
                              /
                              HHD1 1044.099166
                              HHD2 519.730181
                              HHD3 705.075924
                              HHD4 498.474312
                              HHD5 650.820111
                              HHD6 0.000000
                              HHD7 0.000000
                              HHD8 0.000000
                              HHD9 0.000000
                              /
importdemand0(sec)            Local Demand for Imports
inputoutput(sec,sec2)         Input-Output Coefficient Matrix
intermeddomestic0(sec,sec2)   Intermediate Input Purchased Domestically
                              /
                              AGRI.AGRI 0.665582
                              AGRI.MINE 0.035106
                              AGRI.UTIL 0.000367
                              AGRI.CONS 0.243362
                              AGRI.MFTG 29.670690
                              AGRI.WHOL 0.004504
                              AGRI.TRAN 0.001359
                              AGRI.RETA 0.013452
                              AGRI.INFO 0.006979
                              AGRI.FINC 0.001407
                              AGRI.REAL 0.365475
                              AGRI.PROF 0.021808
                              AGRI.MGMT 0.000000
                              AGRI.ADMI 1.153993
                              AGRI.EDUC 0.001548
                              AGRI.HEAL 0.138915
                              AGRI.ARTS 0.054203
                              AGRI.ACCO 1.886993
                              AGRI.OTHR 0.059718
                              AGRI.GNNC 0.039325
                              MINE.AGRI 0.066798
                              MINE.MINE 218.184300
                              MINE.UTIL 71.986290
                              MINE.CONS 7.611319
                              MINE.MFTG 174.351300
                              MINE.WHOL 0.908359
                              MINE.TRAN 3.361138
                              MINE.RETA 0.837169
                              MINE.INFO 1.660122
                              MINE.FINC 0.221590
                              MINE.REAL 0.727207
                              MINE.PROF 1.107276
                              MINE.MGMT 0.172473
                              MINE.ADMI 0.803422
                              MINE.EDUC 0.145780
                              MINE.HEAL 4.349598
                              MINE.ARTS 0.154003
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MINE.ACCO 3.661668
MINE.OTHR 2.033102
MINE.GNNC 4.516460
UTIL.AGRI 0.366760
UTIL.MINE 70.033070
UTIL.UTIL 1.129073
UTIL.CONS 6.060678
UTIL.MFTG 148.635200
UTIL.WHOL 16.616600
UTIL.TRAN 7.680413
UTIL.RETA 42.195460
UTIL.INFO 11.626350
UTIL.FINC 10.734520
UTIL.REAL 72.914390
UTIL.PROF 14.521850
UTIL.MGMT 12.061120
UTIL.ADMI 11.987830
UTIL.EDUC 2.107307
UTIL.HEAL 30.502900
UTIL.ARTS 5.923954
UTIL.ACCO 34.364000
UTIL.OTHR 16.679680
UTIL.GNNC 9.307366
CONS.AGRI 0.105779
CONS.MINE 0.409956
CONS.UTIL 19.707650
CONS.CONS 1.608930
CONS.MFTG 20.983500
CONS.WHOL 5.627998
CONS.TRAN 5.508753
CONS.RETA 12.259190
CONS.INFO 11.759800
CONS.FINC 10.255330
CONS.REAL 40.797050
CONS.PROF 8.648234
CONS.MGMT 7.363369
CONS.ADMI 2.798665
CONS.EDUC 7.699459
CONS.HEAL 15.381430
CONS.ARTS 3.279276
CONS.ACCO 10.971780
CONS.OTHR 11.625780
CONS.GNNC 43.912480
MFTG.AGRI 1.855735
MFTG.MINE 181.835200
MFTG.UTIL 13.069370
MFTG.CONS 152.908900
MFTG.MFTG 1161.511000
MFTG.WHOL 29.141930
MFTG.TRAN 65.342260
MFTG.RETA 27.623960
MFTG.INFO 53.215840
MFTG.FINC 9.102745
MFTG.REAL 20.174440
MFTG.PROF 35.553300
MFTG.MGMT 6.556956
MFTG.ADMI 25.377440
MFTG.EDUC 4.594595
MFTG.HEAL 134.142000
MFTG.ARTS 4.940357
MFTG.ACCO 111.572100
MFTG.OTHR 62.324870
MFTG.GNNC 24.439970
WHOL.AGRI 1.004954
WHOL.MINE 71.875110
WHOL.UTIL 6.146931
WHOL.CONS 59.807830
WHOL.MFTG 707.257800
WHOL.WHOL 63.695400
WHOL.TRAN 39.416900
WHOL.RETA 15.240820

WHOL.INFO 38.134250
WHOL.FINC 4.741089
WHOL.REAL 8.819109
WHOL.PROF 15.850820
WHOL.MGMT 2.435498
WHOL.ADMI 18.280770
WHOL.EDUC 3.573939
WHOL.HEAL 61.304490
WHOL.ARTS 2.570565
WHOL.ACCO 65.546840
WHOL.OTHR 27.693520
WHOL.GNNC 11.926550
TRAN.AGRI 0.489085
TRAN.MINE 73.973990
TRAN.UTIL 74.970400
TRAN.CONS 30.390340
TRAN.MFTG 284.990600
TRAN.WHOL 46.964050
TRAN.TRAN 156.061300
TRAN.RETA 55.848310
TRAN.INFO 31.238450
TRAN.FINC 38.944960
TRAN.REAL 27.346610
TRAN.PROF 50.629410
TRAN.MGMT 1.462710
TRAN.ADMI 25.425170
TRAN.EDUC 4.022041
TRAN.HEAL 59.631610
TRAN.ARTS 3.943894
TRAN.ACCO 23.299660
TRAN.OTHR 20.619140
TRAN.GNNC 9.411531
RETA.AGRI 0.046942
RETA.MINE 13.567090
RETA.UTIL 0.923770
RETA.CONS 196.434500
RETA.MFTG 36.162190
RETA.WHOL 22.013680
RETA.TRAN 16.500300
RETA.RETA 45.915260
RETA.INFO 7.878970
RETA.FINC 4.847683
RETA.REAL 37.274180
RETA.PROF 19.842340
RETA.MGMT 0.025931
RETA.ADMI 47.937420
RETA.EDUC 0.681764
RETA.HEAL 24.135120
RETA.ARTS 2.292591
RETA.ACCO 20.214880
RETA.OTHR 27.355020
RETA.GNNC 29.506920
INFO.AGRI 0.090262
INFO.MINE 18.863120
INFO.UTIL 3.913149
INFO.CONS 18.087610
INFO.MFTG 93.646950
INFO.WHOL 29.305930
INFO.TRAN 16.214380
INFO.RETA 37.495160
INFO.INFO 294.138300
INFO.FINC 39.071430
INFO.REAL 30.426820
INFO.PROF 77.829570
INFO.MGMT 27.845770
INFO.ADMI 24.554960
INFO.EDUC 7.045538
INFO.HEAL 52.929920
INFO.ARTS 5.668813
INFO.ACCO 21.027030
INFO.OTHR 21.901830

INFO.GNNC	5.017855
FINC.AGRI	0.405471
FINC.MINE	60.312290
FINC.UTIL	8.944800
FINC.CONS	24.302480
FINC.MFTG	124.167700
FINC.WHOL	34.687710
FINC.TRAN	33.758510
FINC.RETA	55.486160
FINC.INFO	31.706810
FINC.FINC	704.618700
FINC.REAL	83.758170
FINC.PROF	46.373240
FINC.MGMT	2.182659
FINC.ADMI	21.295990
FINC.EDUC	6.235458
FINC.HEAL	73.374220
FINC.ARTS	6.718875
FINC.ACCO	27.155000
FINC.OTHR	17.995570
FINC.GNNC	60.310860
REAL.AGRI	1.242324
REAL.MINE	212.209500
REAL.UTIL	4.647207
REAL.CONS	23.198070
REAL.MFTG	104.261600
REAL.WHOL	58.866070
REAL.TRAN	44.685260
REAL.RETA	148.635000
REAL.INFO	60.314330
REAL.FINC	106.535800
REAL.REAL	202.389100
REAL.PROF	127.653500
REAL.MGMT	41.401560
REAL.ADMI	37.762660
REAL.EDUC	42.421890
REAL.HEAL	211.513100
REAL.ARTS	19.382560
REAL.ACCO	70.831140
REAL.OTHR	97.071890
REAL.GNNC	33.808780
PROF.AGRI	0.488668
PROF.MINE	132.704500
PROF.UTIL	25.475750
PROF.CONS	95.025700
PROF.MFTG	354.594300
PROF.WHOL	96.520890
PROF.TRAN	52.101620
PROF.RETA	137.096500
PROF.INFO	173.584600
PROF.FINC	148.995600
PROF.REAL	113.238700
PROF.PROF	230.040000
PROF.MGMT	82.918110
PROF.ADMI	60.484490
PROF.EDUC	10.364970
PROF.HEAL	130.832400
PROF.ARTS	16.357060
PROF.ACCO	44.563590
PROF.OTHR	44.435940
PROF.GNNC	35.746030
MGMT.AGRI	0.015663
MGMT.MINE	145.956800
MGMT.UTIL	0.522560
MGMT.CONS	1.974303
MGMT.MFTG	252.418200
MGMT.WHOL	45.351460
MGMT.TRAN	9.645301
MGMT.RETA	122.819000
MGMT.INFO	11.011830
MGMT.FINC	22.139100

MGMT.REAL	6.105235
MGMT.PROF	9.352163
MGMT.MGMT	0.000000
MGMT.ADMI	21.588820
MGMT.EDUC	0.613872
MGMT.HEAL	33.152480
MGMT.ARTS	3.452754
MGMT.ACCO	5.187511
MGMT.OTHR	9.028913
MGMT.GNNC	0.097099
ADMI.AGRI	0.036981
ADMI.MINE	12.330750
ADMI.UTIL	4.763295
ADMI.CONS	19.358520
ADMI.MFTG	55.967660
ADMI.WHOL	59.540570
ADMI.TRAN	53.706960
ADMI.RETA	60.530340
ADMI.INFO	43.564960
ADMI.FINC	37.892280
ADMI.REAL	141.329600
ADMI.PROF	125.974200
ADMI.MGMT	0.864892
ADMI.ADMI	64.650470
ADMI.EDUC	10.055350
ADMI.HEAL	135.682400
ADMI.ARTS	8.813200
ADMI.ACCO	19.762660
ADMI.OTHR	38.200950
ADMI.GNNC	20.199510
EDUC.AGRI	0.000000
EDUC.MINE	1.464029
EDUC.UTIL	3.100648
EDUC.CONS	0.232534
EDUC.MFTG	7.926968
EDUC.WHOL	2.618211
EDUC.TRAN	0.979604
EDUC.RETA	2.097137
EDUC.INFO	4.839476
EDUC.FINC	1.430970
EDUC.REAL	1.150342
EDUC.PROF	3.548268
EDUC.MGMT	0.000000
EDUC.ADMI	0.767121
EDUC.EDUC	2.225501
EDUC.HEAL	5.689630
EDUC.ARTS	0.700253
EDUC.ACCO	0.338849
EDUC.OTHR	1.222692
EDUC.GNNC	0.134560
HEAL.AGRI	0.000000
HEAL.MINE	0.000000
HEAL.UTIL	0.000000
HEAL.CONS	0.000000
HEAL.MFTG	0.000000
HEAL.WHOL	0.000000
HEAL.TRAN	0.478069
HEAL.RETA	0.008562
HEAL.INFO	0.000000
HEAL.FINC	0.005737
HEAL.REAL	0.000000
HEAL.PROF	0.402804
HEAL.MGMT	0.000000
HEAL.ADMI	0.227565
HEAL.EDUC	0.212231
HEAL.HEAL	42.081030
HEAL.ARTS	0.167584
HEAL.ACCO	0.006434
HEAL.OTHR	0.329202
HEAL.GNNC	0.000000
ARTS.AGRI	0.011639

ARTS.MINE 39.558800
ARTS.UTIL 0.271760
ARTS.CONS 0.908338
ARTS.MFTG 9.016811
ARTS.WHOL 2.685351
ARTS.TRAN 0.483499
ARTS.RETA 2.531410
ARTS.INFO 18.532140
ARTS.FINC 3.981034
ARTS.REAL 3.801083
ARTS.PROF 11.666800
ARTS.MGMT 0.148485
ARTS.ADMI 2.971850
ARTS.EDUC 0.916306
ARTS.HEAL 3.556260
ARTS.ARTS 26.858100
ARTS.ACCO 7.563195
ARTS.OTHR 3.976062
ARTS.GNNC 0.151592
ACCO.AGRI 0.016840
ACCO.MINE 4.383390
ACCO.UTIL 6.531071
ACCO.CONS 3.055462
ACCO.MFTG 53.437360
ACCO.WHOL 13.324320
ACCO.TRAN 19.856520
ACCO.RETA 18.831030
ACCO.INFO 12.792060
ACCO.FINC 29.604360
ACCO.REAL 23.494630
ACCO.PROF 45.798530
ACCO.MGMT 0.101718
ACCO.ADMI 17.110670
ACCO.EDUC 1.435730
ACCO.HEAL 64.203610
ACCO.ARTS 1.588848
ACCO.ACCO 15.168410
ACCO.OTHR 7.984955
ACCO.GNNC 0.653771
OTHR.AGRI 0.271344
OTHR.MINE 7.822951
OTHR.UTIL 1.737197
OTHR.CONS 19.480270
OTHR.MFTG 133.657800
OTHR.WHOL 22.315940
OTHR.TRAN 19.757320
OTHR.RETA 21.736480
OTHR.INFO 32.470050
OTHR.FINC 14.077760
OTHR.REAL 26.318540
OTHR.PROF 24.156970
OTHR.MGMT 12.651320
OTHR.ADMI 24.083340
OTHR.EDUC 3.639488
OTHR.HEAL 27.177140
OTHR.ARTS 5.466441
OTHR.ACCO 14.649990
OTHR.OTHR 17.394820
OTHR.GNNC 19.388810
GNNC.AGRI 0.121368
GNNC.MINE 25.620270
GNNC.UTIL 2.527595
GNNC.CONS 4.406951
GNNC.MFTG 78.294950
GNNC.WHOL 11.073970
GNNC.TRAN 14.333190
GNNC.RETA 16.918250
GNNC.INFO 17.507830
GNNC.FINC 20.910690
GNNC.REAL 31.506510
GNNC.PROF 11.992550

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                              GNNC.MGMT 4.876816
                              GNNC.ADMI 6.430217
                              GNNC.EDUC 1.544314
                              GNNC.HEAL 16.562710
                              GNNC.ARTS 2.343422
                              GNNC.ACCO 13.497490
                              GNNC.OTHR 8.184114
                              GNNC.GNNC 6.233780
                              /
intermedimport0(sec,sec2)     Intermediate Input Imported
                              /
                              AGRI.AGRI 8.523177
                              AGRI.MINE 0.273127
                              AGRI.UTIL 0.003680
                              AGRI.CONS 3.113107
                              AGRI.MFTG 379.915200
                              AGRI.WHOL 0.046403
                              AGRI.TRAN 0.015655
                              AGRI.RETA 0.162008
                              AGRI.INFO 0.007603
                              AGRI.FINC 0.001352
                              AGRI.REAL 4.664010
                              AGRI.PROF 0.228764
                              AGRI.MGMT 0.000000
                              AGRI.ADMI 14.764800
                              AGRI.EDUC 0.015800
                              AGRI.HEAL 1.763988
                              AGRI.ARTS 0.573729
                              AGRI.ACCO 24.130620
                              AGRI.OTHR 0.747240
                              AGRI.GNNC 0.503186
                              MINE.AGRI 0.220335
                              MINE.MINE 852.233300
                              MINE.UTIL 282.235700
                              MINE.CONS 26.445420
                              MINE.MFTG 658.111000
                              MINE.WHOL 2.940317
                              MINE.TRAN 11.731370
                              MINE.RETA 2.709877
                              MINE.INFO 5.373736
                              MINE.FINC 0.717601
                              MINE.REAL 2.438441
                              MINE.PROF 3.624025
                              MINE.MGMT 0.558415
                              MINE.ADMI 2.600639
                              MINE.EDUC 0.471883
                              MINE.HEAL 14.081930
                              MINE.ARTS 0.498499
                              MINE.ACCO 11.861760
                              MINE.OTHR 6.584706
                              MINE.GNNC 17.185400
                              UTIL.AGRI 0.014495
                              UTIL.MINE 3.061534
                              UTIL.UTIL 0.144133
                              UTIL.CONS 0.243072
                              UTIL.MFTG 6.061165
                              UTIL.WHOL 0.656427
                              UTIL.TRAN 0.305220
                              UTIL.RETA 1.666741
                              UTIL.INFO 0.459455
                              UTIL.FINC 0.424263
                              UTIL.REAL 2.880419
                              UTIL.PROF 0.573764
                              UTIL.MGMT 0.476429
                              UTIL.ADMI 0.473547
                              UTIL.EDUC 0.083239
                              UTIL.HEAL 1.204912
                              UTIL.ARTS 0.234001
                              UTIL.ACCO 1.357437
                              UTIL.OTHR 0.658876
                              UTIL.GNNC 0.372877
```

CONS.AGRI	0.003009
CONS.MINE	0.011663
CONS.UTIL	0.560685
CONS.CONS	0.045774
CONS.MFTG	0.596983
CONS.WHOL	0.160117
CONS.TRAN	0.156725
CONS.RETA	0.348775
CONS.INFO	0.334568
CONS.FINC	0.291765
CONS.REAL	1.160681
CONS.PROF	0.246043
CONS.MGMT	0.209489
CONS.ADMI	0.079622
CONS.EDUC	0.219051
CONS.HEAL	0.437604
CONS.ARTS	0.093296
CONS.ACCO	0.312149
CONS.OTHR	0.330755
CONS.GNNC	1.249316
MFTG.AGRI	5.983962
MFTG.MINE	582.403100
MFTG.UTIL	41.127490
MFTG.CONS	490.491500
MFTG.MFTG	3743.058000
MFTG.WHOL	89.786980
MFTG.TRAN	209.046600
MFTG.RETA	82.970780
MFTG.INFO	164.109300
MFTG.FINC	22.432730
MFTG.REAL	59.960240
MFTG.PROF	104.270200
MFTG.MGMT	17.326930
MFTG.ADMI	79.300680
MFTG.EDUC	14.386450
MFTG.HEAL	428.060700
MFTG.ARTS	15.222450
MFTG.ACCO	359.052700
MFTG.OTHR	199.652500
MFTG.GNNC	77.425080
WHOL.AGRI	0.071590
WHOL.MINE	5.120188
WHOL.UTIL	0.437891
WHOL.CONS	4.260548
WHOL.MFTG	50.383130
WHOL.WHOL	4.537488
WHOL.TRAN	2.807953
WHOL.RETA	1.085715
WHOL.INFO	2.716581
WHOL.FINC	0.337742
WHOL.REAL	0.628249
WHOL.PROF	1.129169
WHOL.MGMT	0.173498
WHOL.ADMI	1.302273
WHOL.EDUC	0.254598
WHOL.HEAL	4.367166
WHOL.ARTS	0.183120
WHOL.ACCO	4.669380
WHOL.OTHR	1.972811
WHOL.GNNC	0.849615
TRAN.AGRI	0.141820
TRAN.MINE	21.450300
TRAN.UTIL	21.739230
TRAN.CONS	8.812311
TRAN.MFTG	82.638960
TRAN.WHOL	13.618200
TRAN.TRAN	45.253220
TRAN.RETA	16.194380
TRAN.INFO	9.058238
TRAN.FINC	11.292900
TRAN.REAL	7.929719

TRAN.PROF	14.681050
TRAN.MGMT	0.424143
TRAN.ADMI	7.372559
TRAN.EDUC	1.166275
TRAN.HEAL	17.291430
TRAN.ARTS	1.143614
TRAN.ACCO	6.756222
TRAN.OTHR	5.978949
TRAN.GNNC	2.729069
RETA.AGRI	0.002614
RETA.MINE	0.755386
RETA.UTIL	0.051433
RETA.CONS	10.937040
RETA.MFTG	2.013432
RETA.WHOL	1.225673
RETA.TRAN	0.918700
RETA.RETA	2.556461
RETA.INFO	0.438684
RETA.FINC	0.269908
RETA.REAL	2.075345
RETA.PROF	1.104778
RETA.MGMT	0.001444
RETA.ADMI	2.669050
RETA.EDUC	0.037959
RETA.HEAL	1.343791
RETA.ARTS	0.127646
RETA.ACCO	1.125520
RETA.OTHR	1.523068
RETA.GNNC	1.642881
INFO.AGRI	0.077166
INFO.MINE	12.027860
INFO.UTIL	2.719107
INFO.CONS	15.774650
INFO.MFTG	99.734020
INFO.WHOL	33.005360
INFO.TRAN	18.453360
INFO.RETA	40.456100
INFO.INFO	435.917200
INFO.FINC	41.355510
INFO.REAL	32.575580
INFO.PROF	91.141880
INFO.MGMT	32.543450
INFO.ADMI	30.352050
INFO.EDUC	9.598519
INFO.HEAL	65.334950
INFO.ARTS	6.685371
INFO.ACCO	26.972230
INFO.OTHR	28.326460
INFO.GNNC	3.137465
FINC.AGRI	0.255336
FINC.MINE	37.421520
FINC.UTIL	6.096604
FINC.CONS	16.348650
FINC.MFTG	83.820240
FINC.WHOL	22.810080
FINC.TRAN	22.455920
FINC.RETA	35.376660
FINC.INFO	20.717280
FINC.FINC	485.544000
FINC.REAL	53.850170
FINC.PROF	29.496570
FINC.MGMT	0.667015
FINC.ADMI	13.970830
FINC.EDUC	3.451444
FINC.HEAL	46.476780
FINC.ARTS	4.255585
FINC.ACCO	17.352330
FINC.OTHR	10.477680
FINC.GNNC	41.056290
REAL.AGRI	0.379651
REAL.MINE	64.850710

REAL.UTIL	1.420175
REAL.CONS	7.089273
REAL.MFTG	31.862100
REAL.WHOL	17.989330
REAL.TRAN	13.655710
REAL.RETA	45.422500
REAL.INFO	18.431910
REAL.FINC	32.557070
REAL.REAL	61.849600
REAL.PROF	39.010610
REAL.MGMT	12.652220
REAL.ADMI	11.540180
REAL.EDUC	12.964020
REAL.HEAL	64.637890
REAL.ARTS	5.923264
REAL.ACCO	21.645820
REAL.OTHR	29.664940
REAL.GNNC	10.331880
PROF.AGRI	0.140524
PROF.MINE	38.118130
PROF.UTIL	7.321145
PROF.CONS	27.330730
PROF.MFTG	102.193000
PROF.WHOL	27.847490
PROF.TRAN	15.034820
PROF.RETA	39.521100
PROF.INFO	51.970820
PROF.FINC	42.937810
PROF.REAL	32.639070
PROF.PROF	66.430850
PROF.MGMT	23.942910
PROF.ADMI	17.498610
PROF.EDUC	3.021730
PROF.HEAL	37.850880
PROF.ARTS	4.724820
PROF.ACCO	12.915330
PROF.OTHR	12.886080
PROF.GNNC	10.267150
MGMT.AGRI	0.007440
MGMT.MINE	69.331980
MGMT.UTIL	0.248225
MGMT.CONS	0.937828
MGMT.MFTG	119.903000
MGMT.WHOL	21.542720
MGMT.TRAN	4.581682
MGMT.RETA	58.341100
MGMT.INFO	5.230808
MGMT.FINC	10.516450
MGMT.REAL	2.900091
MGMT.PROF	4.442437
MGMT.MGMT	0.000000
MGMT.ADMI	10.255060
MGMT.EDUC	0.291600
MGMT.HEAL	15.747990
MGMT.ARTS	1.640117
MGMT.ACCO	2.464157
MGMT.OTHR	4.288888
MGMT.GNNC	0.046124
ADMI.AGRI	0.016837
ADMI.MINE	5.835624
ADMI.UTIL	2.252329
ADMI.CONS	8.863122
ADMI.MFTG	25.716730
ADMI.WHOL	27.312300
ADMI.TRAN	24.647130
ADMI.RETA	27.755060
ADMI.INFO	19.948570
ADMI.FINC	17.349680
ADMI.REAL	64.866720
ADMI.PROF	57.781070
ADMI.MGMT	0.370932

ADMI.ADMI 29.671390
ADMI.EDUC 4.614709
ADMI.HEAL 62.270690
ADMI.ARTS 4.042209
ADMI.ACCO 9.060664
ADMI.OTHR 17.529380
ADMI.GNNC 9.268073
EDUC.AGRI 0.000000
EDUC.MINE 0.543966
EDUC.UTIL 1.152058
EDUC.CONS 0.086399
EDUC.MFTG 2.945297
EDUC.WHOL 0.972807
EDUC.TRAN 0.363976
EDUC.RETA 0.779199
EDUC.INFO 1.798127
EDUC.FINC 0.531683
EDUC.REAL 0.427414
EDUC.PROF 1.318373
EDUC.MGMT 0.000000
EDUC.ADMI 0.285027
EDUC.EDUC 0.826894
EDUC.HEAL 2.114005
EDUC.ARTS 0.260182
EDUC.ACCO 0.125900
EDUC.OTHR 0.454296
EDUC.GNNC 0.049996
HEAL.AGRI 0.000000
HEAL.MINE 0.000000
HEAL.UTIL 0.000000
HEAL.CONS 0.000000
HEAL.MFTG 0.000000
HEAL.WHOL 0.000000
HEAL.TRAN 0.037930
HEAL.RETA 0.000679
HEAL.INFO 0.000000
HEAL.FINC 0.000455
HEAL.REAL 0.000000
HEAL.PROF 0.031959
HEAL.MGMT 0.000000
HEAL.ADMI 0.018055
HEAL.EDUC 0.016839
HEAL.HEAL 3.338733
HEAL.ARTS 0.013296
HEAL.ACCO 0.000511
HEAL.OTHR 0.026119
HEAL.GNNC 0.000000
ARTS.AGRI 0.003057
ARTS.MINE 10.317860
ARTS.UTIL 0.072037
ARTS.CONS 0.241246
ARTS.MFTG 2.367055
ARTS.WHOL 0.704518
ARTS.TRAN 0.128482
ARTS.RETA 0.666302
ARTS.INFO 4.838780
ARTS.FINC 1.044729
ARTS.REAL 0.996139
ARTS.PROF 3.051949
ARTS.MGMT 0.042605
ARTS.ADMI 0.777502
ARTS.EDUC 0.239335
ARTS.HEAL 0.933144
ARTS.ARTS 7.001745
ARTS.ACCO 1.973557
ARTS.OTHR 1.038509
ARTS.GNNC 0.041198
ACCO.AGRI 0.002592
ACCO.MINE 0.624036
ACCO.UTIL 0.787982
ACCO.CONS 0.378215

```
                               ACCO.MFTG 6.477439
                               ACCO.WHOL 1.630077
                               ACCO.TRAN 2.409624
                               ACCO.RETA 2.333545
                               ACCO.INFO 1.566691
                               ACCO.FINC 3.610711
                               ACCO.REAL 2.919173
                               ACCO.PROF 5.568925
                               ACCO.MGMT 0.031085
                               ACCO.ADMI 2.076072
                               ACCO.EDUC 0.192067
                               ACCO.HEAL 7.821733
                               ACCO.ARTS 0.200005
                               ACCO.ACCO 1.857416
                               ACCO.OTHR 1.004995
                               ACCO.GNNC 0.094056
                               OTHR.AGRI 0.047193
                               OTHR.MINE 1.366447
                               OTHR.UTIL 0.303241
                               OTHR.CONS 3.391048
                               OTHR.MFTG 23.251970
                               OTHR.WHOL 3.884060
                               OTHR.TRAN 3.437094
                               OTHR.RETA 3.785326
                               OTHR.INFO 5.652926
                               OTHR.FINC 2.454554
                               OTHR.REAL 4.580678
                               OTHR.PROF 4.210666
                               OTHR.MGMT 2.203332
                               OTHR.ADMI 4.189521
                               OTHR.EDUC 0.633182
                               OTHR.HEAL 4.730793
                               OTHR.ARTS 0.951068
                               OTHR.ACCO 2.548884
                               OTHR.OTHR 3.026026
                               OTHR.GNNC 3.372230
                               GNNC.AGRI 0.014921
                               GNNC.MINE 2.774060
                               GNNC.UTIL 0.654705
                               GNNC.CONS 0.579632
                               GNNC.MFTG 6.931949
                               GNNC.WHOL 1.261349
                               GNNC.TRAN 2.155462
                               GNNC.RETA 1.962121
                               GNNC.INFO 1.736296
                               GNNC.FINC 2.591461
                               GNNC.REAL 2.883918
                               GNNC.PROF 1.689407
                               GNNC.MGMT 0.468054
                               GNNC.ADMI 0.726872
                               GNNC.EDUC 0.314530
                               GNNC.HEAL 2.346054
                               GNNC.ARTS 0.243495
                               GNNC.ACCO 1.210990
                               GNNC.OTHR 1.046735
                               GNNC.GNNC 0.634455
                               /
investdemand0(sec)             Investment Demand for Local Goods
                               /
                               AGRI 0.024419
                               MINE 281.384370
                               UTIL 0.123397
                               CONS 1518.111000
                               MFTG 561.246140
                               WHOL 216.489940
                               TRAN 18.086952
                               RETA 79.683590
                               INFO 56.173038
                               FINC 3.918466
                               REAL 74.327060
                               PROF 233.034008
```

```
                                MGMT 0.000000
                                ADMI 0.512193
                                EDUC 0.000000
                                HEAL 0.000000
                                ARTS 0.417549
                                ACCO 0.182611
                                OTHR 0.286785
                                GNNC 16.232624
                                /
investnewcapital0(sec)          Investment by Sectors in New Capital
                                /
                                AGRI 0.002247
                                MINE 0.359201
                                UTIL 0.018918
                                CONS 0.161420
                                MFTG 2.753216
                                WHOL 0.300008
                                TRAN 0.465498
                                RETA 0.192876
                                INFO 0.787383
                                FINC 0.867791
                                REAL 0.637877
                                PROF 0.293428
                                MGMT 0.083676
                                ADMI 0.141298
                                EDUC 0.010813
                                HEAL 0.294280
                                ARTS 0.034141
                                ACCO 0.287900
                                OTHR 0.149243
                                GNNC 0.197180
                                /
labordemand0(sec)               Aggregate Labor Demand by Sector
                                /
                                AGRI 14.049380
                                MINE 1517.954700
                                UTIL 277.053600
                                CONS 921.835300
                                MFTG 2385.163800
                                WHOL 993.995050
                                TRAN 974.113470
                                RETA 1297.436700
                                INFO 614.579360
                                FINC 1126.455100
                                REAL 596.553800
                                PROF 1664.889500
                                MGMT 333.040290
                                ADMI 1015.570800
                                EDUC 179.902035
                                HEAL 2346.121600
                                ARTS 154.008490
                                ACCO 603.575440
                                OTHR 700.538890
                                GNNC 5353.306000
                                /
laborhdemand0(sec)              High Skilled Labor Demand
                                /
                                AGRI 0.415862
                                MINE 338.655694
                                UTIL 209.258584
                                CONS 159.293140
                                MFTG 639.939448
                                WHOL 369.766159
                                TRAN 167.839751
                                RETA 79.013895
                                INFO 420.187908
                                FINC 738.391318
                                REAL 133.389430
                                PROF 1046.383051
                                MGMT 182.173039
                                ADMI 113.439258
```

```
                               EDUC 116.270685
                               HEAL 893.872330
                               ARTS 14.461397
                               ACCO 15.753319
                               OTHR 64.939955
                               GNNC 2316.375506
                               /
laborhsupply0                  Regional High Skilled Labor Supply
laborldemand0(sec)             Low Skilled Labor Demand
                               /
                               AGRI 13.633518
                               MINE 1179.299006
                               UTIL 67.795016
                               CONS 762.542160
                               MFTG 1745.224352
                               WHOL 624.228891
                               TRAN 806.273719
                               RETA 1218.422805
                               INFO 194.391452
                               FINC 388.063782
                               REAL 463.164370
                               PROF 618.506449
                               MGMT 150.867251
                               ADMI 902.131542
                               EDUC 63.631350
                               HEAL 1452.249270
                               ARTS 139.547093
                               ACCO 587.822121
                               OTHR 635.598935
                               GNNC 3036.930494
                               /
laborlsupply0                  Regional Low Skilled Labor Supply
migranthconsumption0(sec)      High Skilled Migrant Consumption
migrantlconsumption0(sec)      Low Skilled Migrant Consumption
misccost0(sec)                 Miscellaneous Production Costs
                               /
                               AGRI 1.932955
                               MINE 391.099361
                               UTIL 141.253196
                               CONS 15.511344
                               MFTG 147.840996
                               WHOL 413.146604
                               TRAN 56.501828
                               RETA 455.021764
                               INFO 122.739006
                               FINC 107.035246
                               REAL 243.979368
                               PROF 41.605947
                               MGMT 7.221616
                               ADMI 27.779631
                               EDUC 7.955191
                               HEAL 45.294803
                               ARTS 28.735149
                               ACCO 105.732316
                               OTHR 84.558632
                               GNNC 252.288291
                               /
mps(h)                         Household Marginal Propensity to Save
                               /
                               HHD1 0.000000
                               HHD2 0.000000
                               HHD3 0.000000
                               HHD4 0.000000
                               HHD5 0.000000
                               HHD6 0.139958
                               HHD7 0.062143
                               HHD8 0.169054
                               HHD9 0.275680
                               /
pcapital0                      Returns to Capital
pcomposite0(sec)               Composite Good Price
```

```
        pdomestic0(sec)                 Price of Domestic Prod in Local Mkt
        plabor0(sec)                    Aggregate Labor Bill
        plaborh0                        High Skilled Labor Price
        plaborl0                        Low Skilled Labor Price
        poutput0(sec)                   Producer Price of Output
        pworld0(sec)                    World Price of Production
        statelocalgovtdemand0(sec)      S&L Government Demand for Production
                                        /
                                        AGRI 0.484188
                                        MINE 4.074497
                                        UTIL 90.591618
                                        CONS 622.378160
                                        MFTG 105.722650
                                        WHOL 63.442078
                                        TRAN 44.279659
                                        RETA 0.376602
                                        INFO 45.952435
                                        FINC 60.619661
                                        REAL 71.450091
                                        PROF 111.267450
                                        MGMT 0.000000
                                        ADMI 60.803704
                                        EDUC 7.996143
                                        HEAL 15.868410
                                        ARTS 1.132114
                                        ACCO 44.512622
                                        OTHR 48.404536
                                        GNNC 2211.752048
                                        /
        totaloutput0(sec)               Total Local Production

* Calibrated Parameters

* Tech Coefficients

        alphaF(sec)                     Technology Coeff - Value Added
        alphaL(sec)                     Tech Coeff - Labor
        alphaA(sec)                     Tech Coeff - Armington Function

* Share Coefficients

        gammaF(sec)                     VA Share
        gammaA(sec)                     Armington Share
        gammaL(sec)                     Labor Share

* Substitution Elasticities

        sigmaA(sec)                     Initial substitution elasticities of Armington fn
                                        /
                                        AGRI 1.500000
                                        MINE 1.062000
                                        UTIL 1.500000
                                        CONS 1.500000
                                        MFTG 0.550000
                                        WHOL 0.500000
                                        TRAN 1.500000
                                        RETA 0.500000
                                        INFO 1.500000
                                        FINC 1.500000
                                        REAL 1.500000
                                        PROF 1.500000
                                        MGMT 0.500000
                                        ADMI 1.500000
                                        EDUC 0.500000
                                        HEAL 0.500000
                                        ARTS 0.500000
                                        ACCO 0.500000
                                        OTHR 1.500000
                                        GNNC 0.500000
                                        /
        sigmaF(sec)                     CES capital-labor substitution elasticity
```

```
                                    /
                                    AGRI 0.610000
                                    MINE 0.800000
                                    UTIL 0.800000
                                    CONS 0.800000
                                    MFTG 0.800000
                                    WHOL 0.800000
                                    TRAN 0.800000
                                    RETA 0.800000
                                    INFO 0.800000
                                    FINC 0.800000
                                    REAL 0.800000
                                    PROF 0.800000
                                    MGMT 0.800000
                                    ADMI 0.800000
                                    EDUC 0.800000
                                    HEAL 0.800000
                                    ARTS 0.800000
                                    ACCO 0.800000
                                    OTHR 0.800000
                                    GNNC 0.800000
                                    /
        sigmaL(sec)                 CES labor skill substitution elasticity
                                    /
                                    AGRI 0.150000
                                    MINE 0.150000
                                    UTIL 0.150000
                                    CONS 0.150000
                                    MFTG 0.150000
                                    WHOL 0.150000
                                    TRAN 0.150000
                                    RETA 0.150000
                                    INFO 0.150000
                                    FINC 0.150000
                                    REAL 0.150000
                                    PROF 0.150000
                                    MGMT 0.150000
                                    ADMI 0.150000
                                    EDUC 0.150000
                                    HEAL 0.150000
                                    ARTS 0.150000
                                    ACCO 0.150000
                                    OTHR 0.150000
                                    GNNC 0.150000
                                    /

* Household Labor Supply Elasticities

        sigmalaborH                 High Skilled Household Labor Supply Elasticity
                                    /0.8/
        sigmalaborL                 Low Skilled Household Labor Supply Elasticity
                                    /3.0/
* Migrant Labor Supply Elasticities

        sigmaMigLaborH              High Skilled Migrant Elasticity
                                    /1.5/
        sigmaMigLaborL              Low Skilled Migrant Elasticity
                                    /1/
* Commuter Labor Supply Elasticities

        sigmaComLaborH(location)    High Skilled Commuter Elasticity
                                    /
                                    canadian       1.500000
                                    cleveland      1.500000
                                    grady          1.500000
                                    lincoln        1.500000
                                    logan          1.500000
                                    mcclain        1.500000
                                    pottawatomie   1.500000
                                    otherokla      0.150000
                                    outofstate     0.015000
```

```
                                      /

        sigmaComLaborL(location)        Low Skilled Commuter Elasticity
                                        /
                                        canadian       1.000000
                                        cleveland      1.000000
                                        grady          1.000000
                                        lincoln        1.000000
                                        logan          1.000000
                                        mcclain        1.000000
                                        pottawatomie   1.000000
                                        otherokla      0.100000
                                        outofstate     0.010000
                                        /

* Export Demand Elasticities

        sigmaExp(sec)                   Export Demand Elasticities
                                        /
                                        AGRI 1.650000
                                        MINE 1.650000
                                        UTIL 1.650000
                                        CONS 1.650000
                                        MFTG 1.650000
                                        WHOL 0.650000
                                        TRAN 1.650000
                                        RETA 0.650000
                                        INFO 1.650000
                                        FINC 1.650000
                                        REAL 1.650000
                                        PROF 1.650000
                                        MGMT 1.650000
                                        ADMI 1.650000
                                        EDUC 0.650000
                                        HEAL 0.650000
                                        ARTS 0.650000
                                        ACCO 0.650000
                                        OTHR 0.650000
                                        GNNC 0.650000
                                        /
;



*##################### Parameter Calibration Module #########################



* Calibrate Paramters

* CES Production parameters

gammaF(sec)$totaloutput0(sec) = 1/(1+(capitaldemand0(sec)
         /labordemand0(sec))**(-1/sigmaF(sec)));


alphaF(sec)$totaloutput0(sec) = totaloutput0(sec) / (gammaF(sec)*capitaldemand0(sec)**
                 ((sigmaF(sec)-1)/sigmaF(sec)) +
                 (1-gammaF(sec))*labordemand0(sec)**
                 ((sigmaF(sec)-1)/sigmaF(sec)))
                 **(sigmaF(sec)/(sigmaF(sec)-1))
;

* CES Labor Skill parameters

gammaL(sec)$totaloutput0(sec) = 1/(1+(laborhdemand0(sec)
         /laborldemand0(sec))**(-1/sigmaL(sec)));

alphaL(sec)$totaloutput0(sec) = labordemand0(sec) / (gammaL(sec)*laborhdemand0(sec)**
                 ((sigmaL(sec)-1)/sigmaL(sec)) +
```

```
                 (1-gammaL(sec))*laborldemand0(sec)**
                 ((sigmaL(sec)-1)/sigmaL(sec)))
                 **(sigmaL(sec)/(sigmaL(sec)-1))
;

* Armington function parameters

gammaA(sec)$domesticdemandfordomestic0(sec) = 1/(1+(importdemand0(sec)
         /domesticdemandfordomestic0(sec))**(-1/sigmaA(sec)));


alphaA(sec)$domesticdemandfordomestic0(sec) =
compositegood0(sec)/(gammaA(sec)*importdemand0(sec)**
         ((sigmaA(sec)-1)/sigmaA(sec))+
         (1-gammaA(sec))*domesticdemandfordomestic0(sec)**
         ((sigmaA(sec)-1)/sigmaA(sec)))
         **(sigmaA(sec)/(sigmaA(sec)-1));

* CES Utility Function Parameter

scalars
         sigmaC                  substitution elasticity /.75/
;

variable alpha                   Consumption Share Parameter;

alpha.l(sec,h) = (hhdconsumption0(sec,h)**(1/sigmaC))/
         (sum(sec2, hhdconsumption0(sec2,h)**(1/sigmaC)));

parameter
         alphaC(sec,h)             Consumption Share Parameter
;

alphaC(sec,h) = alpha.l(sec,h);

$Title CGE Calibration Check

* Program to check the validity of the calibrated parameters


* Declare Check Parameters

parameters

         kdemchck(sec)                   Check capital demand
         kdemtmp(sec)                    Temp capital demand place holder
         ldemchck(sec)                   Check aggregate labor demand
         ldemtmp(sec)                    Temp labor demand place holder
         lsdemtmp(sec)                   Temp skilled labor demand
         ludemtmp(sec)                   Temp unskilled labor demand
         lsdemchck(sec)                  Check skilled labor
         ludemchck(sec)                  Check unskilled labor
         zeroprofitcheck(sec)            Check Zero Profit Equation
;

* Check Zero Profit Equation

* EQZEROPROFIT(sec)..

zeroprofitcheck(sec) = round(
                 poutput0(sec) * totaloutput0(sec)
                 - pcapital0 * capitaldemand0(sec)
                 - plaborh0 * laborhdemand0(sec)
                 - plaborl0 * laborldemand0(sec)
                 - sum(sec2, inputoutput(sec2,sec) * totaloutput0(sec)
                 * pcomposite0(sec))
                 - misccost0(sec)
                 ,6)
;

display zeroprofitcheck;
```

```
* Check capital and labor demand parameters

* EQK..
kdemtmp(sec) = (totaloutput0(sec)/alphaF(sec))*
                         (gammaF(sec)/(pcapital0))**sigmaF(sec)*
                         (gammaF(sec)**sigmaF(sec)*(pcapital0)
                         **(1-sigmaF(sec))+(1-gammaF(sec))**sigmaF(sec)
                         *(plabor0(sec))**(1-sigmaF(sec))
                         )**(sigmaF(sec)/(1-sigmaF(sec)))
;

* EQL..
ldemtmp(sec) = (totaloutput0(sec) / alphaF(sec)) *
                         ((1-gammaF(sec))/(plabor0(sec)))**sigmaF(sec)*
                         (gammaF(sec)**sigmaF(sec)*(pcapital0)
                         **(1-sigmaF(sec))+(1-gammaF(sec))**sigmaF(sec)
                         *(plabor0(sec))**(1-sigmaF(sec)))
                         **(sigmaF(sec)/(1-sigmaF(sec)))
;

kdemchck(sec) = round((capitaldemand0(sec) - kdemtmp(sec)),6);
ldemchck(sec) = round((labordemand0(sec) - ldemtmp(sec)),6);

display kdemchck, ldemchck;

* Check High and Low skilled labor

* EQLS(sec)..

lsdemtmp(sec) = (ldemtmp(sec) / alphaL(sec))*
                         (gammaL(sec)/(plaborh0))**sigmaL(sec)*
                         (gammaL(sec)**sigmaL(sec)*(plaborh0)
                         **(1-sigmaL(sec))+(1-gammaL(sec))**sigmaL(sec)
                         *(plaborl0)**(1-sigmaL(sec))
                         )**(sigmaL(sec)/(1-sigmaL(sec)))

                 ;

* EQLU(sec)..

ludemtmp(sec) = (ldemtmp(sec) / alphaL(sec))*
                         ((1-gammaL(sec))/(plaborl0))**sigmaL(sec)*
                         (gammaL(sec)**sigmaL(sec)*(plaborh0)
                         **(1-sigmaL(sec))+(1-gammaL(sec))**sigmaL(sec)
                         *(plaborh0)**(1-sigmaL(sec)))
                         **(sigmaL(sec)/(1-sigmaL(sec)))

                 ;

lsdemchck(sec) = round((laborhdemand0(sec) - lsdemtmp(sec)),6);
ludemchck(sec) = round((laborldemand0(sec) - ludemtmp(sec)),6);

display lsdemchck,ludemchck;

*************** Check Zero Profit Eqution

variable zpcheck(sec)                 Check Zero Profit;

*EQZP(sec)..

zpcheck.l(sec) = round(poutput0(sec) * totaloutput0(sec) - (pcapital0
         * capitaldemand0(sec) + plaborh0 * laborhdemand0(sec) + plaborl0
         * laborldemand0(sec) + sum(sec2, inputoutput(sec2,sec)
         * totaloutput0(sec) * pcomposite0(sec))
         + investdemand0(sec) + misccost0(sec)), 6);
display zpcheck.l;

*************** Check Labor Market clearing conditions

parameters
```

```
        lsmrktchck                      Check skilled labor market
        lumrktchck                      Check unskilled labor market
;
* EQMARKETLS..

lsmrktchck = round((sum(sec, laborhdemand0(sec))
        - sum(h, hhdlaborhsupply0(h))
        - sum(location, commuterlaborhsupply0(location))),6)
;

* EQMARKETLU..

lumrktchck = round((sum(sec, laborldemand0(sec)) - sum(h, hhdlaborlsupply0(h))
        - sum(location, commuterlaborlsupply0(location))),6)
;

display lsmrktchck, lumrktchck;

*************** Check Armington parameters

parameters
        qarmprofchck(sec)               Check armington zero profit
        qcomptmp(sec)                   Temp composite place holder
        qdomimpchck(sec)                Check domestic share of armington
        qimpchck(sec)                   Check imports
        qimptmp(sec)                    Temp import place holder
        qdomdomtmp(sec)                 Temp domestic place holder
;

* EQIMPORT(sec)..

qimptmp(sec)$importdemand0(sec) = (compositegood0(sec)
        /alphaA(sec))*(gammaA(sec)/pworld0(sec))**sigmaA(sec)
        *((gammaA(sec)**sigmaA(sec))*
        (pworld0(sec)**(1-sigmaA(sec))) +
        ((1-gammaA(sec))**sigmaA(sec))
        *(pdomestic0(sec)**(1-sigmaA(sec))))
        **(sigmaA(sec)/(1-sigmaA(sec)))
;

* EQARMD(sec)..

qdomdomtmp(sec)$importdemand0(sec) = (compositegood0(sec)
        /alphaA(sec))*((1-gammaA(sec))/pdomestic0(sec))
        **sigmaA(sec)*((gammaA(sec)**sigmaA(sec))*
        (pworld0(sec)**(1-sigmaA(sec))) +
        ((1-gammaA(sec))**sigmaA(sec))
        *(pdomestic0(sec)**(1-sigmaA(sec))))
        **(sigmaA(sec)/(1-sigmaA(sec)))
        ;

* EQPROFITA(sec)..

qcomptmp(sec) = (pworld0(sec)*importdemand0(sec)
        + pdomestic0(sec)*domesticdemandfordomestic0(sec))
        /pcomposite0(sec)
;

qimpchck(sec)$importdemand0(sec) = round((qimptmp(sec) - importdemand0(sec)),6);
qdomimpchck(sec) = round((qdomdomtmp(sec) - domesticdemandfordomestic0(sec)),6);
qarmprofchck(sec) = round((qcomptmp(sec) - compositegood0(sec)),6);

display qimpchck, qdomimpchck, qdomdomtmp, domesticdemandfordomestic0, alphaA,
        qarmprofchck;

********************* Check Foreign sector parameters

parameters

        qoutchck(sec)                   Check zero profit (CET)
```

```
        qouttmp(sec)                    Temp output place holder
;


* EQPROFITT(sec)..

qouttmp(sec) = (pworld0(sec)*exportdemand0(sec) + pdomestic0(sec)
        *domesticdemandfordomestic0(sec)) / poutput0(sec);

qoutchck(sec) = round((qouttmp(sec) - totaloutput0(sec)),6);

display qoutchck;

********************* Check Households

parameters

        cpichk                          Check CPI
        cpitmp                          Temp cpi place holder
        pxcomptmp(sec)                  Temp pxcomp place holder
        qconschk(sec)                   Check consumption parameters
        qconstmp(sec,h)                 Temp consumption place holder
;


qconstmp(sec,h) = alpha.l(sec,h)**sigmaC*cbud0(h) / (pcomposite0(sec)**sigmaC *
sum(sec2, alpha.l(sec2,h)**sigmaC*pcomposite0(sec2)**(1-sigmaC)))
;

qconschk(sec) = round((sum(h,qconstmp(sec,h))
        - sum(h, hhdconsumption0(sec,h))),6);

display qconschk;



*############################## OKCGE Model ####################################



* Declare Model Variables

VARIABLES

        CBUD(h)                         Regional Consumption Budget
        CPI                             Consumer Price Index
        INVESTNEWCAPITAL(sec)           New Regional Investment
        CAPITALDEMAND(sec)              Sectoral Capital Demand
        CAPITALSUPPLY                   Regional Capital Supply
        COMMUTERLABORHSUPPLY(location)  High Skilled Commuters
        COMMUTERLABORLSUPPLY(location)  Low Skilled Commuters
        HHDLABORHSUPPLY(h)              Household High Skilled Labor Supply
        HHDLABORLSUPPLY(h)              Household Low Skilled Labor Supply
        LABORDEMAND(sec)                Sectoral Aggregate Labor Demand
        LABORHDEMAND(sec)               Sectoral Skilled Labor Demand
        LABORHSUPPLY                    Regional Skilled Labor Supply
        LABORLDEMAND(sec)               Sectoral Unskilled Labor Demand
        LABORLSUPPLY                    Regional Unskilled Labor Supply
        MIGRANTHCONSUMPTION(sec)        High Skilled Migrant Consumption
        MIGRANTLCONSUMPTION(sec)        Low Skilled Migrant Consumption
        MIGRANTLABORHSUPPLY             High Skilled Migrant Labor
        MIGRANTLABORLSUPPLY             Low Skilled Migrant Labor
        PCAPITAL                        Returns to Capital
        PLABOR(sec)                     Sectoral Returns to Aggregate Labor
        PLABORH                         Returns to Skilled Labor
        PLABORL                         Returns to Unskilled Labor
        POUTPUT(sec)                    Regional Producer Output Price
        PCOMPOSITE(sec)                 Composite Good Price
        COMPOSITEGOOD(sec)              Composite Good
```

```
        HHDCONSUMPTION(sec,h)           Consumption Demand
        DOMESTICDEMANDFORDOMESTIC(sec)  Domestic Production for Domestic Use
        EXPORTDEMAND(sec)               Domestic Production for Export Use
        IMPORTDEMAND(sec)               Import Good
        INVESTNEWCAPITALDEMAND(sec)     Investment Final Demand
        TOTALOUTPUT(sec)                Total Domestic Production
        STATELOCALGOVTDEMAND(sec)       S&L Government Expenditure
        TRICK                           Dummy Objective Variable
        HHDINCOME(h)                    Household Income
;

* Set Initial Variable values

CBUD.L(h)                        =      cbud0(h)                         ;
CPI.L                            =      cpi0                             ;
INVESTNEWCAPITAL.L(sec)          =      investnewcapital0(sec)           ;
CAPITALDEMAND.L(sec)             =      capitaldemand0(sec)              ;
CAPITALSUPPLY.L                  =      capitalsupply0                   ;
COMMUTERLABORHSUPPLY.L(location) =      commuterlaborhsupply0(location)  ;
COMMUTERLABORLSUPPLY.L(location) =      commuterlaborlsupply0(location)  ;
HHDLABORHSUPPLY.L(h)             =      hhdlaborhsupply0(h)              ;
HHDLABORLSUPPLY.L(h)             =      hhdlaborlsupply0(h)              ;
HHDCONSUMPTION.L(sec,h)          =      hhdconsumption0(sec,h)           ;
LABORDEMAND.L(sec)               =      labordemand0(sec)                ;
LABORHDEMAND.L(sec)              =      laborhdemand0(sec)               ;
LABORHSUPPLY.L                   =      laborhsupply0                    ;
LABORLDEMAND.L(sec)              =      laborldemand0(sec)               ;
LABORLSUPPLY.L                   =      laborlsupply0                    ;
MIGRANTHCONSUMPTION.L(sec)       =      migranthconsumption0(sec)        ;
MIGRANTLCONSUMPTION.L(sec)       =      migrantlconsumption0(sec)        ;
MIGRANTLABORHSUPPLY.L            =      0                                ;
MIGRANTLABORLSUPPLY.L            =      0                                ;
PLABOR.L(sec)                    =      plabor0(sec)                     ;
PLABORH.L                        =      plaborh0                         ;
PLABORL.L                        =      plaborl0                         ;
POUTPUT.L(sec)                   =      poutput0(sec)                    ;
PCOMPOSITE.L(sec)                =      pcomposite0(sec)                 ;
COMPOSITEGOOD.L(sec)             =      compositegood0(sec)              ;
DOMESTICDEMANDFORDOMESTIC.L(sec) =      domesticdemandfordomestic0(sec)  ;
EXPORTDEMAND.L(sec)              =      exportdemand0(sec)               ;
IMPORTDEMAND.L(sec)              =      importdemand0(sec)               ;
INVESTNEWCAPITALDEMAND.L(sec)    =      investdemand0(sec)               ;
TOTALOUTPUT.L(sec)               =      totaloutput0(sec)                ;
STATELOCALGOVTDEMAND.L(sec)      =      statelocalgovtdemand0(sec)       ;
TRICK.L                          =      1                                ;
HHDINCOME.L(h)                   =      hhdincome0(h)                    ;

* Set Variable Bounds

CBUD.LO(h)                        =     almostzero                       ;
CPI.LO                            =     almostzero                       ;
INVESTNEWCAPITAL.LO(sec)          =     almostzero                       ;
CAPITALDEMAND.LO(sec)             =     almostzero                       ;
CAPITALSUPPLY.LO                  =     almostzero                       ;
COMMUTERLABORHSUPPLY.LO(location) =     0                                ;
COMMUTERLABORLSUPPLY.LO(location) =     0                                ;
LABORDEMAND.LO(sec)               =     almostzero                       ;
LABORHSUPPLY.LO                   =     almostzero                       ;
LABORHDEMAND.LO(sec)              =     almostzero                       ;
LABORLDEMAND.LO(sec)              =     almostzero                       ;
MIGRANTHCONSUMPTION.LO(sec)       =     0                                ;
MIGRANTLCONSUMPTION.LO(sec)       =     0                                ;
MIGRANTLABORHSUPPLY.LO            =     0                                ;
MIGRANTLABORLSUPPLY.LO            =     0                                ;
PLABOR.LO(sec)                    =     almostzero                       ;
PLABORH.LO                        =     almostzero                       ;
PLABORL.LO                        =     almostzero                       ;
POUTPUT.LO(sec)                   =     almostzero                       ;
PCOMPOSITE.LO(sec)                =     almostzero                       ;
COMPOSITEGOOD.LO(sec)             =     almostzero                       ;
DOMESTICDEMANDFORDOMESTIC.LO(sec) =     almostzero                       ;
```

```
EXPORTDEMAND.LO(sec)             =       almostzero                     ;
IMPORTDEMAND.LO(sec)             =       almostzero                     ;
INVESTNEWCAPITALDEMAND.LO(sec)   =       almostzero                     ;
TOTALOUTPUT.LO(sec)              =       almostzero                     ;
STATELOCALGOVTDEMAND.LO(sec)     =       almostzero                     ;
HHDINCOME.LO(h)                  =       almostzero                     ;

* Fix the Numeraire

PCAPITAL.FX                      =       pcapital0                      ;

* Declare the Model Equations

EQUATIONS

* Firms

        EQCAPITALDEMAND(sec)            Capital Demand Equation
        EQAGGREGATELABORDEMAND(sec)     Aggregate Labor Demand Equation
        EQLABORHDEMAND(sec)             High Skilled Labor Demand Equation
        EQLABORLDEMAND(sec)             Low Unskilled Labor Demand Equation
        EQLABORZEROPROFIT(sec)          Aggregate Labor Zero Profit Equation
        EQZEROPROFIT(sec)               Firm Zero Profit Equation

* Foreign Sector

        EQEXPORTDEMANDOUT(sec)          Export Supply
        EQEXPORTDEMAND(sec)             Export Demand
        EQARMDOM(sec)                   Armington Domestic Demand Equation
        EQARMIMP(sec)                   Armington Import Demand Equation
        EQARMZP(sec)                    Armington Zero Profit Equation

* Households

        EHHDCONSUMPTION(sec,h)          Household Consumption Equation
        EQINCOME(h)                     Household (Regional) Income Equation
        EQCBUD(h)                       Household Consumption Budget Equation
        EQCPI                           Price Deflator Equation
        EQHHDLABORHSUPPLY(h)            HHD High Skilled Labor Supply
        EQHHDLABORLSUPPLY(h)            HHD Low Skilled Labor Supply
        EQMIGRANTHCONSUMPTION           High Skilled Migrant Consumption
        EQMIGRANTLCONSUMPTION           Low Skilled Migrant Consumption

* Market Clearing

        EQMKTK                          Capital Market Clearing Equation
        EQMKTLABORL                     Low Skilled Labor Market Clearing Equation
        EQMKTLABORH                     High Skilled Labor Market Clearing Equation
        EQMKTGOOD(sec)                  Goods Market Clearing Equation

* Investment

        EINVESTNEWCAPITALDEMANDEST(sec) Aggregate Regional Investment Equation
        EINVESTNEWCAPITALDEMANDDEM(sec) Investment Demand Equation

* Labor Supplies

        EQLABORHSUPPLY                  High Skilled Labor Supply Equation
        EQLABORLSUPPLY                  Low Skilled Labor Supply Equation
        EQMIGRANTLABORHSUPPLY           High Skilled Migrant Equation
        EQMIGRANTLABORLSUPPLY           Low Skilled Migrant Equation
        EQCOMMUTERLABORHSUPPLY(location) Commuter High Skilled Labor Supply Equation
        EQCOMMUTERLABORLSUPPLY(location) Commuter Low Skilled Labor Supply Equation

* Govt

        EQSLGOV(sec)                    Government Final Demand

* Dummy Objective

        OBJ                             Dummy Objective Equation
```

```
;

* Model Equations

* Firms

EQCAPITALDEMAND(sec)..

CAPITALDEMAND(sec) =E= gammaF(sec)**sigmaF(sec) * PCAPITAL
                         **(-sigmaF(sec)) *(gammaF(sec)**sigmaF(sec) * PCAPITAL
                         **(1-sigmaF(sec))+(1-gammaF(sec))**sigmaF(sec)
                         * PLABOR(sec)**(1-sigmaF(sec)))**(sigmaF(sec)
                         /(1-sigmaF(sec))) * (TOTALOUTPUT(sec) / alphaF(sec))
;

EQAGGREGATELABORDEMAND(sec)..

LABORDEMAND(sec) =E= (1-gammaF(sec))**sigmaF(sec) * PLABOR(sec)
                         **(-sigmaF(sec))*(gammaF(sec)**sigmaF(sec) * PCAPITAL
                         **(1-sigmaF(sec))+(1-gammaF(sec))**sigmaF(sec)
                         * PLABOR(sec)**(1-sigmaF(sec)))**(sigmaF(sec)
                         /(1-sigmaF(sec))) * (TOTALOUTPUT(sec) / alphaF(sec))
;

EQLABORHDEMAND(sec)..

LABORHDEMAND(sec) =E= gammaL(sec)**sigmaL(sec) * PLABORH
                         **(-sigmaL(sec))* (gammaL(sec)**sigmaL(sec) * PLABORH
                         **(1-sigmaL(sec)) + (1-gammaL(sec))**sigmaL(sec)
                         * PLABORL**(1-sigmaL(sec)))**(sigmaL(sec)
                         /(1-sigmaL(sec))) * (LABORDEMAND(sec) / alphaL(sec))
;

EQLABORLDEMAND(sec)..

LABORLDEMAND(sec) =E= (1-gammaL(sec))**sigmaL(sec) * PLABORL
                         **(-sigmaL(sec))* (gammaL(sec)**sigmaL(sec) * PLABORH
                         **(1-sigmaL(sec)) + (1-gammaL(sec))**sigmaL(sec)
                         * PLABORL**(1-sigmaL(sec)))**(sigmaL(sec)
                         /(1-sigmaL(sec))) * (LABORDEMAND(sec) / alphaL(sec))
;

EQLABORZEROPROFIT(sec)..

PLABOR(sec) * LABORDEMAND(sec) =E= PLABORH * LABORHDEMAND(sec)
                         + PLABORL * LABORLDEMAND(sec)
;

EQZEROPROFIT(sec)..

POUTPUT(sec) * TOTALOUTPUT(sec) =E= PCAPITAL * CAPITALDEMAND(sec)
                         + PLABORH * LABORHDEMAND(sec)
                         + PLABORL * LABORLDEMAND(sec)
                         + sum(sec2, inputoutput(sec2,sec) * TOTALOUTPUT(sec)
                         * PCOMPOSITE(sec))
                         + misccost0(sec)
;

* Foreign Sector

EQEXPORTDEMANDOUT(sec)..

TOTALOUTPUT(sec) =E= EXPORTDEMAND(sec) + DOMESTICDEMANDFORDOMESTIC(sec)
;

EQEXPORTDEMAND(sec)..

EXPORTDEMAND(sec) =E= exportdemand0(sec) * (pworld0(sec)/POUTPUT(sec))
                         **sigmaexp(sec)
;
```

```
EQARMDOM(sec)..

DOMESTICDEMANDFORDOMESTIC(sec) =E= (1-gammaA(sec))**sigmaA(sec)
                         * POUTPUT(sec)**(-sigmaA(sec)) * (gammaA(sec)
                         **sigmaA(sec) * pworld0(sec)**(1-sigmaA(sec))
                         + (1-gammaA(sec))**sigmaA(sec) * POUTPUT(sec)
                         **(1-sigmaA(sec)))**(sigmaA(sec) / (1-sigmaA(sec)))
                         * (COMPOSITEGOOD(sec) / alphaA(sec))
;

EQARMIMP(sec)..

IMPORTDEMAND(sec) =E= gammaA(sec)**sigmaA(sec) * pworld0(sec)
                         **(-sigmaA(sec)) * (gammaA(sec)**sigmaA(sec)
                         * pworld0(sec)**(1-sigmaA(sec)) + (1-gammaA(sec))
                         **sigmaA(sec) * POUTPUT(sec)**(1-sigmaA(sec)))
                         **(sigmaA(sec) / (1-sigmaA(sec))) * (COMPOSITEGOOD(sec)
                         / alphaA(sec))
;

EQARMZP(sec)..

PCOMPOSITE(sec) * COMPOSITEGOOD(sec) =E= pworld0(sec)
                         * IMPORTDEMAND(sec) + POUTPUT(sec)
                         * DOMESTICDEMANDFORDOMESTIC(sec)
;

* Households

EHHDCONSUMPTION(sec,h)..

HHDCONSUMPTION(sec,h) =E= alphaC(sec,h)**sigmaC * CBUD(h)
                         / (PCOMPOSITE(sec)**sigmaC
                         * sum(sec2, alphac(sec2,h)**sigmaC * PCOMPOSITE(sec2)
                         **(1-sigmaC)))
;

EQINCOME(h)..

HHDINCOME(h) =E= PCAPITAL * hhdcapitalsupply0(h) + PLABORL
                 * HHDLABORLSUPPLY(h) + PLABORH * HHDLABORHSUPPLY(h)
                 + hhdmiscincome0(h)
;

EQCBUD(h)..

CBUD(h) =E= HHDINCOME(h) * (1 - mps(h))
;

EQCPI..

         CPI =E= sum((sec,h), PCOMPOSITE(sec) * hhdconsumption0(sec,h)) /
sum((sec,h), pcomposite0(sec) * hhdconsumption0(sec,h))
;

EQHHDLABORHSUPPLY(h)..

HHDLABORHSUPPLY(h) =E= hhdlaborhsupply0(h) * ((PLABORH / CPI)
                 / (plaborh0 /cpi0))**sigmalaborh
;

EQHHDLABORLSUPPLY(h)..

HHDLABORLSUPPLY(h) =E= hhdlaborlsupply0(h) * ((PLABORL / CPI)
                 / (plaborl0 /cpi0))**sigmalaborl
;

EQMIGRANTHCONSUMPTION(sec)..

MIGRANTHCONSUMPTION(sec) =E= alphaC(sec,'HHD7')**sigmaC
                         * (MIGRANTLABORHSUPPLY / HHDLABORHSUPPLY('HHD7'))
```

```
                         *CBUD('HHD7') / (PCOMPOSITE(sec)**sigmaC
                         * sum(sec2, alphaC(sec2,'HHD7')**sigmaC
                         * PCOMPOSITE(sec2)**(1-sigmaC)))
;

EQMIGRANTLCONSUMPTION(sec)..

MIGRANTLCONSUMPTION(sec) =E= alphaC(sec,'HHD4')**sigmaC
                         * (MIGRANTLABORLSUPPLY / HHDLABORLSUPPLY('HHD4'))
                         * CBUD('HHD4') / (PCOMPOSITE(sec)**sigmaC
                         * sum(sec2, alphaC(sec2,'HHD4')**sigmaC
                         * PCOMPOSITE(sec2)**(1-sigmaC)))
;

* Market Clearing

EQMKTK..

sum(sec, CAPITALDEMAND(sec)) =E= CAPITALSUPPLY
;

EQMKTLABORL..

sum(sec, LABORLDEMAND(sec)) =E= LABORLSUPPLY
;

EQMKTLABORH..

sum(sec, LABORHDEMAND(sec)) =E= LABORHSUPPLY
;

EQMKTGOOD(sec)..

COMPOSITEGOOD(sec) =E= sum(sec2, inputoutput(sec,sec2)
                         * TOTALOUTPUT(sec2)) + STATELOCALGOVTDEMAND(sec)
                         + fedgovtdemand0(sec) + sum(h, HHDCONSUMPTION(sec,h))
                         + INVESTNEWCAPITALDEMAND(sec)

;

* Investment

EINVESTNEWCAPITALDEMANDEST(sec)..

INVESTNEWCAPITAL(sec) =E= investnewcapital0(sec) * CAPITALDEMAND(sec)
                         / capitaldemand0(sec)
;

EINVESTNEWCAPITALDEMANDDEM(sec)..

INVESTNEWCAPITALDEMAND(sec) =E= investdemand0(sec)
                         * sum(sec2, INVESTNEWCAPITAL(sec2))
                         / sum(sec2, investnewcapital0(sec2))
;

* Labor Supplies

* Equilibria

EQLABORHSUPPLY..

         LABORHSUPPLY =E= sum(h, HHDLABORHSUPPLY(h)) + MIGRANTLABORHSUPPLY
                 + sum(location, COMMUTERLABORHSUPPLY(location))
;

EQLABORLSUPPLY..

         LABORLSUPPLY =E= sum(h, HHDLABORLSUPPLY(h)) + MIGRANTLABORLSUPPLY
                 + sum(location, COMMUTERLABORLSUPPLY(location))
;
```

```
* Migrants

EQMIGRANTLABORHSUPPLY..

         MIGRANTLABORHSUPPLY =E= laborhsupply0 * sigmaMigLaborH * log((PLABORH
                 /CPI)/(plaborh0/cpi0))
;

EQMIGRANTLABORLSUPPLY..

         MIGRANTLABORLSUPPLY =E= laborlsupply0 * sigmaMigLaborL * log((PLABORL
                 /CPI)/(plaborl0/cpi0))
;


* Commuters

EQCOMMUTERLABORHSUPPLY(location)..

COMMUTERLABORHSUPPLY(location) =E= commuterlaborhsupply0(location)
                 * (PLABORH / plaborh0) ** sigmaComLaborH(location)
;

EQCOMMUTERLABORLSUPPLY(location)..

COMMUTERLABORLSUPPLY(location) =E= commuterlaborlsupply0(location)
                 * (PLABORL / plaborl0) ** sigmaComLaborL(location)
;

* Govt

EQSLGOV(sec)..

STATELOCALGOVTDEMAND(sec) =E= statelocalgovtdemand0(sec)
                         * sum(sec2, TOTALOUTPUT(sec2))
                         / sum(sec2, totaloutput0(sec2))
;

* Dummy Objective

OBJ..

         TRICK =E= 1
;

option iterlim = 5;

MODEL OKCGE /all/;
SOLVE OKCGE using NLP Maximizing TRICK;

* Solve Counterfactuals

option iterlim = 2000;

parameters

         exportdemandtmp(sec)            Temporary Export Demand Placeholder
         commuterhincome(location)       High Skilled Commuter Income
         commuterhincchange(location)    Percent Change in income
         commuterlincome(location)       Low Skilled Commuter Income
         commuterlincchange(location)    Percent Change in income
         commutertotincome(location)     Total Commuter Income by Location
         commutertotincome0(location)    Bench Total Commuter Income
         commutertotincchange(location)  Percent Change in Income
         commuternearincome              Commuter Income to Nearby Counties
         commuternearincome0             Bench Commuter Income to Nearby Counties
         commuternearincchange           Percent Change in Income
;

exportdemandtmp(sec) = exportdemand0(sec);
commutertotincome0(location) = commuterlaborlsupply0(location)
```

```
        + commuterlaborhsupply0(location);
commuternearincome0 = sum(nearloc, commutertotincome0(nearloc));

* Simulation 1: No Change to LFPR, Commuter or Migration Elasticities

*exportdemand0('MFTG') = exportdemand0('MFTG') * 1.5;
SOLVE OKCGE using NLP Maximizing TRICK;

* set benchmark export demand back to original value for comparison

exportdemand0(sec) = exportdemandtmp(sec);
commuterhincome(location) = PLABORH.L * COMMUTERLABORHSUPPLY.L(location);
commuterlincome(location) = PLABORL.L * COMMUTERLABORLSUPPLY.L(location);
commutertotincome(location) = commuterhincome(location)
        + commuterlincome(location);
commuternearincome = sum(nearloc, commutertotincome(nearloc));
commuterhincchange(location) = (commuterhincome(location)
        - commuterlaborhsupply0(location))
        / commuterlaborhsupply0(location) * 100;
commuterlincchange(location) = (commuterlincome(location)
        - commuterlaborlsupply0(location))
        / commuterlaborlsupply0(location) * 100;
commutertotincchange(location) = (commutertotincome(location)
        - commutertotincome0(location))
        / commutertotincome0(location) * 100;
commuternearincchange = (commuternearincome - commuternearincome0)
        / commuternearincome0 * 100;

* Create Reports

$include '%PROGPATH%OKCGE Report Writer.gms'



*########################### Report Writer Module ##############################

*******************************************************************************
*                                                                             *
* This module creates an output file and reports results                      *
*                                                                             *
*******************************************************************************

* Create the report file

FILE Report / "%PROGPATH%Report.txt" /;

PUT Report;

* Set output parameters

Report.lw=0;
Report.nr =  0;
Report.nw = 0;
Report.nd = 4;
Report.nz = 0;

* Create Change Parameters for Reporting

PARAMETER DIFF(*);
SCALAR DIFF1;
PARAMETER PERDIFF(*);
SCALAR PERDIFF1;

* Write the output report

put//////;
put
"*****************************************************************************************
*"/;
```

```
put "*
*"/;
put "*                  Report on the Impact of Increased Economic Activity on
*"/;
put "*                      Regional Cooperation and Income Distribution
*"/;
put "*
*"/;
put "*                             Kyle Dean - Dissertation 2008
*"/;
put "*
*"/;
put "*                        File Written on: ", system.date," at ", system.time,"
*"/;
put "*
*"/;
put
"*****************************************************************************************
*"/;
put/////;

put "------------------------------- Factor Supply ---------------------------------------
-----"/////;

put "HHDLABORLSUPPLY", @30, HHDLABORLSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(h) = HHDLABORLSUPPLY.L(h) - hhdlaborlsupply0(h);
PERDIFF(h) = 0;
PERDIFF(h)$hhdlaborlsupply0(h) = 100*DIFF(h)/hhdlaborlsupply0(h);
loop(h, put @3, h.tl, @15, hhdlaborlsupply0(h), @35, HHDLABORLSUPPLY.L(h), @55, DIFF(h),
@75, PERDIFF(h) /);
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "MIGRANTLABORLSUPPLY", @30, MIGRANTLABORLSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual'//;
put @15, '0.0000', @35, MIGRANTLABORLSUPPLY.L /;
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "COMMUTERLABORLSUPPLY", @30, COMMUTERLABORLSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(location) = COMMUTERLABORLSUPPLY.L(location) - commuterlaborlsupply0(location);
PERDIFF(location) = 0;
PERDIFF(location) = 100*DIFF(location)/commuterlaborlsupply0(location);
loop(location, put @3, location.tl, put @15, commuterlaborlsupply0(location),
         @35, COMMUTERLABORLSUPPLY.L(location),@55, DIFF(location), @75,
PERDIFF(location) /);
put /;
DIFF1 = sum(location, COMMUTERLABORLSUPPLY.L(location)) - sum(location,
commuterlaborlsupply0(location));
PERDIFF1 = 100*DIFF1/sum(location, commuterlaborlsupply0(location));
put "Total: ";
put @15, sum(location, commuterlaborlsupply0(location)), @35, sum(location,
COMMUTERLABORLSUPPLY.L(location)), @55, DIFF1, @75, PERDIFF1 /;
put//;
DIFF1 = sum(nearloc, COMMUTERLABORLSUPPLY.L(nearloc)) - sum(nearloc,
commuterlaborlsupply0(nearloc));
PERDIFF1 = 100*DIFF1/sum(nearloc, commuterlaborlsupply0(nearloc));
put "Total Near:";
put @15, sum(nearloc, commuterlaborlsupply0(nearloc)), @35, sum(nearloc,
COMMUTERLABORLSUPPLY.L(nearloc)), @55, DIFF1, @75, PERDIFF1 /;
put//;

put "------------------------------------------------------------------------------------
-----"/////;
```

```
put "LABORLSUPPLY", @30, LABORLSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = LABORLSUPPLY.L - laborlsupply0;
PERDIFF1 = 0;
PERDIFF1 = 100*DIFF1/laborlsupply0;
put @15, laborlsupply0, @35, LABORLSUPPLY.L, @55, DIFF1, @75, PERDIFF1 /;
put//;

put "---------------------------------------------------------------------------------
-----"//;

parameters

         totallaborhsupply0                      Total Benchmark High Skilled Supply
         totallaborhsupplyC                      Counterfactual total HS Supply
         totallaborlsupply0                      Total Benchmark Low Skilled Supply
         totallaborlsupplyC                      Counterfactual total LS Supply
;

totallaborlsupply0 = sum(h, hhdlaborlsupply0(h)) + sum(location,
commuterlaborlsupply0(location));
totallaborlsupplyC = sum(h, HHDLABORLSUPPLY.L(h)) + sum(location,
COMMUTERLABORLSUPPLY.L(location))
         + MIGRANTLABORLSUPPLY.L;


put @30, "Low Skilled Labor Supply Summary"//;
put @15, "Local Households", @35, "Commuters", @55, "Migrants", @75, "Total"//;
put 'Benchmark:', @15, sum(h, hhdlaborlsupply0(h)), @35, sum(location,
commuterlaborlsupply0(location)), @55, '0.0000', @75, totallaborlsupply0/;
put 'Share of Tot:', @15, (sum(h,hhdlaborlsupply0(h)) / totallaborlsupply0), @35,
(sum(location, commuterlaborlsupply0(location))/totallaborlsupply0), @55, '0.0000'/////;
put 'Counterfac:', @15, sum(h, HHDLABORLSUPPLY.L(h)), @35, sum(location,
COMMUTERLABORLSUPPLY.L(location)), @55, MIGRANTLABORLSUPPLY.L, @75, totallaborlsupplyC/;
put 'Share of Tot:', @15, (sum(h,HHDLABORLSUPPLY.L(h)) / totallaborlsupplyC), @35,
(sum(location, COMMUTERLABORLSUPPLY.L(location))/totallaborlsupplyc), @55,
(MIGRANTLABORLSUPPLY.L/totallaborlsupplyC)//;
put//;

put "---------------------------------------------------------------------------------
-----"//;

put "HHDLABORHSUPPLY", @30, HHDLABORHSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(h) = HHDLABORHSUPPLY.L(h) - hhdlaborhsupply0(h);
PERDIFF(h) = 0;
PERDIFF(h)$hhdlaborhsupply0(h) = 100*DIFF(h)/hhdlaborhsupply0(h);
loop(h, put @3, h.tl, @15, hhdlaborhsupply0(h), @35, HHDLABORHSUPPLY.L(h), @55, DIFF(h),
@75, PERDIFF(h) /);
put//;

put "---------------------------------------------------------------------------------
-----"//;

put "MIGRANTLABORHSUPPLY", @30, MIGRANTLABORHSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual'//;
put @15, '0.0000', @35, MIGRANTLABORHSUPPLY.L /;
put//;

put "---------------------------------------------------------------------------------
-----"//;

put "COMMUTERLABORHSUPPLY", @30, COMMUTERLABORHSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(location) = COMMUTERLABORHSUPPLY.L(location) - commuterlaborhsupply0(location);
PERDIFF(location) = 0;
PERDIFF(location) = 100*DIFF(location)/commuterlaborhsupply0(location);
loop(location, put @3, location.tl, put @15, commuterlaborhsupply0(location),
         @35, COMMUTERLABORHSUPPLY.L(location),@55, DIFF(location), @75,
PERDIFF(location) /);
put /;
```

```
DIFF1 = sum(location, COMMUTERLABORHSUPPLY.L(location)) - sum(location,
commuterlaborhsupply0(location));
PERDIFF1 = 100*DIFF1/sum(location, commuterlaborhsupply0(location));
put "Total: ";
put @15, sum(location, commuterlaborhsupply0(location)), @35, sum(location,
COMMUTERLABORHSUPPLY.L(location)), @55, DIFF1, @75, PERDIFF1 /;
put//;
DIFF1 = sum(nearloc, COMMUTERLABORHSUPPLY.L(nearloc)) - sum(nearloc,
commuterlaborhsupply0(nearloc));
PERDIFF1 = 100*DIFF1/sum(nearloc, commuterlaborhsupply0(nearloc));
put "Total Near:";
put @15, sum(nearloc, commuterlaborhsupply0(nearloc)), @35, sum(nearloc,
COMMUTERLABORHSUPPLY.L(nearloc)), @55, DIFF1, @75, PERDIFF1 /;
put//;

put "--------------------------------------------------------------------------------
-----"//;

put "LABORHSUPPLY", @30, LABORHSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = LABORHSUPPLY.L - laborhsupply0;
PERDIFF1 = 0;
PERDIFF1 = 100*DIFF1/laborhsupply0;
put @15, laborhsupply0, @35, LABORHSUPPLY.L, @55, DIFF1, @75, PERDIFF1 /;
put//;

put "--------------------------------------------------------------------------------
-----"//;

totallaborhsupply0 = sum(h, hhdlaborhsupply0(h)) + sum(location,
commuterlaborhsupply0(location));
totallaborhsupplyC = sum(h, HHDLABORHSUPPLY.L(h)) + sum(location,
COMMUTERLABORHSUPPLY.L(location))
         + MIGRANTLABORHSUPPLY.L;

put @30, "High Skilled Labor Supply Summary"//;
put @15, "Local Households", @35, "Commuters", @55, "Migrants", @75, "Total"//;
put 'Benchmark:', @15, sum(h, hhdlaborhsupply0(h)), @35, sum(location,
commuterlaborhsupply0(location)), @55, '0.0000', @75, totallaborhsupply0/;
put 'Share of Tot:', @15, (sum(h,hhdlaborhsupply0(h)) / totallaborhsupply0), @35,
(sum(location, commuterlaborhsupply0(location))/totallaborhsupply0), @55, '0.0000'/////;
put 'Counterfac:', @15, sum(h, HHDLABORHSUPPLY.L(h)), @35, sum(location,
COMMUTERLABORHSUPPLY.L(location)), @55, MIGRANTLABORHSUPPLY.L, @75, totallaborhsupplyC/;
put 'Share of Tot:', @15, (sum(h,HHDLABORHSUPPLY.L(h)) / totallaborhsupplyC), @35,
(sum(location, COMMUTERLABORHSUPPLY.L(location))/totallaborhsupplyc), @55,
(MIGRANTLABORHSUPPLY.L/totallaborhsupplyC)//;
put//;

put "--------------------------------------------------------------------------------
-----"//;
put "hhdcapitalsupply0", @30, hhdcapitalsupply0.ts //;
put @15, 'Benchmark', @35//;
loop(h, put @3, h.tl, @15, hhdcapitalsupply0(h) /);
put//;

put "--------------------------------------------------------------------------------
-----"//;

put "CAPITALSUPPLY",@30, CAPITALSUPPLY.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = CAPITALSUPPLY.L - capitalsupply0;
PERDIFF1 = 0;
PERDIFF1 = 100*DIFF1/capitalsupply0;
put @15, capitalsupply0, @35, CAPITALSUPPLY.L, @55, DIFF1, @75, PERDIFF1 /;
put//;
put "--------------------------------------------------------------------------------
-----"/////;

put "------------------------------- Factor Demand --------------------------------------
-----"/////;
```

```
put "LABORHDEMAND",@30, LABORHDEMAND.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = LABORHDEMAND.L(sec) - laborhdemand0(sec);
PERDIFF(sec) = DIFF(sec)*100 / laborhdemand0(sec);
loop(sec, put @3, sec.tl, @15, laborhdemand0(sec), @35, LABORHDEMAND.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "LABORLDEMAND",@30, LABORLDEMAND.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = LABORLDEMAND.L(sec) - laborldemand0(sec);
PERDIFF(sec) = DIFF(sec)*100 / laborldemand0(sec);
loop(sec, put @3, sec.tl, @15, laborldemand0(sec), @35, LABORLDEMAND.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "LABORDEMAND",@30, LABORDEMAND.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = LABORDEMAND.L(sec) - labordemand0(sec);
PERDIFF(sec) = DIFF(sec)*100 / labordemand0(sec);
loop(sec, put @3, sec.tl, @15, labordemand0(sec), @35, LABORDEMAND.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
put /;
DIFF1 = sum(sec, LABORDEMAND.L(sec)) - sum(sec, labordemand0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, labordemand0(sec));
put "Total: ";
put @15, sum(sec, labordemand0(sec)), @35, sum(sec, LABORDEMAND.L(sec)), @55, DIFF1, @75,
PERDIFF1 /;
put//;
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "CAPITALDEMAND",@30, CAPITALDEMAND.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = CAPITALDEMAND.L(sec) - capitaldemand0(sec);
PERDIFF(sec) = DIFF(sec)*100 / capitaldemand0(sec);
loop(sec, put @3, sec.tl, @15, capitaldemand0(sec), @35, CAPITALDEMAND.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
put /;
DIFF1 = sum(sec, CAPITALDEMAND.L(sec)) - sum(sec, capitaldemand0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, capitaldemand0(sec));
put "Total: ";
put @15, sum(sec, capitaldemand0(sec)), @35, sum(sec, CAPITALDEMAND.L(sec)), @55, DIFF1,
@75, PERDIFF1 /;
put//;

put "------------------------------------------------------------------------------------
-----"/////;


put "--------------------------- Production Quantities ----------------------------------
-----"/////;

put "TOTALOUTPUT",@30,TOTALOUTPUT.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = TOTALOUTPUT.L(sec) - totaloutput0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$totaloutput0(sec) = 100*DIFF(sec)/totaloutput0(sec);
loop(sec, put @3, sec.tl, @15, totaloutput0(sec), @35, TOTALOUTPUT.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec)/);
put /;
DIFF1 = sum(sec, TOTALOUTPUT.L(sec)) - sum(sec, totaloutput0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, totaloutput0(sec));
```

```
put "Total: ";
put @15, sum(sec, totaloutput0(sec)), @35, sum(sec, TOTALOUTPUT.L(sec)), @55, DIFF1, @75,
PERDIFF1 /;
put//;

put "----------------------------------------------------------------------------------
-----"//;

put "EXPORTDEMAND",@30, EXPORTDEMAND.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = EXPORTDEMAND.L(sec) - exportdemand0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$exportdemand0(sec) = 100*DIFF(sec)/exportdemand0(sec);
loop(sec, put @3, sec.tl, @15, exportdemand0(sec), @35, EXPORTDEMAND.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
put /;
DIFF1 = sum(sec, EXPORTDEMAND.L(sec)) - sum(sec, exportdemand0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, exportdemand0(sec));
put "Total: ";
put @15, sum(sec, exportdemand0(sec)), @35, sum(sec, EXPORTDEMAND.L(sec)), @55, DIFF1,
@75, PERDIFF1 /;
put//;

put "----------------------------------------------------------------------------------
-----"//;

put "DOMESTICDEMANDFORDOMESTIC",@30, DOMESTICDEMANDFORDOMESTIC.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = DOMESTICDEMANDFORDOMESTIC.L(sec) - domesticdemandfordomestic0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$domesticdemandfordomestic0(sec) =
100*DIFF(sec)/domesticdemandfordomestic0(sec);
loop(sec, put @3, sec.tl, @15, domesticdemandfordomestic0(sec), @35,
DOMESTICDEMANDFORDOMESTIC.L(sec), @55, DIFF(sec), @75, PERDIFF(sec) /);
put /;
DIFF1 = sum(sec, DOMESTICDEMANDFORDOMESTIC.L(sec)) - sum(sec,
domesticdemandfordomestic0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, domesticdemandfordomestic0(sec));
put "Total: ";
put @15, sum(sec, domesticdemandfordomestic0(sec)), @35, sum(sec,
DOMESTICDEMANDFORDOMESTIC.L(sec)), @55, DIFF1, @75, PERDIFF1 /;
put//;

put "----------------------------------------------------------------------------------
-----"//;

put "IMPORTDEMAND",@30, IMPORTDEMAND.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = IMPORTDEMAND.L(sec) - importdemand0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$importdemand0(sec) = 100*DIFF(sec)/importdemand0(sec);
loop(sec, put @3, sec.tl, @15, importdemand0(sec), @35, IMPORTDEMAND.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
put /;
DIFF1 = sum(sec, IMPORTDEMAND.L(sec)) - sum(sec, importdemand0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, importdemand0(sec));
put "Total: ";
put @15, sum(sec, importdemand0(sec)), @35, sum(sec, IMPORTDEMAND.L(sec)), @55, DIFF1,
@75, PERDIFF1 /;
put//;

put "----------------------------------------------------------------------------------
-----"//;

put "COMPOSITEGOOD", @30,COMPOSITEGOOD.ts //;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = COMPOSITEGOOD.L(sec) - compositegood0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$compositegood0(sec) = 100*DIFF(sec)/compositegood0(sec);
loop(sec, put @3, sec.tl, @15, compositegood0(sec), @35, COMPOSITEGOOD.L(sec), @55,
DIFF(sec), @75, PERDIFF(sec) /);
```

```
put /;
DIFF1 = sum(sec, COMPOSITEGOOD.L(sec)) - sum(sec, compositegood0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, compositegood0(sec));
put "Total: ";
put @15, sum(sec, compositegood0(sec)), @35, sum(sec, COMPOSITEGOOD.L(sec)), @55, DIFF1,
@75, PERDIFF1 /;
put//;

put "--------------------------------------------------------------------------------
-----"/////;

put "------------------------------------- Final Demand ---------------------------------
-----"/////;

put "HHDCONSUMPTION",@30,HHDCONSUMPTION.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = sum(h,HHDCONSUMPTION.L(sec,h)) - sum(h,hhdconsumption0(sec,h));
PERDIFF(sec) = 0;
PERDIFF(sec)$(sum(h,hhdconsumption0(sec,h))>almostzero) =
100*DIFF(sec)/sum(h,hhdconsumption0(sec,h));
loop(sec, put$(sum(h,hhdconsumption0(sec,h))>0.00000001) @3, sec.tl, @15,
sum(h,hhdconsumption0(sec,h)), @35, sum(h,HHDCONSUMPTION.L(sec,h)), @55, DIFF(sec), @75,
PERDIFF(sec)/);
put /;
DIFF1 = sum((sec,h), HHDCONSUMPTION.L(sec,h)) - sum((sec,h), hhdconsumption0(sec,h));
PERDIFF1 = 100*DIFF1/sum((sec,h), hhdconsumption0(sec,h));
put "Total: ";
put @15, sum((sec,h), hhdconsumption0(sec,h)), @35, sum((sec,h),
HHDCONSUMPTION.L(sec,h)), @55, DIFF1, @75, PERDIFF1 /;
put//;

put "--------------------------------------------------------------------------------
-----"//;

put "INTERMEDIATE",@30,"Intermediate demand for Domestic..."//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = sum(sec2, inputoutput(sec,sec2)*TOTALOUTPUT.L(sec2)) - sum(sec2,
inputoutput(sec,sec2)*totaloutput0(sec2));
PERDIFF(sec) = 100*DIFF(sec)/sum(sec2, inputoutput(sec,sec2)*totaloutput0(sec2));
loop(sec, put @3, sec.tl, @15, sum(sec2, inputoutput(sec,sec2)*totaloutput0(sec2)), @35,
sum(sec2, inputoutput(sec,sec2)*TOTALOUTPUT.L(sec2)), @55 DIFF(sec), @75, PERDIFF(sec)/);
put /;
DIFF1 = sum((sec2,sec), inputoutput(sec,sec2)*TOTALOUTPUT.L(sec2)) - sum((sec2,sec),
inputoutput(sec,sec2)*totaloutput0(sec2));
PERDIFF1 = 100*DIFF1/sum((sec2,sec), inputoutput(sec,sec2)*totaloutput0(sec2));
put "Total: ";
put @15, sum((sec2,sec), inputoutput(sec,sec2)*totaloutput0(sec2)), @35, sum((sec2,sec),
inputoutput(sec,sec2)*TOTALOUTPUT.L(sec2)), @55, DIFF1, @75, PERDIFF1 /;
put//;

put "--------------------------------------------------------------------------------
-----"//;

put "INVESTNEWCAPITALDEMAND",@30,INVESTNEWCAPITALDEMAND.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = INVESTNEWCAPITALDEMAND.L(sec) - investdemand0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$(investdemand0(sec)>almostzero) = 100*DIFF(sec)/investdemand0(sec);
loop(sec, put$(investdemand0(sec)>0.00000001) @3, sec.tl, @15, investdemand0(sec), @35,
INVESTNEWCAPITALDEMAND.L(sec), @55, DIFF(sec), @75, PERDIFF(sec)/);
put /;
DIFF1 = sum(sec, INVESTNEWCAPITALDEMAND.L(sec)) - sum(sec, investdemand0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, investdemand0(sec));
put "Total: ";
put @15, sum(sec, investdemand0(sec)), @35, sum(sec, INVESTNEWCAPITALDEMAND.L(sec)), @55,
DIFF1, @75, PERDIFF1 /;
put//;

put "--------------------------------------------------------------------------------
-----"//;
```

```
put "STATELOCALGOVTDEMAND",@30,STATELOCALGOVTDEMAND.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = STATELOCALGOVTDEMAND.L(sec) - statelocalgovtdemand0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$(statelocalgovtdemand0(sec)>almostzero) =
100*DIFF(sec)/statelocalgovtdemand0(sec);
loop(sec, put$(statelocalgovtdemand0(sec)>0.00000001) @3, sec.tl, @15,
statelocalgovtdemand0(sec), @35, STATELOCALGOVTDEMAND.L(sec), @55, DIFF(sec), @75,
PERDIFF(sec)/);
put /;
DIFF1 = sum(sec, STATELOCALGOVTDEMAND.L(sec)) - sum(sec, statelocalgovtdemand0(sec));
PERDIFF1 = 100*DIFF1/sum(sec, statelocalgovtdemand0(sec));
put "Total: ";
put @15, sum(sec, statelocalgovtdemand0(sec)), @35, sum(sec,
STATELOCALGOVTDEMAND.L(sec)), @55, DIFF1, @75, PERDIFF1 /;
put//;

put "-----------------------------------------------------------------------------------
-----"//;

put "MIGRANTHCONSUMPTION",@30,MIGRANTHCONSUMPTION.ts//;
put @15, 'Benchmark', @35, 'Counterfactual'//;
loop(sec, put @3, sec.tl, @15, '0.0000', @35, MIGRANTHCONSUMPTION.L(sec)/);
put /;
put "Total: ";
put @15, '0.0000', @35, sum(sec, MIGRANTHCONSUMPTION.L(sec))/;
put//;

put "-----------------------------------------------------------------------------------
-----"//;

put "MIGRANTLCONSUMPTION",@30,MIGRANTLCONSUMPTION.ts//;
put @15, 'Benchmark', @35, 'Counterfactual'//;
loop(sec, put @3, sec.tl, @15, '0.0000', @35, MIGRANTLCONSUMPTION.L(sec)/);
put /;
put "Total: ";
put @15, '0.0000', @35, sum(sec, MIGRANTLCONSUMPTION.L(sec))/;
put//;

put "-----------------------------------------------------------------------------------
-----"/////;

put "---------------------------------- Prices -----------------------------------------
-----"/////;

put "CPI",@30,CPI.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = CPI.L - cpi0;
PERDIFF1 = 0;
PERDIFF1$cpi0 = 100*DIFF1/cpi0;
put @15, cpi0, @35, CPI.L, @55, DIFF1, @75, PERDIFF1 /;
put//;

put "-----------------------------------------------------------------------------------
-----"//;

put "POUTPUT",@30,POUTPUT.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = POUTPUT.L(sec) - poutput0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$poutput0(sec) = 100*DIFF(sec)/poutput0(sec);
loop(sec, put @3, sec.tl, @15, poutput0(sec), @35, POUTPUT.L(sec), @55, DIFF(sec), @75,
PERDIFF(sec)/);
put//;

put "-----------------------------------------------------------------------------------
-----"//;

put "PCOMPOSITE",@30,PCOMPOSITE.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = PCOMPOSITE.L(sec) - pcomposite0(sec);
```

```
PERDIFF(sec) = 0;
PERDIFF(sec)$pcomposite0(sec) = 100*DIFF(sec)/pcomposite0(sec);
loop(sec, put @3, sec.tl, @15, pcomposite0(sec), @35, PCOMPOSITE.L(sec), @55, DIFF(sec),
@75, PERDIFF(sec)/);
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "PCAPITAL",@30,PCAPITAL.ts,"Fixed at 1.0000"//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = PCAPITAL.L - pcapital0;
PERDIFF1 = 0;
PERDIFF1$pcapital0 = 100*DIFF1/pcapital0;
put @15, pcapital0, @35, PCAPITAL.L, @55, DIFF1, @75, PERDIFF1/;
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "PLABOR",@30,PLABOR.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(sec) = PLABOR.L(sec) - plabor0(sec);
PERDIFF(sec) = 0;
PERDIFF(sec)$plabor0(sec) = 100*DIFF(sec)/plabor0(sec);
loop(sec, put @3, sec.tl, @15, plabor0(sec), @35, PLABOR.L(sec), @55, DIFF(sec), @75,
PERDIFF(sec)/);
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "PLABORL",@30,PLABORL.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = PLABORL.L - plaborl0;
PERDIFF1 = 100*DIFF1/plaborl0;
put @15, plaborl0, @35, PLABORL.L, @55, DIFF1, @75, PERDIFF1/;
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "PLABORL Real", @30, "Real Low Skilled Wage"//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = PLABORL.L/CPI.L - plaborl0;
PERDIFF1 = 100 * DIFF1/plaborl0;
put @15, plaborl0, @35, (PLABORL.L/CPI.L), @55, DIFF1, @75, PERDIFF1/;
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "PLABORH",@30,PLABORH.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = PLABORH.L - plaborh0;
PERDIFF1 = 100*DIFF1/plaborh0;
put @15, plaborh0, @35, PLABORH.L, @55, DIFF1, @75, PERDIFF1/;
put//;

put "------------------------------------------------------------------------------------
-----"//;

put "PLABORH Real", @30, "Real High Skilled Wage"//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF1 = PLABORH.L/CPI.L - plaborh0;
PERDIFF1 = 100 * DIFF1/plaborh0;
put @15, plaborh0, @35, (PLABORH.L/CPI.L), @55, DIFF1, @75, PERDIFF1/;
put//;

put "------------------------------------------------------------------------------------
-----"/////;
```

```
put "--------------------------------- Households ---------------------------------------
-----"/////;

put "HHDINCOME", @30, HHDINCOME.ts//;
put @15, 'Benchmark', @35, 'Counterfactual', @55, 'Difference', @75, 'Percent Diff'//;
DIFF(h) = HHDINCOME.L(h) - hhdincome0(h);
PERDIFF(h) = 0;
PERDIFF(h) = 100*DIFF(h)/hhdincome0(h);
loop(h, put @3, h.tl, @15, hhdincome0(h), @35, HHDINCOME.L(h), @55, DIFF(h), @75,
PERDIFF(h)/);
put /;
DIFF1 = sum(h, HHDINCOME.L(h)) - sum(h, hhdincome0(h));
PERDIFF1 = 100*DIFF1/sum(h, hhdincome0(h));
put "Total: ";
put @15, sum(h, hhdincome0(h)), @35, sum(h, HHDINCOME.L(h)), @55, DIFF1, @75, PERDIFF1 /;
put//;
put "------------------------------------------------------------------------------------
-----"//;



put///;
put "---------------------------------- End Run ----------------------------------------
-----"/;

*############################ OKCGE Excel Module ###############################

* Output

solution(sec,'TotalOutput') = TOTALOUTPUT.L(sec);
solution('TOTAL','TotalOutput') = sum(sec, TOTALOUTPUT.L(sec));
solution(sec,'ExportDemand') = EXPORTDEMAND.L(sec);
solution('TOTAL','ExportDemand') = sum(sec, EXPORTDEMAND.L(sec));
solution(sec,'LocalDemand') = DOMESTICDEMANDFORDOMESTIC.L(sec);
solution('TOTAL','LocalDemand') = sum(sec, DOMESTICDEMANDFORDOMESTIC.L(sec));

* Imports

solution(sec,'ImportDemand') = IMPORTDEMAND.L(sec);
solution('TOTAL','ImportDemand') = sum(sec, IMPORTDEMAND.L(sec));

* Composite Goods

*solution(sec,'CompositeGood') = COMPOSITEGOOD.L(sec);
*solution('TOTAL','ImportDemand') = sum(sec, COMPOSITEGOOD.L(sec));

* HHD Consumption

solution(sec,h) = HHDCONSUMPTION.L(sec,h);
solution('TOTAL',h) = sum(sec, HHDCONSUMPTION.L(sec,h));

* State & Local Demand

solution(sec,'S&L Demand') = STATELOCALGOVTDEMAND.L(sec);
solution('TOTAL','S&L Demand') = sum(sec, STATELOCALGOVTDEMAND.L(sec));

* Investment Demand

solution(sec,'InvDemand') = INVESTNEWCAPITALDEMAND.L(sec);
solution('TOTAL','InvDemand') = sum(sec, INVESTNEWCAPITALDEMAND.L(sec));

* Intermediate Demand

solution(sec,'IntermedDemand') = sum(sec2, inputoutput(sec,sec2)*TOTALOUTPUT.L(sec));
solution('TOTAL','IntermedDemand') = sum((sec2,sec),
inputoutput(sec,sec2)*TOTALOUTPUT.L(sec));

* HHD Income

solution(h,'Income') = HHDINCOME.L(h);
```

```
solution('TOTAL','Income') = sum(h, HHDINCOME.L(h));

* Commuter Income

solution(location,'Income') = COMMUTERLABORLSUPPLY.L(location) * PLABORL.L +
         COMMUTERLABORHSUPPLY.L(location) * PLABORH.L;

* Labor Supplies

* HHD Labor

solution(h,'HSkilledHHD') = HHDLABORHSUPPLY.L(h);
solution('TOTAL','HSkilledHHD') = sum(h, HHDLABORHSUPPLY.L(h));
solution(h,'LSkilledHHD') = HHDLABORLSUPPLY.L(h);
solution('TOTAL','LSkilledHHD') = sum(h, HHDLABORLSUPPLY.L(h));

* Commuters

solution(location,'HSkilledCOM') = COMMUTERLABORHSUPPLY.L(location);
solution('TOTAL','HSkilledCOM') = sum(location, COMMUTERLABORHSUPPLY.L(location));
solution(location,'LSkilledCOM') = COMMUTERLABORLSUPPLY.L(location);
solution('TOTAL','LSkilledCOM') = sum(location, COMMUTERLABORLSUPPLY.L(location));

* Migrants

solution('TOTAL','HSkilledMIG') = MIGRANTLABORHSUPPLY.L;
solution('TOTAL','LSkilledMIG') = MIGRANTLABORLSUPPLY.L;

* Prices

solution('Price','CPI') = CPI.L;
solution(sec,'POutput') = POUTPUT.L(sec);
solution(sec,'PComposite') = PCOMPOSITE.L(sec);
solution('Price','PLaborH') = PLABORH.L;
solution('Price','PLaborL') = PLABORL.L;
solution(sec,'PLabor') = PLABOR.L(sec);
solution('Price','PCapital') = PCAPITAL.L;
```

VITA

KYLE DAVID DEAN

Candidate for the Degree of

Doctor of Philosophy

Dissertation: REGIONAL DEVELOPMENT – A COMPUTABLE GENERAL EQUILIBRIUM (CGE) ANALYSIS OF THE BENEFITS TO LOCAL RESIDENTS, COMMUTERS AND MIGRANTS

Major Field: Urban and Regional Economics

Biographical:

Personal Data: Born in Seville, Spain in January 1966. Currently reside in Edmond OK with wife and two children.

Education: Received Bachelors of Business Administration in Management Information Systems from the University of Oklahoma in May 1989. Completed the requirements for the Doctor of Philosophy in Economics at Oklahoma State University, Stillwater, Oklahoma in December, 2008.

Experience: Partner, Economist, Economic Impact Group, Edmond, OK, 2005 to present. Adjunct Professor of Economics, University of Central Oklahoma, Edmond, OK, 2005 to present. Adjunct professor, MBA Program, Oklahoma Christian University, Edmond, OK, 2007 – 2008. Graduate Teaching Associate, Oklahoma State University, Stillwater, OK, 2000 – 2005. Lead Network Analyst, Dobson Communications Corporation, Edmond, OK, 1997 – 1999. Vice President, Comtrek Computing Solutions, Oklahoma City, OK 1996 – 1997, Systems Engineer, Electronic Data Systems, Midwest City, OK, 1995 – 1996. Information Systems Specialist, Department of the Air Force, Tinker AFB, OK, 1989 – 1995.

Professional Memberships and Boards: Oklahoma State Board of Examiners of Psychologists, 2006 – Present. Oklahoma State Board of Dentistry, 2006.

Name: Kyle D. Dean Date of Degree: December, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: REGIONAL COOPERATION – A COMPUTABLE GENERAL EQUILIBRIUM (CGE) ANALYSIS OF THE BENEFITS TO LOCAL RESIDENTS, COMMUTERS AND MIGRANTS

Pages in Study: 160 Candidate for the Degree of Doctor of Philosophy

Major Field: Urban and Regional Economics

Scope and Method of Study: This study uses a Computable General Equilibrium (CGE) model to estimate the impacts of local development on the original residents of the local region. The study addresses the aggregate and distributional income effects of a 50% increase in export demand for manufacturing for production in Oklahoma County, Oklahoma. The model includes nine disparate households, two labor skill types, commuters and migrants. Five simulations are used to provide a reasonable impact estimate with sensitivity analysis based on a range of commuter and migration elasticities.

Findings and Conclusions: Local development increased local household income for all nine households regardless of commuter or migration elasticities. The distributional impacts were not uniform across all simulations, however, differences were relatively minor. The greatest aggregate income increase occurred when migration elasticities were decreased. Increased migration elasticities led to the smallest increase in aggregate income. Changes in commuter elasticities led to smaller changes in aggregate local household income. Commuter income was enhanced in every scenario with greater commuter elasticities resulting in greater commuter income.

ADVISER'S APPROVAL: Michael J. Applegate