DISSERTATION

# USING A COMPUTABLE GENERAL EQUILIBRIUM MODEL TO EXPLORE ECONOMIC IMPACTS OF AGGLOMERATION ECONOMIES ON WAGES IN NORTHERN COLORADO


Submitted by

Anne Grace Gongwe

Department of Economics


In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Spring 2011

Doctoral Committee:

Advisor: Harvey Cutler

Chuen-mei Fan
Martin Shields
Stephen Davies

ABSTRACT

USING A COMPUTABLE GENERAL EQUILIBRIUM MODEL TO EXPLORE ECONOMIC IMPACTS OF AGGLOMERATION ECONOMIES ON WAGES IN NORTHERN COLORADO

Agglomeration economies are forces that lead to concentration of workers and businesses in one location, and are also known as external economies of scale. This dissertation explores the economic impacts of agglomeration economies on nominal and real wages using a data intensive computable general equilibrium (CGE) model. The dissertation is divided into three essays. The first essay focuses on establishing the impacts of export-led expansions on nominal and real wages for two cities of different sizes and labor market characteristics in northern Colorado. Results of this essay show that when employment is expanded for each sector separately, nominal and real wages increases more in Loveland (a thinner labor market) than Fort Collins (a thicker labor market). A larger number of households are attracted to Fort Collins as opposed to Loveland and this leads to high supply of labor. Increased labor supply causes a downward pressure on wages in Fort Collins. These results suggest that “labor supply effects” outweigh “productivity effects” in the thicker labor market.

The second essay analyzes the performance of nominal and real wages when two cities of different sizes and labor market characteristics are exposed to various levels of

production externalities. The results demonstrate that when sector-specific export demand and production externalities is increased, the nominal and real wages increase more in Fort Collins than Loveland supporting previous studies findings that productivity increases with city size. The results also reflect that wages increases more with the level of production externalities. The results also show that different sectors are impacted differently with the same economic shock, making sector-wise analysis more appropriate than the aggregate analysis.

The third essay has two major parts. The first part focuses on the economic impacts of consumption externalities on nominal and real wages. The results show that an increase in sector-specific export demand and level of migration elasticity increase nominal wages in all labor groups in all three productive sectors with the exception of labor group three in the retail sector in both cities. The second part of this essay focuses on the net economic impacts of production and consumption externalities wages in these two cities. The results show that nominal wages and real wages increase in all sectors for all labor groups except for the higher skilled workers in the retail case in Loveland. Results also show that, the nominal and real wage increase is less with the higher level of consumption externalities. These results suggest that when the level of consumption externalities is sufficiently higher than production externalities, real wages will decrease.

ACKNOWLEDGEMENTS

I would like to thank GOD for giving me energy and strength to endure all the things that I went through during my time at CSU. I am heartily thankful to my supervisor Dr Harvey Cutler, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject. I also owe my deepest gratitude to my family who has provided support and more important still, light relief. I am indebted to our department staff and to many of my colleagues for their support during the completion of the project.

# DEDICATIONS

This dissertation is dedicated to my parents, the late Dr Vincent Gongwe and Mrs. Jane Gongwe who love and nurture me to the best of their ability.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

# 1. EXECUTIVE SUMMARY

Agglomeration economies are forces that lead to concentration of workers and businesses in one location, and are also known as external economies of scale. Chatterjee (2003) argues that agglomeration economies can cause a location with some small advantage in terms of natural resources to become a place with a large concentration of diverse businesses and households. As a location grows in size, business's costs falls and the location's attractiveness as a potential spot for other businesses and households' rises causing more people and businesses to move in.

Marshall (1920) suggests three sources of agglomeration economies. The first source is the sharing of inputs whose production involves internal increasing return to scale. The second source is labor market pooling where agglomeration allows a better match between employers' needs and employees' skills, reducing risk from labor market shocks. The third source is knowledge spillovers that occur when new knowledge that has been generated by one firm is used by other firms. Stranger and Rosenthal (2004) add to this list by examining other sources of agglomeration as "home market effects" that occur when the concentration of demand encourages agglomeration and "economies in consumption" implying that cities exist because people like bright lights.

This dissertation explores the economic impacts of agglomeration economies on nominal and real wages using a data intensive computable general equilibrium (CGE) model. Although there are seventeen productive sectors in the CGE model, this dissertation focuses on four sectors namely manufacturing, computer manufacturing, high service and retail sectors. The CGE model is useful in this study due to the fact that it provides details and allows analysis of narrow policies that affect small segments of the economy (in this case the three productive sectors). The CGE model in this dissertation has six groups of households and seventeen productive sectors. In this CGE model, changes in personal income distribution of household groups and consumer price indices may have different implications on welfare of distinct household groups. This dissertation finds that labor groups, household groups and sectors are impacted differently by sector-specific export expansion and various levels of production and consumption externalities.

The study focuses on economic impacts of production and consumption externalities (agglomeration economies) on thick and thin labor markets. It specifically explores how agglomeration economies impact nominal and real wages. The literature on agglomeration suggests that external economies (externalities) exist when the scale of urban environment adds to productivity (production externalities) and utility (consumption externalities). There are externalities that arise from concentration of various industries in the city (urbanization) and those that arise from the concentration of one industry in the city (localization). The literature therefore suggests that nominal wages increase with city size due to increased productivity while real wages decrease with city size due to increased amenities in a larger city. In this study, production externalities are modeled by varying the level of coefficient for production externalities in the production function. In the production function, the efficiency parameter is a function of population size which captures the urbanization economies. As city size increases, the productivity increases due to Marshallian externalities. Consumption externalities are modeled by varying the level of coefficient for consumption externalities in the household migration equation. The equation shows that migration of household depends on the natural rate of population growth, real income, the level of unemployment and domestic supply of goods and services. The coefficient for migration elasticity in the migration equation shows how strongly changes in domestic supply affect household migration. The higher the domestic supply of goods and services, the higher the migration of households who want to maximize their utility due to increased amenities.

Many economists have expressed their satisfaction with using the CGE model as a tool in policy analysis. Waters et al (1997) argue that the application of the CGE model allows them to access the impacts of exogenous shocks primarily through changing prices and that the enormous flexibility of possible CGE specifications accommodate a wide range of policy variables and adjustment periods. Wing (2004) agrees and states that, "the advantage of this approach is its ability to measure policies ultimate impact on the aggregate welfare in a theoretically consistent way, by quantifying the changes in the income and consumption of the representative agent that results from the interactions and feedbacks among all of the market economy. Yet CGE models' usefulness in policy analysis owes less to their predictive accuracy and more to their ability to shed light on the economic mechanisms through which price and quantity adjustments are transmitted among markets"

Almost all studies that attempted to identify the agglomeration economies used econometric models. Graham (2007) argues that this empirical work typically proceeds by constructing variables that measure the extent of industry and urban concentration, and uses these within a production or cost function framework to estimate effects on productivity. In these studies urbanization is often represented by the total population or total employment of an urban area. He emphasizes that, "the previous literature has indicated that agglomeration externalities do exist for the manufacturing sector but the sectoral coverage of existing work is incomplete and the analysis of agglomeration is typically based on data for relatively aggregated industries and spatial areas."

This dissertation uses the CGE model and sector-specific level data to explore the impacts of agglomeration economies (production and consumption externalities) experienced by different sectors in two cities of different sizes in northern Colorado. By using sector-specific data, this study is able to capture a high degree of spatial detail in measuring economic impacts of agglomeration and avoids using data based on large predefined geographic units such as metropolitan definitions. Sector-specific data also permits the use of a more flexible functional form to represent technology of each sector therefore analyzes some distinct effects of production and consumption externalities on nominal and real wages for each labor group in each sector. The cities to be studies are Fort Collins and Loveland in northern Colorado. Fort Collins is a larger city with a population twice that of Loveland. Fort Collins also has a thicker labor market than Loveland. Loveland due to its size has a thinner labor market.

In order to facilitate the main objective of the study, this dissertation is divided into three essays. The first essay focuses on establishing the marginal impacts of export-led expansions on nominal and real wages for two cities of different sizes and labor market characteristics in northern Colorado. The literature predicts higher nominal wages in Fort Collins which is larger and therefore has a thicker labor market than Loveland, which is smaller and has a thinner labor market. The higher nominal wages reflect higher productivity in Fort Collins because of its thicker labor market. Since firms pay workers the value of their marginal product in a competitive labor market the literature argues that a natural test of agglomeration economies is whether firms pay a wage premium in areas with concentrated economic activity. The literature also predicts lower real wages for workers in Fort Collins than in Loveland due to the fact that workers might be willing to accept lower real wages to take advantage of consumption externalities that the city offers.

Results of this essay show that when employment is expanded for each sector separately, nominal and real wages increases more in Loveland (a thinner labor market) than Fort Collins (a thicker labor market). These results support Rivera-Batiz (1988) who argues that the traditional effect of an increase in labor force is to induce an excess supply of labor that reduces the city's wage rate. He called this "labor supply effect". On the production side, Rivera-Batiz argues that in the present context, an increase in the size of the urban population increases the size of the industrial sector and therefore, it shift upwards the demand for producers services. This leads to an expansion of the service sector that raises the variety of such services. With a wider diversity of services available, the industrial sector can obtain more specialized services and its productivity is therefore enhanced. This productivity increase is then embodied into higher wage rates. He called this "productivity effect". He concluded that the impact of changes in the labor force of the city L on the wage rate is an ambiguous sign. This study's results demonstrate that in this case "labor supply effect" outweighs "productivity effect" in Fort Collins.

The second essay analyzes the performance of nominal and real wages when two cities of different sizes and labor market characteristics are exposed to various levels of production externalities. In this essay the simulations are done in such a way that sector's export demand is expanded and the level of production externalities is varied simultaneously. Production externalities are modeled through a production function. In the production function, a change in population (proxy for city size) is thought of as a city's characteristic that is imbedded in the constant term of production function. It is a shift term that represents scale economies. In this study the scale economies are measured by the change in population to capture the urbanization economies. It is believed that population size exerts a positive influence on a sector's productivity; hence there is a positive correlation between output and variable representing agglomeration economies. The coefficient for production externalities measures the response of sector's export demand due to change in population. To explore the impact of production externalities, the coefficient for production externalities is altered and the impacts on nominal and real wages are then observed.

The results demonstrate that when sector-specific export demand and production externalities is increased, the nominal and real wages increase more in Fort Collins than Loveland supporting previous studies findings that productivity increases with city size. The results also reflect wages increases with the level of production externalities. The results also show that different sectors are impacted differently with the same economic shock, making sector-wise analysis more appropriate than the aggregate analysis which is common in the agglomeration literature.

The third essay has two major parts. The first part focuses on the economic impacts of consumption externalities on nominal and real wages. The simulations are set in such a way that sector's export demand is expanded and the level of migration elasticity (proxy for consumption externalities) is varied simultaneously. To represent the consumption externalities, migration equation in the model is used. Migration coefficient is the elasticity that shows how people migrate in response to changes in domestic supply of goods. More supply of goods indicates higher utility due to greater variety of goods hence, increased consumption externalities. In this essay, the values of the coefficient for migration elasticity are set at 0.07 and 0.12 following Tabuchi and Yoshida's (2000) values. The results are then analyzed and compared across two cities of different sizes and labor market characteristics in northern Colorado.

The results show that an increase in sector-specific export demand and level of migration elasticity increase nominal wages in all labor groups in all three productive sectors with the exception of labor group three in the retail sector in both cities. This dissertation also finds that real wage results increases in some cases and decrease in some cases irrespective of the city size. The mixed results demonstrate that modeling and data aggregation can produce different results when exploring agglomeration economies and therefore results should be presented with caution.

The second part of this essay focuses on the net economic impacts of production and consumption externalities wages in these two cities. This part of the study is done in the spirit of two major studies that analyze the impacts of production and consumption externalities on wages simultaneously. Tabuchi and Yoshida (2000) using Japanese data find that doubling city size increases nominal wages by 10 percent and decrease real wage by 7-12 percent. Puga (2010) claimed that "if big cities are associated with both better amenities and higher productivity, the net effect on wages may be ambiguous." Using CGE the simulations are set in such a way that sector's export demand is expanded while the level of production externalities and consumption externalities are varied simultaneously.

The results show that nominal wages and real wages increase in all sectors for all labor groups except for the higher skilled workers in the retail case in Loveland. The nominal and real wages decrease for this labor group with a nominal and real wage increase for the middle and low skilled labor in the same sector. For the high service case in Loveland, the nominal wages seem to be increasing more for all labor groups in Loveland compared to Fort Collins, irrespective of the level of production and consumption externalities. In general, the nominal wage increases more in Fort Collins than in Loveland for retail and manufacturing cases, suggesting that workers in Fort Collins are more productive than in Loveland. The results seem to suggest that in the high service case, workers in Loveland are more productive than in Fort Collins. The results also show that the nominal and real wage increase is less with the higher level of consumption externalities. These results suggest that when the level of consumption externalities is sufficiently higher than production externalities, then real wages will decrease. The results also depend on the price level (CPI). These results therefore fall more within Puga's findings (2010) than Tabuchi and Yoshiba's (2000).

REFERENCES:


Chatterjee, S.(2003), "Agglomeration economies: The spark that ignites a city?" *Business Review*, (Q4) 6-13.

Graham, Daniel J. (2007), "Agglomeration, Productivity and Transport Investment". *Journal of Transport Economics and Policy*, 41(3): 317-343

Puga, Diego. (2010), "The magnitude and causes of agglomeration economies," *Journal of Regional Science*, 50:203-219.

Rivera-Batiz, Francisco L. (1988), "Increasing returns, monopolistic competition, and agglomeration economies in consumption and production," *Regional Science and Urban Economics*, Elsevier, vol. 18(1): 125-153.

Rosenthal, S S. and W.C. Strange (2004). "Evidence on the nature and sources of agglomeration economies". In Vernon Henderson and Jacques-François Thisse (eds.) *Handbook of Regional and Urban Economics,* Volume 4. Amsterdam: North Holland: 2119-2171

Tabuchi, T. and A. Yoshida (2000). "Separating Urban Agglomeration Economies in Consumption and Production," *Journal of Urban Economics*, 48: 70-84.

Waters, E., D. Holland and B. Weber (1997). " Economic Impacts of a Property Tax Limitation. A Computable General Equilibrium Analysis of Oregon's Measure 5," *Land Economics* 73(1): 72-89

Wing, I.S. 2004. "Computable General Equilibrium Models and Their Use in the Economy- Wide Policy Analysis: Everything you Ever Wanted to Know (But were afraid to Ask)," (Unpublished). http://people.bu.edu/isw/papers/cge.pdf

# 2. DESCRIPTION OF CGE MODEL AND DATA

## 2.1 CGE MODEL

CGE models combine the abstract general equilibrium structure formalized by Arrow and Debreu with realistic economic data. The data is used to solve numerically for the levels of supply and demand and for prices that support equilibrium across a specified set of markets. Wing (2007) defines CGE models as standard tools of empirical analysis, which are widely used to analyze the aggregate welfare and distributional impacts of policies whose effects may be transmitted through multiple markets. Those policies can also contain menus of different tax, subsidy, quota or transfer instruments.

This study uses a CGE model based closely on Golan and Smith's (1996) Dynamic Revenue Analysis (DRAM) developed as a tool for policy analysis in California. It is expanded by Cutler and Davies (2007) to incorporate base data that reflect the City of Fort Collins.

## 2.2 DATA

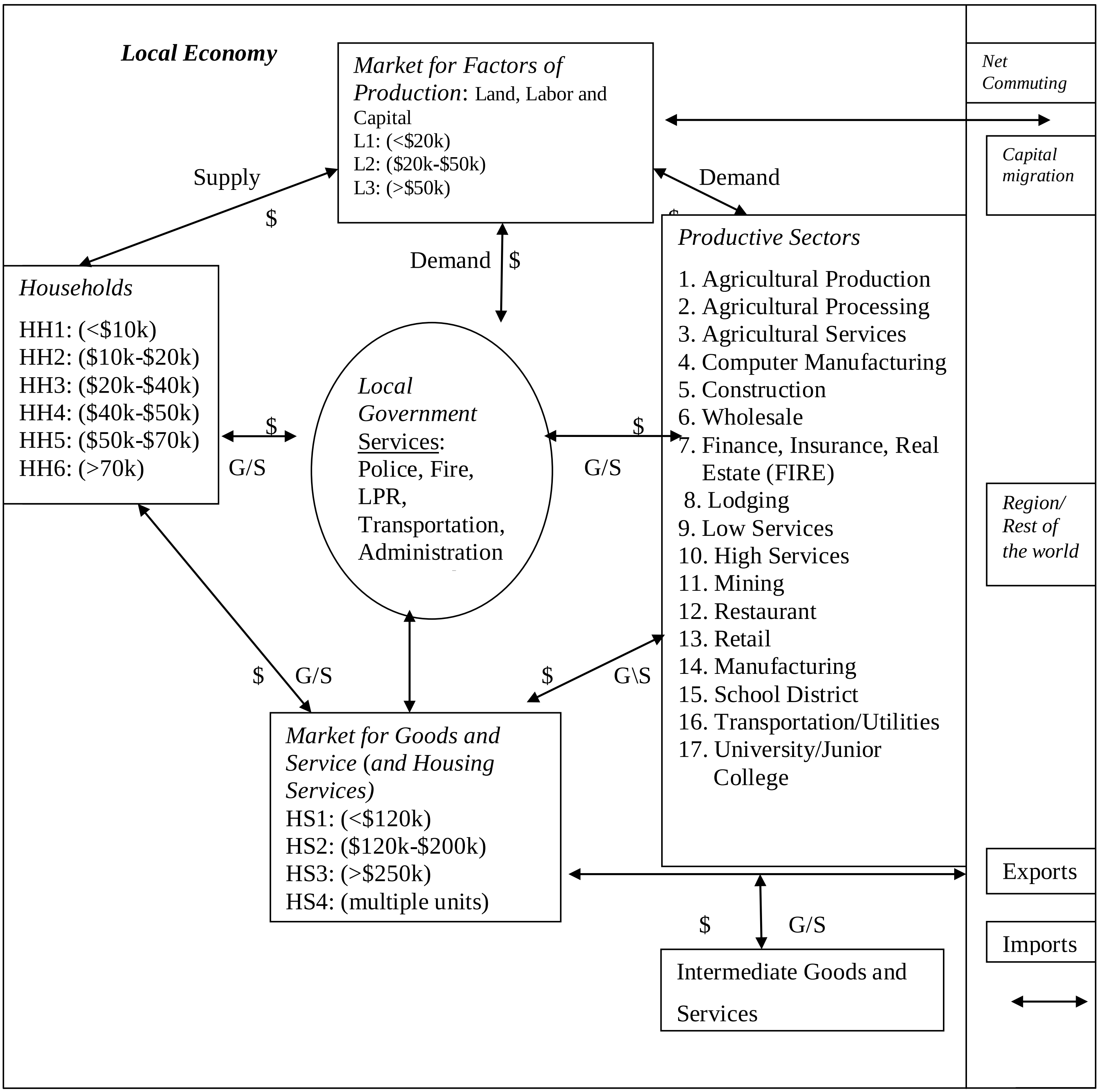
### *2.2.1 Profit maximizing sectors*

Figure 2.1 presents a summary of the structure of the model. There are 17 productive sectors in the economy. These sectors rent factors of production (labor, land and capital) from households for the purpose of producing goods and services that the households then consume. Labor is divided into three groups according to the level of income they receive as factor suppliers. These three labor groups are L1, representing low wage earners; L2, representing midle income earners and L3, representing higher wage earners[1]. Production and consumption decisions are driven by profit and utility

[1] Their wage brackets are well presented in figure 2.1

maximization respectively. Sectors' profit is maximized subject to technology (in this case; Cobb Douglas production functions).

Figure 2.1: Model Structure



*2.2.2 Producer Behavior and Factor Supply*

Firms in this model are divided into 17 productive sectors. These sectors demand three factors of production; factor demand for labor ($FD_L$), factor demand for capital ($FD_K$) and factor demand for land ($FD_{LA}$) from households and combine them with intermediate commodities (VI) in fixed proportions ($AD_{I,J}$) [equation 4] to determine the level of output. Working members of households are disaggregated into three categories according to wage rate ($RA_L$). One of the major assumptions in this model is that the output market is perfectly competitive and the production function has constant return characteristics and there is a free mobility of factors of production. Equation (1) models value added prices ($PVA_I$). Equations (1) and (2) models sector output which is also domestic supply ($DS_I$) produced using the Cobb-Douglas specifications and equation (3) shows the first order conditions. In these equations $DELTA_I$ represents scale parameters while $ALPHA_{F,I}$ are factors relative income shares. $TAUFX_{GF,F,I}$ and $TAUQ_{GS,I}$ represents taxes.

$$PVA_I = PD_I - \Sigma_J AD_{J,I} * P_J * (1 + \Sigma_{GS} TAUQ_{GS,J}) \; ; \qquad (1)$$

$$DS_I = DELTA_I * \Pi_F (FD_{F,I}{}^{ALPHA_{F,I}}); \qquad (2)$$

$$R_{F,I} * RA_F * (1 + \Sigma_{GF} TAUFX_{GF,F,I}) * FD_{F,I} = PVA_I * DS_I * ALPHA_{F,I}; \qquad (3)$$

$$V_I = \Sigma_J AD_{I,J} * DS_J \; ; \qquad (4)$$

Figure 2.1 describes groupings for these factors. The production process is shown in equation (4). Calculations for each factor income are shown in equations (10)-(12).

*2.2.3 Factors Supply*

Sources of local labor supply are households (divided into six groups), commuters into the city ($CMI_L$) and from in-migration of households ($MI_H$). Equation (8) shows that the number of total households is determined by the base number of households in the city (HH0) times the natural rate of population growth ($NRPG_H$) and real household income ($YD_H/CPI_H$). Also, total households are inversely related to the relative proportion of non working households in the economy ($HN_H/HH_H$). Net migration and population growth in the model are the difference between changes in households after simulations and their base values. In the same equation elasticities are presented by parameters $ETAYD_H$ and $ETAU_H$. The proportion of local working households ($HW_H/HH_H$) is determined in equation (9) as a function of real wages internal to the city ($RA_L/CPI_H$) compared to the external wages ($EXWGE_L$). As described earlier, local labor supply depends on households who commute in and out and their patterns are modeled in equations (6) and (7) respectively. The number of households commuting out ($CMO_L$) depends on its base value (CMO0) and external wage rate ($EXWGE_L$). Responsiveness of workers to commute out as a result of wage changes is shown by parameter $ECOMO_L$. Equation (7) describes the behavior of workers commuting in. $JOBCORR_{H,L}$ translates households into workers.

$$HN_H = HH_H - HW_H; \qquad (5)$$

$$CMO_L = CMO0_L * (EXWGE_{1L} / RA_L)\ ECOMO_L; \qquad (6)$$

$$CMI_L = CMI0_L * (RA_L / EXWGE_{2L})\ ECOMI_L; \qquad (7)$$

$$HH_H = HH0_H * NRPG_H + MI0_H * [(YD_H / HH_H/(YD_{0H}/ HH_{0H} )$$
$$/ (CPI_H / CPI0_H)]^{ETAYDH} * [(HN_H/ HH_H)/(HN_{0H}/ HH_{0H})]^{ETAU}{}_H$$
$$- MO0_H*[(YD0_H/ HH0_H)/(YD_H/ HH_H)/ ( CPI0_H/CPI_H)]^{ETAYD}{}_H$$
$$* [(HN0_H/ HH0_H)/(HN_H/HH_H)]^{ETAU}{}_H; \quad (8)$$

$$HW_H/HH_H = HW0_H/HH0_H \quad * ((\Sigma_L, RA_L) / RA0_L))/3)/ (CPI_H) / CPI0_H)$$
$$* (\Sigma_{Z, L} FD_{L, Z})/ (\Sigma_{H1} HW_{H1} * \Sigma_L JOBCOR_{H1,L}) +$$
$$\Sigma_L CMI_L + \Sigma_L EXWGE2_L)/RA_L)/3 *(\Sigma_L CMO_L)/( \Sigma_{H1} HW_{H1})$$
$$* \Sigma_L JOBCORH_{1, L}) + \Sigma_L CMI_L)) ETARA_H * (\Sigma_G TP_{H, G} / CPI_H)/$$
$$(\Sigma_G TP_{H, G} / CPI0_H) ETAP_{TH}; \quad (9)$$

Supply of capital is modeled in two major steps. The first step models the new capital or gross investment decisions and the second step the demand for this new capital. The new capital ($N_{K,I}$) by the firm is described in equation (10) as a function of its base value $N0_{K,I}$ , its relative returns ($R_{K,I}/R0_{K,I}$) and the ratio of domestic output relative to its base value ($DS/DS0_I$). ETAIX is the parameter for investment elasticity. Sector's investment demand ($CN_I$) is calculated in equation (11) as a function of new capital supply. Equation (12) shows that capital stock ($KS_{K, IG}$) is the function of its base value, the rate of depreciation (DEPR) and new capital ($N_{K,I}$).

Supply of land is described in equation (13) while that of capital is described in equation (20). Supply of land is a function of the base land area in the city (LASO), the relative return to land ($R_{LA}/R0_{LA,I}$) and the ratio of domestic supply relative to its base

($DS/DS0_I$). Equations (14)-(16) presents factor income (Y) as functions of factor demands and their rental rates. Equation (14) represents total labor income ($Y_L$) as a function of the initial sector's rental rate for labor ($R_{L,IG}$), average labor rental rate ($RA_L$) and labor demand ($FD_{L,IG}$). Equation (15) represents the total capital income as the function of initial sector's rental rate for capital ($R_{K,IG}$), the average capital rental rate ($RA_K$) and sector's capital demand ($FD_{K,IG}$). Equation (16) represents total land income as the result of initial sector's initial rental rate for land ($R_{LA,IG}$), average land rental rate ($RA_{LA}$) and sector's demand for land ($FD_{LA,IG}$).

$$N_{K,I} = N0_{K,I} * (R_{K,I}/R0_{K,I})^{ETAIX_{K,I}} * (DS_I / DS0_I)^{ETAIX1_{K,I}}; \qquad (10)$$

$$P_I * (1 + \Sigma_{GS}\, TAUN_{GS,I}) * CN_I = \Sigma_{IG}\, B_{I,IG} * (\Sigma_K, N_{K,IG}); \qquad (11)$$

$$KS_{K,IG} = KS0_{K,IG} * (1 - DEPR) + N_{K,IG}); \qquad (12)$$

$$LAS_{LA,I} = LAS0_{LA,I} * (RL_{A,I}) / R0L_{A,I}) ETAL_{LA,I} * (DSI / DS0_I) ETAL1_{LA,I}; \qquad (13)$$

$$Y_L = \Sigma_{IG}\, (R_{L,IG} * RA_L * FD_{L,IG}); \qquad (14)$$

$$Y_K = \Sigma_{IG}\, (R_{K,IG} * RA_K * FD_{K,IG}); \qquad (15)$$

$$Y_{LA} = \Sigma_{IG}\, (R_{LA,IG} * RA_{LA} * FD_{LA,IG}); \qquad (16)$$

*2.2.4 Households*

There are six households groups that are differentiated by income as shown in table 1. Households' behavior is described well in equations (17) through (21) below. Equation (17) describes overall price level faced by each group defined as a consumer price index ($CPI_H$). Household income is shown in equation (18) to come from labor ($Y_L$), land ($Y_{LA}$) and capital ($Y_K$). Labor income is the product of earnings within the city and wages paid to workers who commute out ($CMO_L$) minus the earnings of workers who commute in calculated as $CMI_L$*$CMIWAGE_L$. Equation (19) estimates disposable income as the payments to the factors of production (labor, capital, land) that households own. Additional household income is also from retirement flows and remittances minus taxes. Equation (20) shows that consumption demand (which is derived from household utility maximization under Cobb-Douglas production function) depends on real disposable income ($YD_H$) and relative price ($P_I/P0_I$). Household savings is described by equation (21) which depicts household saving as a residual from disposable income after utility maximizing consumption and taxes.

Households also demand services from housing services. Housing services are divided into four categories: houses less than $100,000 (HS1); houses between $100,000 and $200,000 (HS2); houses valued over $200,000 (HS3); and multiple units such as apartments and condominiums (HS4). The six household groups maximize utility through purchases of goods and services subject to their budget constraint (factor income less taxes plus transfers). Utility maximization is achieved using a constant elasticity of substitution (CES) function, and households purchase optimal quantities of the composite private goods, treating local and imported commodities as imperfect substitutes (Schwarm and Cutler, 2003). Households use their income to pay direct taxes, save, consume and make transfer to other economic agencies like the local government.

$$CPI_H = \Sigma_I P_I * (1 + \Sigma_{GS} TAUC_{GS,I}) * CH_{I,H} / \Sigma_I (P0_I * (1 + \Sigma_{GS} TAUQ_{GS,I})) * CH_{I,H} ; \qquad (17)$$

$$Y_H = \Sigma_L A_{H,L} * HW_H / \Sigma_{H1} A_{H1,L} * HW_{H1} * (Y_L + (CMIWAGE_L)*CMI_L)) * (1 - \Sigma_G TAUFL_{G,L})) + A_H COMMO*CMOWAGE_L*CMO_L + \Sigma_{LA} A_{H,LA} * HW_H / \Sigma_{H1} A_{H1,LA} * HW_{H1} * (Y_{LA}) + LNFOR_{LA})* (1 - \Sigma_G TAUFLA_{G,LA} ) ) + \Sigma_K A_{H,K} * HW_H / \Sigma_{H1} A_{H1,K} * HW_{H1} * (Y_K + KPFOR_K) * (1 - \Sigma_G TAUFK_{G,K} ); \quad (18)$$

$$YD_H = Y_H + PRIVRET_H * HH_H + \Sigma_G TP_{H,G} * HH_H - \Sigma_{GI} PIT_{GI,H} * HH_H - \Sigma_G TAUH_{G,H} * HH_H; \quad (19)$$

$$CH_{I,H} = CH0_{I,H} * ( ( YD_H / YD0_H ) / ( CPI_H / CPI0_H )) BETA_{I,H} * \Pi_J (P_J * (1 + \Sigma_{GS} TAUC_{GS,J} )/ (P0_J * (1 + \Sigma GS\ TAUQ_{GS,J}) LAMBDA_{J,I} ; \quad (20)$$

$$S_H = YD_H - \Sigma_I P_I * CH_{I,H} *(1 + \Sigma_{GS} TAUC_{GS,I}); \quad (21)$$

*2.2.5 Trade Relations*

Economies of these two cities are modeled as a small open economy; therefore trade is important. These cities are small in such a way that they are price takers. Cutler and Davies (2007) stated that relative changes in external and internal prices can have large effects on simulation outcomes. Quantity of exports ($CX_I$) depends on its base quantity ($CX0_I$) and the ratio between local domestic product price ($PD_I$) and world export price ($PWO_I$) and the elasticity of export demand ($ETAE_1$). Equations (23) and (24) estimate quantities of imports. Equation (23) describes the calculation of proportion of domestic demand supplied locally ($D_I$) as a function of its base value, relative to domestic prices compared to import prices. $ETAD_I$ is the elasticity of import demand. Equation (24) estimates imports as the portion of domestic demand that is not supplied locally.

The price of goods in the domestic market as the weighted average of the domestic producer price and the world price of imports is calculated in equation (25). Equation (26) described the assets side of trade. It calculates net foreign savings/Net capital investment (NKI) as it balances the difference between returns to foreign ownership of labor and capital (LNFOR and KPFOR), net exports, remittances ($PRIVET_H$), government transfers ($GVFOR_G$) and net wages from commuters.

$$CX_I = CX0_I * (PD_I (1 + \Sigma_{GK} TAUX_{GK,I}))/(PW0_I(1 + \Sigma_{GK} TAUQ_{GK,I})^{ETAE}{}_I; \quad (22)$$

$$D_I = D0_I * PD_I / PWM0_I (1 + \Sigma_{GK} TAUM_{GK,I})^{ETAD}{}_I; \quad (23)$$

$$M_I = (1 - D_I) * DD_I; \quad (24)$$

$$P_I = D_I * PD_I + (1 - D_I) * PWM0_I (1 + \Sigma_K TAUM_{GK,I}); \quad (25)$$

$$NK_I = E = \Sigma_I M_I * PWM0_I - \Sigma_I CX_I * PD_I) - \Sigma_H PRIVRET_H * HH_H)$$
$$- \Sigma_{LA} LNFOR_{LA} - \Sigma_K KPFOR_K - \Sigma_G GVFOR_G - \Sigma_L CMOWAGE_L * CMO_L$$
$$- \Sigma_L CMIWAGE_L * CMI_L; \quad (26)$$

*2.6 Local Government*

There are two levels of government state/federal and local government. For the purpose of this study, I concentrate on local government. The local government provides services such as police, fire, transportation, library, parks and recreation, and city administration. Local government collects taxes as a source of revenue and receives transfers from other institutions. The taxes for the local government include; sales ($TAUC_{GX,I}$), use ($TAUM_{GX,I}$) and property ($TAUFH_{GX}$). The local government uses this income to purchase commodities for its consumption and for transfers to other institutions. It is a rule for a local government's budget to be balanced.

Equations (27)-(29) describe different local government variables. Equation (27) shows that for its revenue, local government depends on a wide range of taxes charged on local production, exports, imports, factor payments and household income. Local government's demand for intermediate inputs and factors is described by equation (28) and (29) respectively. Equation (28) shows that real local government consumption of inputs required in the provision of services ($CG_{I,GN}$) should be balanced to aggregate local government expenditures (government outflow).

$$Y_{GX} = \Sigma_I\, TAUV_{GX,I} * V(I) * P_I + \Sigma_I\, TAUXG_{X,I} * CX_I * PD_I$$
$$+ \Sigma_I\, TAUMG_{X,I} * MI * PWM0_I + \Sigma_{H,I}\, TAUCG_{X,I} * CH_{I,H} * P_I$$
$$+ \Sigma_I\, TAUNG_{X,I} *\, _{CNI} * P_I + \Sigma_{GN,I}\, TAUG_{GX,I} * CGI,_{GN} * P_I$$
$$+ \Sigma_{F,I}\, TAUFXG_{X,F,I} * RA_F * R_{F,I} * FD_{F,I} + \Sigma_{F,GN}\, TAUFX_{GX,F,GN} * RA_F * R_{F,GN} *$$
$$FD_{F,GN} + \Sigma_L\, TAUFHGX,_L * (Y_L + CMIWAGE_L * CMI_L)$$
$$+ \Sigma_K\, TAUFH_{GX,K} * Y_K + \Sigma_{LA}\, TAUFH_{GX,LA} * Y_{LA}$$
$$+ \Sigma_H\, PIT_{GX,H} * HH_H + \Sigma_H\, TAUH_{GX,H} * HH_H + \,_{\Sigma GX1}\, IGT_{GX,GX1}; \qquad (27)$$

$$P_I * (1 + \Sigma_{GS} TAUG_{GS,I}) * CG_{I,GN} = AG_{I,GN} * (Y_{GN} + GVFOR_{GN}); \qquad (28)$$

$$FD_{F,GN} * R_{F,GN} * RA_F * (1 + \Sigma_{GF}\, TAUFX_{GF,F,GN}) = A_{GF,GN} * (Y_{GN} + GVFOR_{GN}); \qquad (29)$$

*2.7 Model Closure Equations*

The last four equations close the model in order to provide equilibrium conditions for goods and factor markets. Equation (30) balances labor market by setting total supply equal to the total demand for labor. Labor supply is the product of working households and workers that commute in from other locations to supply labor to the city. To transform working households into workers, parameter $JOBCOR_{H,L}$ is used. Labor demand is the product of local factor demand and workers commuting out of the city. Because labor is divided into three categories, there is one equation for each labor group that determines its wage rate. Equation (31) states that capital stock must equal the capital demand in each of the 17 productive sectors. Return to capital for each sector is established through this equation. The land closure equation (32) is not different from the capital closure equation. All sources and uses of a sector's production are tied by identity (33). Equation (34) modeled the calculation of aggregate local demand for each product.

$$\Sigma_H HW_H * JOBCOR_{H,L} + CMI_L = \Sigma_Z FD_{L,Z} + CMO_L; \quad (30)$$

$$KS_{K,IG} = FD_{K,IG}; \quad (31)$$

$$LAS_{LA,IG} = FD_{LA,IG}; \quad (32)$$

$$DS_I = DD_I + CX_I - M_I; \quad (33)$$

$$DD_I = V_I + \Sigma_H CH_{I,H} + \Sigma_G C_{GI,G} + CN_I; \quad (34)$$

*2.2.7 Data collection*

This dissertation uses employment data gathered from two sources: Quarterly Census Employment and Wages (QCEW) formally ES-202 and Unemployment Insurance (UI) data for the Larimer County, Colorado. QCEW data is derived from quarterly tax report submitted to the Colorado Department of Labor. This data provides the number for employees per month of the quarter and total wage bill of the quarter. UI data is worker specific data for wages earned per quarter.

Land and capital data come from Larimer County Assessor's office and the local government data comes from two sources: The comprehensive Annual Fiscal Report (CAFR) for 1996 and the each city's wage data. The CAFR provide tax and expenditure data for city sectors whereas city's data provides data on employment and wages for the city sectors.

REFERENCES

Berck, P., Golan, E. and Smith, B. (1966). "Dynamic Revenue Analysis for California." Sacramento, CA: California Department of Finance.

Schwarm, W. and H. Cutler (2003). "Building Small City and Town SAMs and CGE Models." *Review of Urban and Regional Development Studies*, 15: 132–47

APENDIX I

***Indices***

I = private sector

IG = private sector and local government services

F = factors (L1, L2, L3, KAP and Land)

L = L1, L2 and L3

LA = Land Categories

K = Capital Categories

H = HH1, HH2, HH3, HH4, HH5 and HH6

G = all governments

GN, GS, GX = indices of different tax jurisdictions

***Variable Descriptions***

$CG_{I, G}$ = local government consumption

$CH_{I, H}$ = household consumption

$CMI_L$ = number of workers commuting out of the city

$CMO_L$ = number of workers commuting into the city

$CN_I$ = investment by sector of source

$CPI_H$ = consumer price index across households

$CX_I$ = export demand

$D_I$ = domestic supply share of domestic demand

$DD_I$ = domestic demand

$DS_I$ = domestic supply

$FD_{F, Z}$ = factor demand

$IGT_{G, GX}$ = intergovernmental transfers

$KS_{K, IG}$ = capital stock

$LAS_{LA, IG}$ = stock of land in acres

$HH_H$ = total number of households

$HN_H$ = number of nonworking households

$HW_H$ = number of working households

$M_I$ = imports

$N_{K, IG}$ = gross investment by sector

$N_{KI}$ = nominal net capital outflow

$KPFOR0_K$ = nominal capital outflow

$LNFOR0_{LA}$ = nominal land outflow

$GVFOR0_G$ = nominal government outflow

$P_{IG}$ = aggregate prices paid by sectors

$PD_I$ = domestic prices

$PV_{AI}$ = value added prices

$PW0_I$ = export prices (demand shifter for export demand)

$PWM0_I$ = import prices

$R_{F, Z}$ = initial sector rental rate for factors

$RA_F$ = average rental rate for factors

$S_H$ = savings

$SP_I$ = total personal income

$V_I$ = intermediate demand

$TP_{H, G}$ = social security payments

$YD_H$ = disposable household income

$Y_H$ = gross household income

***Tax Rates***

$TAUQG_{S, I}$ = all tax rates

$TAUCG_{S, I}$ = sales tax rates and other local tax rates

$TAUMG_{S, I}$ = use tax rates

$TAUXG_{S, I}$ = export taxes

$TAUFXG_{F, F, Z}$ = labor taxes

$TAUFHG_{X, LA}$ = taxes on land

$TAUFHG_{X, K}$ = taxes on capital

$TAUHG_{X, H}$ = personal income tax rates

$TAUVG_{S, I}$ = taxes on intermediate goods

$TAUNG_{S, I}$ = taxes on investment goods

$TAUGG_{S, I}$ = federal taxes

***Parameters***

$BETA_{I, H}$ = income elasticity for demand

$LAMBDA_{J, I}$ = price elasticity

$DELTA_I$ = scale $ALPHA_{F, I}$ = relative share of factors

$ETAE_I$ = elasticity for export demand

$ETAD_I$ = import supply elasticity

$ETAIX_{K, I}$ = price for investment

$ETAIX1_{K, I}$ = domestic supply elasticities for investment

$ETARA_H$ = labor supply elasticities for households

$ETAPT_H$ = elasticity of labor supply of households

$ECOMO_L$ = elasticity of commuting out with respect to relative wages

$ECOMI_L$ = elasticity of commuting in with respect to relative wages

$ETALL_{A, I}$ = elasticity of land supply with respect to rates of return

$ETAL1L_{A, I}$ = elasticity of land supply with respect to domestic supply

$ETAYD_H$ = elasticity of migration with respect to real household income

$ETAU_H$ = elasticity of migration with respect to the ratio of nonworking household to total households

$MI0_H$ = rate of in-migration

$MO0_H$ = rate of out-migration

# 3. ECONOMIC IMPACTS OF EXPORT-LED EXPANSIONS ON THICK AND THIN LABOR MARKETS IN NORTHERN COLORADO

## 3.1 INTRODUCTION

Regional economists define thick labor market as a dense market that reduces cost of finding a suitable job for workers and the cost of recruitment for firms, but also a place whereby the quality of matching is improved. They insist that this is particularly the case in highly specialized markets, where workers in thinner market may accept jobs that are less suited for their skill set. Anderson et al (2004) show that thicker labor market are associated with more matching between workers and firms in specialized markets, and when combined with complementarity of workers and firm quality, this raises productivity. There is also a claim that a thick labor market may be characterized by a lower degree of information imperfection and that firms closer to other firms in characteristic space operate in thicker labor market, which will encourage workers to switch, other factors held constant. Gan and Zhang (2008) argue that, "a thick market means that there are more workers and more firms on a location. When a market is sufficiently thicker worker's expected return from job search is higher than the cost of job search. The larger the pool of workers, that a firm can access, the more likely it is to be able to find the exact skills that suits its need."

This paper examines the link between the size of the labor market and its effect on nominal and real wages. The study provides a quantitative assessment of this relationship concentrating on two cities of different sizes in northern Colorado. These cities are Fort Collins (a thicker labor market) with a population of 118,652 and Loveland (a thinner labor market) with a population of 50,608 (1996 census). It uses Gan and Zhang's (2008) definition that a thick labor market means there are more workers and more firms in a location. The study focuses on two exporting sectors; manufacturing and computer manufacturing and two service sectors; high services and retail. The study finds that when sector's employment is expanded, nominal and real wages increase more in Loveland (a thinner labor market) than in Fort Collins (a thicker labor market).

The results indicate that "labor supply effects" dominate "increased productivity effects" brought about by agglomeration. The "labor supply effects" and "increased productivity effects" are terms defined by Rivera-Batiz (1988). He analyzes impacts of an increase in the population on the demand and supply side of labor market and their effects on wages." He defines "excess labor supply effects" as the result of the traditional effect of an increase in the labor force due to agglomeration economies, which induces excess labor that reduces city's wage rate. He also explains that "increased productivity effect" in the present context is caused by an increase in size of the urban population. This population increase leads to an increased industrial sector which then shifts upwards the demand for producers' services. This later leads to an expansion of the service sector that then raises the variety of such services. He emphasizes that "with a wider diversity of services available, the industrial sector can obtain more specialized services and its productivity is therefore enhanced. He claims that this productivity increase is then embodied into higher wage rates. He then concludes that the net impact of increased population on the equilibrium wage rate in the city is related to the relative importance of the "excess labor supply" and "increased productivity effect."

The motivation for exploring this issue is to establish what happens to nominal and real wages after initiating growth through export-led expansions in a city using a computable general equilibrium (CGE) model. I specifically investigate whether nominal wages will increase more in Fort Collins than Loveland after the relative shock is introduced to each of the four sectors separately. The shock introduced involves export demand expansions which lead to an increase in the sector's employment by 400 workers. Contrary to previous studies that use ordinary least squares regressions on wage and production functions [Glaeser and Mare (2001), Sveikaukas (1975), Yankow (2006), Tabuchi and Yoshida (2000) and Beetsons and Eberts (1989)], this study uses a CGE model to establish a link between city size and wages. Advantages of CGE model in this study is its ability to use disaggregated sector-specific data to explore the economic impacts of agglomeration economies on two medium size cities. This study is also able to explore distributional effects agglomeration economies has on three labor groups individually in the four sectors in each city. The results are then compared across cities, an advantage over other econometric frameworks used previously.

### *3.1.1 CITY AND SECTOR CHARACTERISTICS*

This section gives a description of the two cities that are used in the study, the motivation for the study and the setting of the simulations. The next section will discuss the results of the simulations in each city and a comparison across the cities.

#### *3.1.1.1 City characteristics*

Comparative characteristics for both cities are summarized in table 3.1. Fort Collins city is larger compared to Loveland. So for the purpose of this study, Fort Collins is regarded as an urban city since it has a population that is more than twice that of Loveland (see table 3.1). Because Loveland is smaller than Fort Collins, it is therefore regarded as a non urban city. Loveland's population is about 43 percent (50,608) that of Fort Collins (118,652) according to the 2000 population census. Fort Collins also has a thicker labor market as compared to Loveland. According to the data from Social

Account Matrix of 1996, Fort Collins' total employment is 64,592 workers while Loveland has 26,995 workers (42 percent of Fort Collins).

Table 3.1: Fort Collins and Loveland city characteristics

| Variable | Fort Collins | Loveland |
|---|---|---|
| Population* | 118,652 | 50,608 |
| Total Employment** | 64,592 | 26,995 |

*Source: 2000 US population census

** Source: Cities 1996 Social Account Matrices

Table 3.2 below shows the characteristics of the four productive sectors of interest in each city. The data shows that in Loveland, retail and manufacturing sectors are very important due to the higher percentage of the workforce compared to Fort Collins. For example, in Loveland, the retail sector alone employ 23 percent of all the workers in the city while in Fort Collins, retail employs only about 6.6 percent of all workers. Loveland employs 8.9 percent of all workers in the high service sector while Fort Collins employs 9.7 percent. Looking at this employment distribution it is easy to say that policy changes that are aimed at improving retail sector will impact Loveland more positively (thicker labor market in the retail sector) and those that are aimed at improving the high service sector will benefit Fort Collins' economy more. The importance of the retail sector in Loveland can help to explain a higher average wage observed in the retail sector of Loveland compared to that of Fort Collins.

Table 3.2: Characteristics of Private Sectors and Households in Fort Collins.

| Sector Characteristics | | | | |
|---|---|---|---|---|
| | Manufacturing | Computer Manufacturing | High Services | Retail |
| Employment (Percentage of Total) | 6,007 (9.3%) | 3,784 (5.9%) | 8,459 (13.1%) | 4,208 (6.6%) |
| Average Wage ($) | 24,888 | 60,500 | 24,837 | 10,178 |
| Intermediate Demand (Mil of $) | 1,008.11 (39%) | 230.46 (9%) | 199.96 (8%) | 20.88 (1%) |

Table 3.3: Characteristics of Private Sectors and Households in Loveland.

| Sector Characteristics | | | | |
|---|---|---|---|---|
| | Manufacturing | Computer Manufacturing | High Services | Retail |
| Employment (Percentage of Total) | 4,654 (17.24%) | 982 (3.64%) | 2414 (8.94%) | 6271 (23.23%) |
| Average Wage ($) | 22,262 | 21,857 | 20,064 | 18,405 |
| Intermediate Demand (Mil of $) | 245.14 (34%) | 19.59 (3%) | 54.45 (8%) | 9.25 (1%) |

Table 3.4 Fort Collins Household Characteristics

| *Household Group* | *Number* | *Workers per household* | *Number of non working households* | *Number of unemployed workers* |
|---|---|---|---|---|
| HH1<10,000 | 3491 | 1.1 | 32 | 35 |
| HH2:$10,000-19,000 | 5197 | 1.8 | 91 | 167 |
| HH3:$20,000-39,000 | 8972 | 1.4 | 132 | 188 |
| HH4:$40,000-49,000 | 2981 | 1.9 | 111 | 192 |
| HH5:$50,000-69,000 | 8595 | 1.7 | 293 | 500 |
| HH6>$70,000 | 10883 | 2.1 | 798 | 1,693 |
| TOTAL | 40119 | | 1,456 | 2,776 |

Table 3.5: Loveland Household Characteristics

| *Household Group* | *Number* | *Workers per household* | *Number of non working households* | *Number of unemployed workers* |
|---|---|---|---|---|
| HH1<10,000 | 538 | 1.7 | 25 | 43 |
| HH2:$10,000-19,000 | 2019 | 2.9 | 1028 | 2981 |
| HH3:$20,000-39,000 | 4551 | 1.2 | 102 | 122 |
| HH4:$40,000-49,000 | 1774 | 1.8 | 88 | 158 |
| HH5:$50,000-69,000 | 3745 | 2.3 | 231 | 531 |
| HH6>$70,000 | 4259 | 2.4 | 705 | 1,622 |
| TOTAL | 16889 | | 2,179 | 5,451 |

Tables 3.4 and 3.5 represent household characteristics for the city of Fort Collins and Loveland. Table 3.4 shows that Fort Collins has 40,119 households. A large proportion of the households (27.1 percent) earn more than $70,000 annually while a small proportion of the households (7.4 percent) earns $40,000-$ 49,000 annually. Fort Collins has about 21.7 percent low-income households (earn <$19,000), 51.2 percent of middle- income households (<$70,000) and 27.1 percent are higher-income households. On average household group six has 2.1 workers per household while group 1 (low-income households) has fewer numbers of workers per household. Also a large number of non working households are in group six and the lowest number are in group one. The number of unemployed workers increases with income. There are 1,693 unemployed workers in group six while there are only 43 workers in group one and 167 unemployed workers in group two.

In Loveland (see table 3.5) HH3 (earns $20,000-$39,000) represents the largest group with about 30 percent of the total households. HH1 (earns <$10,000) is a smaller group with about 3.2 percent of the total households. Loveland has about 25.2 percent of households earn >$70,000 (HH6) while about 59.6 percent are middle-income households earn $20,000- $69,000 annually. HH2 has a larger number of workers per household (2.9) followed by HH6 (2.4) and HH5 (2.3). Also HH2 has a large number of non working households (1028) and unemployed workers (2981) while HH6 has 705 non working households and HH5 has 231 non working households. Due to the highest number of non working households, HH6 and HH5 have 1622 and 531 unemployed workers respectively.

Comparing the two cities, Fort Collins has the largest portion of high-income households and low income households while Loveland has the largest number of middle-income households. Loveland also has the largest number of non working households (2,179) and 5,451 unemployed workers while Fort Collins has 1,456 non working households and 2,776 unemployed workers making it the thicker labor market.

## 3.2 THEORETICAL BACKGROUND

One unique characteristic of a CGE model is the ability to use sector-specific disaggregated data to study the relationship between different economic variables. A large number of previous studies used panel and cross sectional data from the Standard Metropolitan Statistical Areas (SMSAs) to analyze wage differentials between urban and non-urban areas; this study uses sector-specific data from cities of different sizes to conduct its analysis. Cutler and Davies (2007) argue that, "sector-specific changes in employment and labor market performance have different effects on economic growth, migration and the level and distribution of household income. As such, it is important to model sectors separately." In this study, impacts of employment growth on wages (nominal and real) are analyzed within three labor groups within each sector first, and within each city second. Results are then compared across cities.

Glaeser and Mare (2001), examines the productivity (and wage) gains from locating in dense, urban environment. The authors ask why wages are 33 percent higher in cities than outside metropolitan areas. Using a combination of standard regressions, individual fixed effect estimations and instrumental variable methods, they find that the urban wage premium is only in part a level effect of productivity. Their analysis reveals a 25 percent wage advantage for workers living in large cities when controlling for basic observational characteristics such as race, schooling, experience and job tenure. Controlling for unobserved differences with a fixed-effects estimator reduces this wage difference significantly, and the urban premium falls to somewhere between 4.5 and 11 percent, depending upon the sample analyzed. They conclude that the bulk of the urban wage premium accrues over time as a result of greater skill accumulation in cities.

The idea that wages increase with city size was also supported by Yankow (2006) who used a model with fixed effects to control for unobservable worker heterogeneity within regions and to trace the origin of the agglomeration wage differentials. He tried to answer the question, “Why might the wages of characteristically similar workers differ between urban and nonurban areas? He took Glaeser and Mare (2001) findings as a point of departure and extended their analysis by providing new evidence on the sources of the urban wage premium. He used an extensive panel data to examine wages of urban and non-urban workers across three distinct modes of analysis; wage levels, year-to-year wage growth and between-job wage growth (returns of job changing in cities or job mobility). He finds, ordinary least squares regressions when controlled for measurable worker characteristics; reveal a 19 percent wage difference between workers in large urban areas and non-urban residents. Fixed-effects panel estimates indicate that about two-thirds of this wage premium can be explained by cities attracting workers of higher unmeasured skills and ability. His results remained robust even when controlling for inter-personal differences in the strength of experience and urban cost of living.

Sveikaukas (1975), used a measure of value added as an indication of output and hence productivity. He analyzes the higher wages paid in large cities and their effects on the capital-labor ratio. He uses ordinary least square regression on wage equation whereby wage is the dependent variable and population and level of education among the independent variables. He finds that money wages increases significantly with city size. He concluded that the implied average increase in wages with city size is 4.77 percent with doubling of city size.

Wheeler (2001) finds that urban agglomeration enhances productivity by facilitating labor market search and this is reflected through higher wages paid by the firms located in large cities. He quantified his results by concluding that doubling a population corresponds to a 2.7 percent increase in workers wage on average.

Combes, Duranton and Gobillon (2004) analyzed the relationship between city size and productivity. They estimate a model of wage determination across local labor markets using a very large panel of French workers. They find that as city size increases, workers‟ productivity increases due to the presence of agglomeration economies present in larger cities. As a result, wages increase more in larger cities than in smaller cities. They find evidence of an urban wage premium using longitudinal data, controlling for homogeneity using worker fixed effects. They conclude that elasticity of wage with respect to employment density is about 2 percent in the French zones of employment.

Beeson and Eberts (1989) assess the relative importance of both supply (amenity) and demand (productivity) factors in determining inter-metropolitan nominal wage differentials. They argue that, "our estimates of productivity and amenity components of the wage differentials for individual SMSA indicate that, on average, the productivity component of wage differential accounts for a larger share of the total differential than the amenity component." They continue to say that, "however, the relative importance of these factors varies from one city to the next. In some cities, relatively low wages are found to be primarily the result of high amenities, which increase the supply of labor to the city. In some cities, relatively low wages are found to be primarily the result of low productivity-enhancing site characteristic which decrease demand for labor." They extend Roback's (1982) general equilibrium model of household and firm location. In their model, cities differ in site characteristics that affect households' utility and firms' productivity.

Analyzing demand and supply sides of agglomeration, Tabuchi and Yoshida (2000) use a general equilibrium model to estimate the net agglomeration economies in the consumption side as well as the production side using Japanese city-based data when interregional net migration nearly ceased. They show that doubling city size increases the nominal wage by approximately 10 percent but decreases the real wage by approximately 7 to 12 percent. They claimed that a 10 percent increase of the nominal wage is attributable to the productivity increase in production activities while a 7 to 12 percent decrease of the real wage is compensation for the net agglomeration economies, which are the benefits from product variety minus the costs of congestion.

They concluded that, “In other words, city bigness not only enhances the productivity of firms but also brings net agglomeration economies to households.”

Hoch (1972, 1974), and Hoch and Drake (1975), also find a positive correlation between city size and wages. They claim that the residents of large SMSA will get positive compensation in the form of money and real wages for agglomeration diseconomies that large cities bring. They concluded that, for an increase of 1 percent in population an increase of 0.1 percentages in nominal wages is predicted or an increase of 0.08 percent in real wage is predicted. Their results differ with Tabuchi and Yoshida’s (2000) findings that doubling city size increases nominal wage by 10 percent due to increased productivity and decreases real wage by 7-12 percent due to net agglomeration economies benefits that consumer enjoy from increased amenities in larger Japanese cities.

This study analyzes two nonmetropolitan cities of different sizes in northern Colorado. In contrast to previous studies, this study compares cities of population less than 500,000. Fort Collins is larger with a population of 118,652 (Fifth most populous city of Colorado) and Loveland has a population of 50,608 (14th most populous city of Colorado). More details about these cities’ characteristics are presented in the appendix section of this study. The study uses Rivera-Batiz’s (1988) “labor supply” and “increased productivity” effects as a point of departure to establish which of the two effects is relatively more important in these two cities. If the “supply effect” is important then a smaller increase in nominal wages is expected in Fort Collins (a thicker labor market) than in Loveland. A thicker market means that there are more workers and more firms in the area. So when firms demand more workers to satisfy increased demand for goods and services, this will not only attract local people to supply their labor, but it will also attract new households to migrate in that city in search of employment. This attraction of workers will lead to higher labor supply than demanded. As such, wages will decrease. On the other hand, thicker labor markets usually "have natural competitive advantages" like the presence of productive amenities and easy flow of skills and technology, which tends to enhance workers productivity. Therefore, if firms pay workers according to their marginal productivities, then they will have to pay workers in thicker labor market higher wages than in thinner labor market. According to agglomeration literature, workers in Fort Collins are supposed to be more productive than in Loveland. If the productivity effect is important, nominal wages will increase more in Fort Collins than in Loveland.

This essay proceeds as follows: section three describes setting up the model. Section four presents the results and discussions and sections five concludes.

## 3.3 EMPIRICAL SETTING

The objective of this section is to present and compare simulation results from separate export-led expansions in two exporting sectors; manufacturing and computer manufacturing and two service sectors; high services and retail. I examine the economic impacts of those expansions on nominal and real wages of each city individually and then compare the results across.

*3.3.1 Setting up the simulations*

In this simulation, the economic growth is initiated through an increase in export sales for manufacturing sector, computer manufacturing, high services and retail by shifting export demand through an increase in domestic price of exports (*pwo*) which reflect an increase in export sales in the following equation:

$$CX_I = CX0_I * (PD_I (1 + \Sigma_{GK} TAUX_{GK,I}))/(PW0_I(1 + \Sigma_{GK} TAUQ_{GK,I})^{ETAE}{}_I;$$

Whereby sector export demand ($CX_I$) depends on the initial export demand ($CX0_I$), price movement relative to initial price (PD/PWO) and taxes charged on those exports (TAUX, TAUQ) and elasticity of export demand (ETAE). The increase in sales for exports shifts out the demand curve through the following equation in the factor market;

$$R_{F,I} * RA_F * (1 + \Sigma_{GF} TAUFX_{GF,F,I}) * FD_{F,I} = PVA_I * DS_I * ALPHA_{F,I};$$

This equation states that firms' expenditure on factors of production is a function of initial sector rental rate for factors ($R_{F,I}$), average rental rate ($RA_F$), labor taxes ($TAUFX_{GF,F,I}$) and factor demand ($FD_{F,I}$) and should be equal to the revenue the firm gets from selling output domestically which is the function of value added prices ($PVA_I$), sector's domestic supply ($DS_I$) and the relative share of factors ($ALPHA_{F,I}$).

The increase in the price of exports is done in such a way that employment for the manufacturing sector, computer manufacturing, high service and retail sectors is expanded by 400 workers in Fort Collins and Loveland. In order to understand where the additional labor comes from, consider a simulation that requires additional workers. The first source of labor is people in non-working households who decide to enter the workforce. A second source would be households choosing to migrate into the city to take advantage of increased employment opportunities. The migration equation is a function of the natural rate of population growth, real household income and the relative size of nonworking to working households in the economy. The third source of labor supply is found in the workers who commute into and out of the city. Commuting equations are a function of relative real wages in and out of town. The migration equation is presented below:

$$HH_H = HH0_H * NRPG_H * (DS/DS0)^{\pi} + MI0_H * [(YD_H / HH_H / (YD_{0H} / HH_{0H}) / (CPI_H / CPI0_H)]^{ETAYD}{}_H * [(HN_H / HH_H)/(HN_{0H} / HH_{0H})]^{ETAU}{}_H - MO0_H * [(YD0_H / HH0_H)/(YD_H / HH_H))/ (CPI0H/CPI_H)]^{ETAYD}{}_H * (HN0_H / HH0_H)/ (HN_H / HH_H)^{ETAU}{}_H;$$

In the above equation HH is the household migration equation, NRPG is the natural rate of population growth; DS is the domestic supply; MI0 is commuting in; MO0 is the commuting out, YD is the real household income, HH is the households, HN is non-working households, CPI is the price index and $\pi$ is migration elasticity with respect to amenities.

To conduct the analysis, hypotheses are set following Rivera-Batiz's (1988) idea of the 'labor supply effect' and 'increased productivity effect.' If labor supply effect dominates then I expect Fort Collins' (a thicker labor market) nominal wages to be lower relative to Loveland. If the productivity effect is important, then nominal wages will increase more in Fort Collins more than in Loveland.

The following section presents the simulation results for percentage change in nominal and real wages after sector-specific export-led expansion. The section also presents the percentage change in average nominal and real wages, changes in labor and also percentage change in new households. This will be the number of new households that move into the town. The results also present changes in Consumer Price Indices (CPI).

## 3.4 SIMULATION RESULTS:

Table 3.6 represents the results for export led expansion of employment in manufacturing, computer manufacturing, high services, and retail sector for the cities of Fort Collins and Loveland.

The results of this study are divided into two major categories. The first category will be to discuss impacts of export-led expansions on aggregate wages (nominal wage and real wages) for each sector in a city. The results then are compared across cities. The second category is to discuss the impact of employment expansion on wages of each labor group in the city and then compare the results across the two cities.

This study not only explores agglomeration impacts detailed wage perspectives (individual labor groups nominal and real wages) but also is able to analyze impacts on aggregate nominal and real wages. The objective of looking at aggregate variables is to be able to compare with the nominal and real wages used in the literature which are commonly aggregated and see if my results will support or not support other studies findings. The aggregate nominal wage which is the total weighted wage of each sector is calculated as follows:

*Aggregate Nominal Wage*$=\sum (L_1/L*NW_1)$

Whereby $NW_1$ is the nominal wage for labor group I, and $I=1, 2, 3$ for the three labor groups (L1, L2, and L3). The same technique is also used to calculate the aggregate real wage.

In this model all prices are treated as index numbers with a value of unity in the benchmark, and all value flows are treated as benchmark quantities. The same formula was used to calculate the aggregate real wages except instead of using nominal wages for labor groups, real wages was used.

*Manufacturing sector:*

Results for the manufacturing sector show that when export-led employment is increased by the same absolute amount, aggregate nominal wages increase in both Fort Collins (0.33 percent) and Loveland (0.86 percent).

Results for individual labor groups indicate that nominal wages increased more for all three labor groups in Loveland than in Fort Collins. About 0.42 percent new households migrated to Fort Collins while employment expanded by 0.64 percent which makes the ratio of new households per labor changes to be about 0.66 percent. In Loveland 0.49 percent new households migrated and the employment expanded by 1.11 percent, therefore the ratio of new households to labor is 0.44 percent. The highest Fort Collins household labor ratio shows that for every firm in the manufacturing sector, there is a high supply of labor compared to Loveland. The thickness of labor in Fort Collins put a downward pressure on nominal wages compared to Loveland which has a relatively thin labor market. The fact that wages increased, shows that there is also a productivity effect that pushes the wages up. So in Fort Collins both forces are acting together but labor supply dominated the productivity effect and hence wages increased less in Fort Collins than in Loveland. The fact that wages increases less in Fort Collins than in Loveland does not support Hoch (1972, 1975), Hoch and Drake (1975) who finds positive correlation between city size and wages (nominal and real wages). The results support Beeson and Eberts (1989) who argue that the productivity component accounts for a larger share of total differential than amenity component although the situation differ from one city to another. They emphasized that in some cities low nominal wages reflect higher amenities which increase the supply of labor while in some cities low nominal wages indicate less productivity enhancing site characteristics which decrease the demand for labor. In this case the former seems to be an appropriate explanation for lower wages in Fort Collins than in Loveland; Lower wages in Fort Collins than Loveland suggest that the amenities component outweighs the productivity effect.

Table 3.6: Sector Specific Nominal and Real Wages Results

| *Sector* | *Manufacturing* | | *Computer Manufacturing* | | *High Services* | | *Retail* | |
|---|---|---|---|---|---|---|---|---|
| City | Fort Collins | Loveland | Fort Collins | Loveland | Fort Collins | Loveland | Fort Collins | Loveland |
| Nominal Wage 1 | 0.34% | 1.09% | -0.17% | 0.55% | 0.26% | 1.08% | 0.58% | 0.75% |
| Nominal Wage 2 | 0.35% | 0.62% | 0.16% | 1.07% | 0.18% | 0.38% | 0.03% | 0.77% |
| Nominal Wage 3 | 0.18% | 0.38% | 1.29% | 0.00% | 0.18% | 0.26% | 0.01% | 0.02% |
| Real Wage 1 | 0.23% | 0.87% | -0.31% | 0.36% | 0.20% | 0.92% | 0.52% | 0.59% |
| Real Wage 2 | 0.24% | 0.14% | 0.03% | 0.88% | 0.12% | 0.23% | -0.02% | 0.16% |
| Real Wage 3 | 0.07% | 0.17% | 1.16% | -0.19% | 0.12% | 0.11% | -0.04% | 0.14% |
| Average Nominal Wage | 0.33% | 0.86% | 0.79% | 0.92% | 0.22% | 0.87% | 0.51% | 0.70% |
| Average Real Wage | 0.22% | 0.64% | 0.66% | 0.73% | 0.16% | 0.67% | 0.45% | 0.51% |
| New Households | 0.42% | 0.49% | 0.69% | 0.28% | 0.28% | 0.42% | 0.28% | 0.29% |

For aggregate real wages, the increase is also substantial (almost three times) in Loveland than in Fort Collins. Real wages increase for all three labor groups in both cities due to the fact that nominal wages increase faster than CPI. Real wages increased more in Loveland than in Fort Collins, a result which is consistent with the agglomeration literature [see Tabuchi and Yoshida, (2000)].The lower real wages in Fort Collins relatively to Loveland is something that is to be expected since workers in Fort Collins are willing to accept lower wages to compensate for the amenities that Fort Collins which is larger in size offers.[2] The literature predicts that increased amenities with city size leads to increased migration of households and firms into the city. The higher migration increases rent and the cost of living in a city. Therefore in this city, workers are willing to accept lower real wage due to high utility derived from higher amenities.

*Computer manufacturing*

In the computer manufacturing sector, aggregate nominal wage increase in both cities in the simulations but the increase was more pronounced in Loveland than in Fort Collins.

Nominal wages are positive for almost every labor group in both cities, but for L1 in Fort Collins it is negative (-0.17 percent), indicating that the increase in the supply of labor is relatively large for this group. Nominal wages increased more for L1 and L2 in Loveland than in Fort Collins but decreased for L3. The higher nominal wage for L3 in Fort Collins shows that there is higher demand for those workers. The higher number of new households migrated to Fort Collins probably belongs to L1 and L2 and to a smaller

[2] Tabuchi and Yoshida (2000), Beeson and Eberts (1989)

extent for L3. In Loveland, there was a demand for L1 and L2 but not for L3 because there was no change in the nominal wage for L3.

The aggregate real wages increased more in Loveland than in Fort Collins. These results follow the same pattern as the results for the manufacturing sector. They are contrary to Hoch and Drake conclusion that real wages increase with city size.

Real wage decreased for L1 in Fort Collins and increased in Loveland. Real wage decreased by 0.19 percent for L3 in Loveland and increased substantially in Fort Collins by 1.16 percent. Despite of these mixed results, for the computer manufacturing sector, the real wage increases more in Loveland in aggregate than in Fort Collins. These aggregate results support what Tabuchi and Yoshida claimed; real wages decrease with city size.

Many new households were attracted to Fort Collins compared to changes in labor. About 0.69 percent of new households migrated to Fort Collins and labor expanded by 1.00 percent while in Loveland only 0.28 percent new households migrated in and employment expanded by 1.12 percent. A high number of new households migration compared to employment suggests that there was higher labor supply in Fort Collins which is the thick labor market compared to Loveland. Therefore lower wages in Fort Collins are to be expected.

*High Service Sector*

The effect on wages for the high services sector was just like the two sections discussed above. The aggregate nominal wage increased more in Loveland than in Fort Collins. For individual labor groups, nominal wages increased more in Loveland especially for L1 (1.08 percent) compared to Fort Collins (0.26 percent).

The difference between this sector and other already discussed sectors is that; after simulation, fewer new households migrated to Fort Collins (0.28 percent) compared to Loveland (0.42 percent). Also employment expanded more in Loveland than in Fort Collins.

Aggregate real wages increased more in Loveland (0.67 percent) than in Fort Collins (0.16 percent). The higher real wages in Loveland is due to the fact that aggregate nominal wages increased more in Loveland but its CPI is lower (0.06 percent) compared to that of Fort Collins (0.16 percent). In all labor groups (especially L1 and L2), real wages increased more in Loveland relative to Fort Collins. This is caused by a larger increase in nominal wages than in the CPI. For higher wage earners (L3), real wages increased by almost the same amount in both cities. The real wages results support Tabuchi and Yoshida's findings that real wages tend to decrease with city size due to increases in cost of living and presence of amenities.

*Retail Sector:*

Our aggregate wage findings for the retail sector follows the same trend as other sectors discussed above. After export led expansion of employment, aggregate nominal wage increased more in Loveland than in Fort Collins and aggregate real wages are almost the same in both cities.

For individual labor groups, nominal wages increased in both cities but the marginal increase is more in Loveland than in Fort Collins especially for L1 and L2. Real wages increased by almost the same amount for L1 in both cities. For L2, real wage decreased in Fort Collins while it increased in Loveland. For L3, real wages decreased for both Fort Collins and Loveland and this time decreased more in Loveland than in Fort Collins.

## 3.5 CONCLUSIONS

The above nominal wage results are in conflict with studies like that of Glaeser and Mare (2001) and Sveikaukas (1975), who argue that workers in more densely populated areas on average earn higher wages in order to compensate for the higher cost of living arising from congestion. This study finds that nominal wages increase more in Loveland than in Fort Collins. Rejection of the idea that Fort Collins should have higher nominal wages than Loveland is caused by thickness of its labor market. A larger number of households are attracted to Fort Collins as opposed to Loveland and this leads to high supply of labor. Increased labor supply causes a downward pressure on wages in Fort Collins. These results support a theory by Rivera-Batiz (1988) who claimed that in a thick labor market there is supply and productivity effects at work and depending on the relative importance of each, nominal wages can go either way. The nominal wage seems to agree with Beetson and Eberts (1989) who argues that cities irrespective of their different sizes differ in site characteristics that affect “household utility and firm productivity”. They find that productivity component account for larger share of total wage differential than amenity component, they stress that the situation differs from one city to another. In some cities low wages reflect higher amenities which leads to increased supply of labor while in some cities low nominal wage imply low productivity enhancing characteristics which decrease the demand of labor. I find the former explanation fits Fort Collins more and I can therefore say with confidence that low wages in Fort Collins relative to Loveland indicates higher amenities that increases supply of labor.

Real wages results (especially the results for middle and high income earners in Fort Collins' retail sector) agree with supply side studies like Gerking and Weirick (1983), Rosen (1979) and Sahling and Smith (1983), and Tabuchi and Yoshida (2000) who concluded that real wages are lower for big cities because the presence of amenities in big cities attract more people and as a result, labor supply increases as people are willing to accept lower wages in order to enjoy benefits associated with high amenities.

Therefore my results accept the fact that although Fort Collins is a thicker labor market than Loveland, workers in Fort Collins accept lower nominal and real wages than in Loveland due to higher utility they get from higher amenities the city of Fort Collins provides.

REFERENCES

Beeson, P.E. and R.W Eberts (1989), "Identifying Productivity and Amenity Effects in Interurban Wage Differentials," *Review of Economics and Statistics* 71: 443-452

Berck, P., E. Golan and B. Smith (1996), "Dynamic Revenue Analysis for California" Report to the California Department of Finance, Sacramento.

Ciccone, A. (2002), "Agglomeration effects in Europe". *European Economic Review* 46: 213-227

Combes, P., D. Gilles and G. Laurent (2004), "Spatial Wage Disparities: Sorting Matters!," CERAS Working Paper 01-03

Cutler, H. and S. Davies (2007), "Impacts of Sector-Specific Changes in Employment" *Journal of Regional Science* 47 (5): 935-963.

Gerking, S and W. Weirick (1983), "Compensating Differences and Interregional Wage Differentials" *The Review of Economics and Statistics* 65:403-487.

Glaeser E. and D.C. Mare (2001), "Cities and Skills," *Journal of Labor Economics* 19: 316-342.

Hoch, I., 1972a. "Income and City Size," *Urban Studies* 9: 299-328.

Hoch, I., 1977. "Variations in the quality of urban life among cities and Regions," in *Public Economics and the Quality of Life* (L.Wingo and A.W Evans, Eds.), John Hopkins University Press, Baltimore.

Hoch, I. and J. Drake (1974), "Wages, Climate and the Quality of Life" *Journal of Environmental Economics and Management* 1: 268-295.

Rivera-Batiz, F., 1988. "Increasing Returns, Monopolistic Competition, and Agglomeration Economies in Consumption and Production" *Regional Science and Urban Economies* 18:125-153.

Roback, J. (1982), "Wages, Rents and the Quality of Life" *The Journal of Political Economy* 90:1257-1278.

Rosen, S. (1979), "Substitution and Division of Labour" NBRE reprints 0007, National Bureau of Economic Research, Inc.

Sahling, L. and S. Smith (1983), "Regional Wage Differentials: Has the South Risen Again?" *The Review of Economics and Statistics* 65: 131-135

Schwarm, W. and H. Cutler (2003), "Building Small City and Town SAMs and CGE Models." *Review of Urban and Regional Development Studies* 15: 132–47.

Sveikaukas, L. (1975), "The Productivities of Cities, *The Quarterly Journal of Economics* 89: 393-413

Tabuchi, T., and A. Yoshida, (2000), "Separating Urban Agglomeration Economies in Consumption and Production," *Journal of Urban Economics* 48: 70-84.

Wheeler, C. ( 2001), "Search, Sorting and Urban Agglomeration," *Journal of Labor Economics* 19*:* 879-99.

Wheaton, W C. and M. J. Lewis (2002), "Urban Wages and Labor Market Agglomeration", *Journal of Urban Economics* 51(3): 542-562

Wing, I.S. (2007), "Computable General Equilibrium Models and Their Use in the Economy-Wide Policy Analysis: Everything you Ever Wanted to Know," (But were afraid to Ask) (Unpublished).

Yankow, J.J. (2006), "Why do Cities Pay More? An Empirical Examination of Some Competing Theories of the Urban Wage Premium," *Journal of Urban Economics* 60: 139-161.

# 4. ECONOMIC IMPACTS OF PRODUCTION EXTERNALITIES ON WAGES AND HOUSEHOLD INCOME PER CAPITA IN NORTHERN COLORADO

## 4.1. INTRODUCTION

Production externalities (agglomeration effects) are external effects among producers in areas with a high density of economic activity. Most of the empirical works that analyze the relationship between productivity and city size come to the conclusion that productivity increases with the city size because of the production externalities associated with larger cities. As the productivity increases with the city size, nominal wages increase as workers are paid according to their marginal production. Real wages can increase or decrease depending on the costs associated with living in a larger city and on the amenities a city provides. Agglomeration literature also indicates that as workers are paid higher wages in larger cities, household income per capita also increases. This research uses a Computable General Equilibrium (CGE) model to examine the economic impacts on the nominal and real wages, and household income per capita when export demand and the level of production externalities are increased in two cities of different sizes in Colorado. The cities to be examined are Fort Collins (a larger city) and Loveland (a smaller city).

I find that an increase in sector-specific export demand and level of production externalities in the manufacturing sector leads to a larger increase in wages (nominal and real) and household income per capita in Fort Collins than in Loveland. The nominal and real wages and household income per capita increased even more than the level of production externalities increased. I also find that when the level of production externalities increases, I get a larger relative income per capita for Loveland than Fort Collins in the high service sector, which counters the literature. In Loveland there are greater productivity gains in the retail sector when the level of production externalities is increased from 10 to 30 percent.

## 4.2 REVIEW OF THE LITERATURE

Many professional economists have studied the link between productivity and city size in the agglomeration economics literature. One of those economists is Sveikauskas (1975) who investigates urban productivity by examining the CES production function framework using the econometric approach and finds productivity increases by 6 percent each time the city doubles in size. He also finds that the increase in money wages is 4.77 percent for each doubling of the city size and concludes that “observed wages are considerably higher in larger cities because productivity is higher in larger cities". Di Addario and Patacchini (2006) agree and add that urban wage premia could be the outcome of either local increasing returns or compensation for urban diseconomies like high crime and congestion. Talking about the variance of estimates of wage premia across and within countries, they state that the estimates depend very much on the agglomeration variable and dataset used.

Glasier and Gottlieb (2006) recapitulate two essential elements of spatial economics. First, migration across cities ensures that cities that are more attractive along one dimension (such as having higher wages) are less attractive along some other dimension (such as having bad weather). Secondly, mobility of firms ensures that cities that provide one kind of producer advantage (like productivity) will have other production disamenities (like workers who will demand higher wages). This argument tells us simultaneously that higher nominal wages imply high levels of productivity and that high real wages (wages controlling for cost of living) imply consumer disamenities. If high nominal wages are not accompanied by higher productivity, then firms will leave. If high real wages were not accompanied by offsetting disamenities, then workers would flock to the city.

Rosenthal and Strange (2004) look at the relationship between wages and agglomeration. They state that wages could also be affected by the fact that agglomeration leads to more intense competition which, on one hand, raises producers' or workers' productivity, but on the other hand, might force employees to work "too long" hours in order to signal effort, which could reduce productivity because of diminishing marginal returns. Goldfarb and Yazer (1976) offer a different opinion about productivity and city size. They find that the labor force in large cities is more productive not because a large city offers a highly productive environment, but because a large city attracts high quality workers and that the supply of high-quality workers is independent of the size distribution of cities.

Fu and Ross (2007) analyze the wage premia in employment clusters. They argue that it is the concentration of economic activity in cities that enhances the efficiency in economic production (agglomeration economies). They mention that one of the common approaches for studying agglomeration is to study wages. The reason given is that, since workers are paid according to the value of their marginal production in competitive labor markets, a natural test for agglomeration economies is whether workers receive a wage premium in areas with concentrated economic activity. They cite Glaeser and Mare (2001), Wheeler (2001), Combes, Duranton and Gobillon (2004), Fu (2007), Rosenthal and Strange (2006), Yankow (2006) and DiAddario and Potacchini (2005) as studies that find wages are higher in large labor markets with higher concentrations of employment. They also cite other studies like Wheaton and Lewis (2002), Combes et al. (2004), and Fu (2007) who find evidence that wages increase with concentration of employment in an individual's own occupation or industry. They find that wages are higher in locations with more educated workers.

Rosenthal and Strange (2001) state that the most commonly used econometric method of measuring agglomeration is to use the production function. They argue that if agglomeration enhances productivity, labor demand will shift out. This will lead to faster employment growth and higher wages. They cite other studies that look at the relationship between productivity and city size and conclude that doubling city size seems to increase productivity by an amount that ranges between 3 and 8 percent. Yankow (2006) uses OLS regression to try to evaluate why cities pay more. The question he tries to answer is why the wages of characteristically similar workers might differ between urban and non-urban areas. He identifies a 19 percent wage advantage for workers in large urban area. He concludes that the long-run equilibrium real wage differentials among similar workers can arise to the extent that there are differences in worker skills and/or productivity between urban and non-urban areas.

Glaeser and Mare (2004) look at perspectives of both demand and supply of labor to explain the difference in wages with city size. Their analysis reveals a 25 percent wage advantage for workers living in large cities when controlling for basic observational characteristics such as race, schooling and job tenure. Controlling for unobserved differences with a fixed-effects estimator reduces this wage difference significantly, and the urban premium falls to somewhere between 4.5 and 11 percent, depending upon the sample analyzed.

Dumond, Hirsch and Macpherson (1999) do not explore the urban wage premium per se. Their analysis does provide some useful benchmark estimates of real wage differences across cities of different size. Their results indicate that workers in areas with population between 200,000 and 500, 000 garner roughly a 5 percent wage advantage, those in areas with population between ½ to 2 million a 7 percent advantage, and those in areas 2 million and over an approximate 10 percent advantage—as compared to workers in the smallest urban areas (those with population less than 200,000)—when applying regression-cost-living adjustment.

Segal (1976) using U.S. data for 1967, found that an agglomeration effect "makes units of labor and capital 8 percent more productive" in the largest cities. Fogarty and Garofalo (1988) examine agglomeration economies in Standard Metropolitan Statistical Areas (SMSAs) in the United States. They find clear evidence of agglomeration economies. They conclude that competitive position of a city in regional competition depends on both productivity growth and the trend in regional factor cost differentials. Analyzing why households in larger cities seem to have higher household income per capita, Hoch (1972) finds that the higher per capita income observed in larger cities (after standardization of demographics and other factors) is indicative of a wage premium that must be paid to compensate for the higher living costs and net disamenities in larger cities.

This study uses a CGE model to examine the impact of sector-specific changes in export demand and production externalities on real and nominal wages, and household income per capita for the two cities. The simulations are set such that the level of the coefficient for production externalities is varied simultaneously with the level of export demand and then the impacts on wages and household income per capita are analyzed. The sector-specific changes in export demand are done in order to expand the sector's employment by 2.5 percent in each city. In order to explore impact of production externalities, a production function approach is used. Changes in the level of production externalities are done in order to evaluate the effects of an increase in the sector's productivity on nominal, real and household income per capita. The results are then compared across the cities.

To my knowledge, this is the first study to examine the impacts of sector-specific export demand expansion and changing level of production externalities in a city and to compare results across median cities using a CGE model. Previous studies used single sector data from Metropolitan Statistical Areas (MSAs) or larger cities with population of 500,000 and above [Tabuchi and Yoshida (2000), Glaeser and Mare (2001) etc.]. The rest of the paper is organized as follows; section 2 presents the empirical results and discussion and section 3 concludes.

## 4.3 SETTING UP SIMULATIONS

In the first part of this study, city growth is initiated through growth in employment and productivity at the same time. This is done in the spirit of Burnett, Cutler and Davies (2008), who argue that regional growth can be categorized into three main processes: changes in export and local demand, productivity and population growth. In this study, export demand and productivity growth are estimated on a sector-specific basis. Of the 17 sectors in the economy, three are chosen as representatives: manufacturing, high services and retail.

Later, population growth which is not sector specific is also analyzed, as it is believed that people are attracted to a location where there is higher concentration of firms in order to increase their chances of finding employment, and firms would like to migrate to a place where there is a higher labor pool and market for their products. Both of these reasons increase the population of a location. This population growth aspect is also discussed by Tolley (1987), who describes several types of agglomeration economies which are production externalities. He gives two examples in which the externalities are a function of population sizes: (1) an increase in the size of the labor market due an expansion by a single firm results in a better match of skills and jobs, increasing labor productivity; and (2) an increase in the number of firms expands the demand for public services, thereby lowering costs when scale economies exist in the provision of public services. In this study, a former explanation is used to reflect production externalities as a function of population size.

Employment growth can be divided into two types: export growth and local growth (capital migration). Employment growth through exports results from an increase in external demand that shifts out the sector's demand curve. The sector increases its factors of production, including land and labor, in order to meet demand for the increased production. This type of growth not only increases quantity of goods to be exported, but also puts upward pressure on prices of outputs and that of factors of production.

In this study, when sector-specific export growth is increased, the sector's aggregate employment is expanded by 2.5 percent in both cities of Fort Collins and

Loveland. In the model, this is accomplished by increasing PWO in [equation (4-1) below] for a specific sector until aggregate employment increases by 1000 additional workers in Fort Collins and 422 in Loveland.

$$CX_I = CX0_I * (PD_I (1 + \Sigma_{GK} TAUX_{GK,I}))/(PW0_I(1 + \Sigma_{GK} TAUQ_{GK,I})^{ETAE}{}_I; \quad (4\text{-}1)$$

Where sector export demand ($CX_I$) depends on the initial export demand ($CX_{0I}$), price movement relative to initial price (PD/PWO), taxes charged on those exports (TAUX, TAUQ) and elasticity of export demand (ETAE). This increase in sales for exports shifts out the factor demand curve through the following equation in the factor market:

$$R_{F,I} * RA_F * (1 + \Sigma_{GF} TAUFX_{GF,F,I}) * FD_{F,I} = PVA_I * DS_I * ALPHA_{F,I}; \quad (4\text{-}2)$$

This identity states that firms' expenditure on factors of production as the function of initial sector rental rate for factors ($R_{F,I}$), average rental rate ($RA_F$), labor taxes ($TAUFX_{GF,F,I}$) and factor demand ($FD_{F,I}$) should be equal to the revenue the firm gets from selling output domestically which is the function of value added prices ($PVA_I$), sector's domestic supply (DSI) and relative share of factors ($ALPHA_{F,I}$).

Productivity changes can be divided into local factor productivity (TFP) and the marginal productivity of labor or capital (MPL or MPK respectively), of which TFP dominates. Since this paper is interested in sector-specific growth, TPF is used to stimulate productivity growth.

To accomplish the objective stated above, consider that a firm in a competitive industry chooses an output, inputs and location with an objective of maximizing profit. Then the firm's production and location decision is presented in this dissertation by the following equation:

$$DS_I = DELTA_I * \sum_H (HH_H / HH0_H)^{\beta} * \Pi_F (FD_{F,I}{}^{ALPHA}{}_{F,I}) \qquad (4\text{-}3)$$

The above equation states that domestic supply (DS) depends on the state of technology which is represented by the production function scale (DELTA) $*\sum_H(HH_H/HH0_H)^{\beta}$, represent how households change (proxy for city size) when productivity increases. $\sum_H(HH_H/HH0_H)^{\beta}$ contains some representation of agglomeration economies. It is a vector of influences on production that arise from agglomeration economies (Hicks-neutral production as a function of population) Moomaw (1988). Within this framework, agglomeration economies can improve the domestic supply indirectly by raising the marginal product of the households hence increasing nominal and real wages leading to more households and firms into the city. Parameter $\beta$ represents productivity externalities (elasticity of productivity with respect to agglomeration). When the value of $\beta$ is altered, the productivity externalities are altered. $\Pi_F$ is the function that represents factor demands (FD) and ALPHA is the relative share of the factors.

In this dissertation the values of $\beta$ are altered between 0.1 and 0.3. These elasticities are chosen following the Graham (2007) who conducted a meta-analysis on the various studies that were done to estimate agglomeration economies. He finds that "the estimates of urbanization economies on manufacturing industries range from 0.01 and 0.2 but the majority of values are under 0.1". He therefore concluded that those results indicate that a doubling of city size is typically associated with an increase in productivity of somewhere between 1 percent and 10 percent. The weighted average elasticity for the service sector is 0.186 which indicates that a doubling of a population is associated with an increase on productivity of just under 20 percent. The value of 0.3 is chosen to extend Graham's range and see if there will be any significant impacts on nominal and real wages and household income per capita.

In the first simulation, the value of $\beta$ is first set at 0.1 and then the export demand function of each sector is increased individually from the normalized value of 1 until the aggregate city employment increases by 2.5 percent (1000 workers in Fort Collins and 422 in Loveland). In both simulations, the export growth and the productivity (production externalities) are both increased simultaneously.

In the second simulation, the value of $\beta$ is set at 0.3 in order to determine whether that change in the level of production externality will have larger impacts on wages relative to the first simulation. As in the first simulation, sector-specific export demand is simultaneously increased as well. What separates this study from previous studies is the fact that sector-specific export demand is increased together with the level of production externalities simultaneously.

In the previous studies, the link between city size and productivity was made through an increase in employment of a manufacturing sector or population for MSA or state, and then the impacts on wages were analyzed (size productivity causality) or manufacturing wages were first increased to see if that would increase employment or population in general (productivity city size causality). Most of the studies favor city size productivity causality.

## 4.4 EMPRICAL RESULTS AND DISCUSSION:

### *4.4.1 When the coefficient of production externalities increases by 0.1*

The simulation results for both cities are presented in Table 4.1 below. The results show that as sector-specific export demand and production externalities increase, wages (both nominal and real) increase in each city as indicated in Table 4.1, with the exception of real wages for labor group three workers in the retail sector in the city of Loveland.

When the coefficient for production externalities increases by 0.1 in all sectors, wages in both cities increase, with the exception of real wages for labor group 3 in the retail sector of Loveland. When the results are compared across the cities, nominal and real wages increase more in Fort Collins than in Loveland with few exceptions.

In the manufacturing sector, results show that the nominal wage increases more in Fort Collins than in Loveland for all labor groups. Results also show that the real wage increases more in Fort Collins than Loveland for labor groups one and two. The real wage increases more (0.94 percent) in Loveland than in Fort Collins (0.92 percent) for the labor group one, although the difference is not significant.

The results for high services sector shows that nominal and real wages increases more in Fort Collins than Loveland for labor groups two and three (middle and high income earners); while for labor group one the nominal and real wages increases more in Loveland than in Fort Collins. The nominal wage for the group one increased by 1.13 percent in Loveland, while that of the same group in Fort Collins increased only by 0.82 percent.

In the retail sector, the nominal wage increases more for labor groups one and three in Fort Collins than in Loveland, but the trend is reversed for labor group two where the nominal wage increases by 0.80 percent in Loveland and only 0.09 percent in Fort Collins. The real wages results do not follow any particular pattern; for the labor group one the real wage increases more in Fort Collins than in Loveland. For the labor group two the real wage increases more in Loveland (0.65 percent) than in Fort Collins (0.07 percent), while for the labor group three the real wage decreases in Loveland (-0.14 percent).

Comparing the average employment data for the two cities, Loveland employs about 23 percent and Fort Collins employs 17 percent of the total employment in the retail sector. The thicker labor market in Loveland for retail workers might be for the reason that when sector specific export demand is expanded, and production externalities coefficient is increased, more middle income workers are demanded in Loveland than in Fort Collins, contributing to significantly wage premium in Loveland.

Generally nominal and real wages increase more in Fort Collins than in Loveland for the rest of the labor groups when the sector-specific export demand is expanded and the level of production externalities increases by 10 percent. These results supports Glaeser and Gottlieb (2006) who argues that higher nominal wages in a larger city imply an increased productivity and higher real wages imply increased consumer disamenities. The nominal wages results also supports Sveikaukas (1975), Rosenthal and Strange (2001), Yankow (2006), Wheeler (2001) who argue that wages usually increases with the city size due to increased productivity. Workers are paid the value of the marginal product in a competitive labor market.

Table 4.1: Production externalities and their impacts on wages (percentage change)

| Sectors | Wages | Productivity (β = 0.1) | | Productivity (β = 0.3) | |
|---|---|---|---|---|---|
| | | Fort Collins | Loveland | Fort Collins | Loveland |
| Manufacturing | Nom. Wage 1 | 1.19% | 1.14% | 1.12% | 1.13% |
| | Nom. Wage 2 | 1.02% | 0.64% | 1.02% | 0.59% |
| | Nom. Wage 3 | 0.64% | 0.39% | 0.82% | 0.35% |
| | Real Wage 1 | 0.92% | 0.94% | 1.10% | 0.99% |
| | Real Wage 2 | 0.75% | 0.44% | 1.00% | 0.45% |
| | Real Wage3 | 0.37% | 0.19% | 0.80% | 0.21% |
| High Services | Nom. Wage 1 | 0.82% | 1.13% | 0.81% | 1.13% |
| | Nom. Wage 2 | 0.50% | 0.39% | 0.52% | 0.35% |
| | Nom. Wage 3 | 0.52% | 0.27% | 0.58% | 0.29% |
| | Real Wage 1 | 0.70% | 0.99% | 0.79% | 1.04% |
| | Real Wage 2 | 0.39% | 0.25% | 0.49% | 0.26% |
| | Real Wage 3 | 0.40% | 0.12% | 0.56% | 0.15% |
| Retail | Nom. Wage 1 | 1.55% | 0.79% | 1.47% | 0.80% |
| | Nom. Wage 2 | 0.09% | 0.80% | 0.12% | 0.78% |
| | Nom. Wage 3 | 0.07% | 0.01% | 0.19% | 0.00% |
| | Real Wage 1 | 1.53% | 0.64% | 1.62% | 0.99% |
| | Real Wage 2 | 0.07% | 0.65% | 0.27% | 0.45% |
| | Real Wage 3 | 0.05% | -0.14% | 0.34% | -0.21% |

*4.4.2 When the coefficient of production externalities increases by 0.3*

When sector specific export demand is expanded and the coefficient of production externalities increases by 0.3, the nominal and real wages increase more in Fort Collins than in Loveland in all the sectors with few exceptions.

In the manufacturing sector, nominal wage increases more in Fort Collins than in Loveland for all labor groups except for labor group one. The results show that the increase in nominal wages is larger as the coefficient of production externalities increases from 0.1 to 0.3 in Fort Collins mainly for labor group three. In Loveland, nominal wage increases less as the level of production externalities increases.

In the high services sector, the nominal and real wage increases more in Fort Collins than in Loveland for labor groups two and three. The nominal wage results support the agglomeration literature that finds wages increase with concentration of employment [(Glaeser and Mare (2001), Wheeler (2001), Combes, Duranton and Gobillon (2004), Fu (2007), Rosenthal and Strange (2006), Yankow (2006) and DiAddario and Potacchini (2005)]. The real wage results supports Glaeser and Gottlieb (2006) findings. The only exception was the results for the labor group one in Loveland. The nominal wage increases more in Loveland for labor group 1 than in Fort Collins. The nominal wage increases by 1.31 percent in Loveland and increases by 0.81 percent in Fort Collins. The higher nominal wage in Loveland than Fort Collins for labor group 1 is the indication that, as sector specific export demand is expanded, there is a higher demand for unskilled labor in Loveland for this sector which leads to higher wages. Loveland employs 8.9 percent of total employment in the high services sector, while Fort Collins employs 9.7 percent of the total employment.

In the retail sector, the nominal wage increases more in Fort Collins than in Loveland for groups 1 and 3, while it increases more in Loveland than Fort Collins for labor group 2. This is an indication that when sector-specific export demand is expanded, demand for middle-income workers increases more in Loveland than in Fort Collins for the retail sector. The results above support studies by Glaeser and Mare (2001), Wheeler (2001), Combes, Duranton and Gobillon (2004), Fu (2007), Rosenthal and Strange (2004), Yankow (2006) and DiAddario and Potacchini (2005) that find wages are higher in large labor markets with higher concentrations of employment. The real wage for labor group three in Loveland decreases in Loveland (-0.21 percent) while it increases in Fort Collins (0.34 percent). The labor group three results support the agglomeration literature that real wages should be lower in a larger city than a small city. The decrease in real wage in the retail sector in Loveland is due to the fact that when the sector's employment expands and production externalities increase, the nominal wage for this group does not increase indicating less demand for skilled workers and maybe the increase in the implicit cost of living for this labor group.

The larger increase in nominal and real wages in Fort Collins than in Loveland also supports what Glaeser and Mare (2004) argue: “the nominal wages premium collected by urban workers may simply reflect a higher cost of living in cities". If that is the case, then real wages may not differ materially across urban and non-urban areas. However, if higher urban prices do not fully account for the higher nominal wages and real wage differences exist, then it must be true that workers in the cities are more productive.”

The differences shown by nominal and real wage directions of the low income earners in high services sector and middle income earners in the retail sector in Loveland also support what Moomaw (1983) suggests: that one ought to estimate agglomeration economies separately for different industries, since there is such substantial variation across industries.

*4.4.3 Household income per capita results*

Table 4.2 represents the results on the changes in income per worker after an expansion in export and increase in production externalities in Fort Collins and Loveland. The results show that income per worker increase more in Fort Collins than Loveland in two of the three sectors (manufacturing and retail sectors) while it increased more in Loveland than Fort Collins in the high services sector. The higher supply of workers in the high services sector in Fort Collins than Loveland might have causes a downward pressure in the household income in that sector.

Table 4.2: Nominal household Income per capita

| Sector | Parameter | Fort Collins | Loveland |
|---|---|---|---|
| Manufacturing | B = 0.1 | 25.16% | 22% |
| | B = 0.3 | 35.57% | 23% |
| High Service | B = 0.1 | 11. 78% | 16.47% |
| | B = 0.3 | 15.73% | 18% |
| Retail | B = 0.1 | 13.47% | 4.21% |
| | B = 0.3 | 19.40% | 13.24% |

In Fort Collins, when sector-specific export demand is expanded and the coefficient for production externalities increases to 0.1, the income per capita increases by 25.16 percent in the manufacturing sector, while it increases by 11.8 percent and 13.47

percent for high services and retail sectors respectively. In the manufacturing sector, when the coefficient for production externalities increases by 0.3, the nominal income per capita increases by 37.57 percent whilst it increases by 15.73 percent and 11.78 percent in the high services and for the retail sector respectively. Comparing the two values of production externalities, I observe that income per capita increases with an increase in the level of production externalities.

In Loveland, when the coefficient for productivity externalities increases by 0.1 and sector-specific export demand is expanded, the nominal income per capita increases by 22 percent in the manufacturing sector, 16.47 percent in the high services sector and 4.21 percent in the retail sector. In the manufacturing sector when the coefficient for productivity externalities increases by 0.3, the nominal income per worker increases by 23 percent. The nominal income per capita also increases by 18 percent in the high services sector and 13.24 percent in the retail sector. With the increased level of production externalities from 10 to 30 percent, the nominal household income increased almost three times for the retail sector (4.21 percent to 13.24 percent), showing larger relative productivity gains for the retail sector than other sectors in Loveland. These results are not unexpected because of a thicker labor market that Loveland has in this sector compared to Fort Collins (localization economies).

The results across the two cities show that income per capital increases more with productivity in Fort Collins than in Loveland for the manufacturing and retail sectors (urbanization economies).

A different pattern is observed in the high service sector where Loveland has lower aggregate employment (8.9 percent) than Fort Collins (9.7 percent) but household income per capita increases more in Loveland for both levels of production externalities. When the coefficient for production externalities increases by 0.3, the nominal household income per capita in this sector follows the same pattern observed when the coefficient for production externalities is increased by 0.1. The nominal household income per capita increases by 1.31 percent in Loveland compared to 0.82 percent in Fort Collins.

In the manufacturing sector, when production externalities are increased by 10 percent, the nominal income per capita increases by 25.1 percent in Fort Collins while it increases by 22 percent in Loveland. When the production externalities level increases to 30 percent; the nominal household income per capita increases by 35.6 percent in Fort Collins while it increases by 23 percent in Loveland. These results show that when the level of production externalities increases from 10 percent to 30 percent, gains in the nominal household income per capita are greater in Fort Collins (about 1.5 times) compared to Loveland (1.15 times).

In the retail sector, when production externalities increase by 10 percent, the nominal income per capita increases more in Fort Collins (13.47 percent) than in Loveland (4.21 percent). The nominal household income per capita increases in Fort Collins by 19.24 percent and it increases by 13.25 percent in Loveland when the level of production externalities increases by 30 percent.

The increase in per capita income in Fort Collins in two of the three sectors supports Hoch's (1972) argument that income per capita increases with city size.

Table 4.3: Real Household Income per capita

| Sector | Parameter | Fort Collins | Loveland |
|---|---|---|---|
| Manufacturing | B = 0.1 | 23.52% | 20% |
| | B = 0.3 | 35.45% | 23% |
| High Service | B = 0.1 | 11.02% | 15.58% |
| | B = 0.3 | 15.56% | 17.74% |
| Retail | B = 0.1 | 13.28% | 3.31% |
| | B = 0.3 | 20.23% | 12.54% |

Table 4.3 above summarizes simulation results for real household income per capita for Fort Collins and Loveland. These results show the same pattern as that of household nominal income per capita.

When export demand and the coefficient for production externalities increases by 0.1, real household income per capita increases in both cities, but the increase is more in Fort Collins than Loveland for the manufacturing and retail sectors. In the high service sector, the real household income per capita increases more in Loveland than in Fort Collins.

In the manufacturing sector, when the level of production externalities is increased by 10 percent, the real household income per capita increase by 23.52 percent in Fort Collins and 20 percent in Loveland. The real household income per capita increases even more when production externalities are increased by 30 percent in both cities. It increases by 35.45 percent in Fort Collins and 23 percent in Loveland. The results therefore show that real household per capita increase more in Fort Collins than in Loveland. These results support Hoch's (1972) findings.

In the high service sector, the results across the two cities show that real household income per capita increases more in a smaller city of Loveland than in Fort Collins when production externalities are increased by 10 and 30 percent. In the high service sector when production externalities are increased by 10 percent, the real household income per capita increases by 15.58 percent in Loveland and 11.02 percent in Fort Collins. The real household income per capita increases by 17.74 percent in Loveland and 15.56 percent in Fort Collins when the level of production externalities increases from 10 percent to 30 percent. The results show that real household income per capita increases with the level of production externalities. The increase in the real household income per capita in this sector is more in Loveland which is a small city compared to Fort Collins. These results do not support what the previous findings claim: that income per capita increases with city size.

In the retail sector, when the level of production externalities increases by 10 percent, real household income per capita increases more in Fort Collins by 13.28 percent than in Loveland where it increases only by 3.31 percent. When the coefficient for production externalities is increased by 0.3, in Fort Collins the real household income per capita increases by 20.23 percent and by 12.54 percent in Loveland.

Within the city of Loveland, the increase of production externalities from 10 percent to 30 percent increases real household income per capita four times as much. When the level of production is 10 percent, the real household per capita increases only by 3.31 percent, and when the level is 30 percent, the increase in real household income is 12.54 percent. This implies that there is a substantial gain in Loveland as the production externalities are increased more in the retail sector than in other sectors.

Policies to expand the retail sector must benefit the people of Loveland more compared to other sectors.

4.5 CONCLUSION:

This study concludes that workers in Fort Collins are more productive than Loveland because of agglomeration economies accrued in Fort Collins due to its size. This conclusion also supports Yankow (2006) who argues that the long-run equilibrium real wage differentials among similar workers can arise to the extent that there are differences in worker skills and/or productivity between urban and non-urban areas. The results also support Goldfarb and Yazer (1976), Fuch (1967), Borjas, Bronars and Trejo (1992) who suggested that larger cities attract high quality workers because they tend to offer a highly productive environment because of severe competition and diverse opportunities. On the other hand, these results also can be explained by the firm level productivity hypothesis that asserts that workers are more productive in firms located within cities due to economies of agglomeration. That is, the marginal product of labor is higher for city-based firms due to the production and consumption benefits of urban density (Ciccone and Hall, 1996).

The household per capital income also increases more in Fort Collins than in Loveland for the manufacturing and retail sectors, but increases less in the high service sector. The household income per capita increases more in Loveland for the high service sector after sector-specific export demand is expanded. Further investigation is required to see what is causing these particular results in this sector. The high service sector results show how important it is to disaggregate data into different sectors and examine the link between productivity and city other than using aggregate data, as different sectors are impacted differently with different economic shocks, as this study shows. Still, the higher increase in nominal and real household income per capita in Fort Collins supports Hoch (1975) arguments that income per capital increases with city size. The nominal and real household per capita increases more with the level of production externalities.

The increase in income per capita and wages in both cities shows an emphasis on increasing returns to scale at some level. In modeling this dissertation, constant return to scale is assumed in the production at the firm level but the results shows increasing returns to scale. These results support Hanson (1997) who argues that, "the agglomeration of economic activity generates external effects (increasing returns) that enhance the productivity of all firms that share a given geographical location. Source of such externalities is that the dense concentration of firms facilitates learning and other types of knowledge spillovers.

There is also another theory in the most recent strand of literature that states that "agglomeration economies result from the interaction of fixed costs and transport costs (Fujita, 1988; Krugman, 1991; Asilis and Rivera-Batiz, 1993). Those fixed production cost imply firms prefer, all else equal to save consumers from a single location; transport imply firms prefer, all else equal to locate near large market. Given increasing returns, industry would be naturally attracted to such a large urban population area.

Graham (2007) argues that because constant return to scale input use is controlled within the production function estimation, the results can thus be interpreted as showing how TFP varies with agglomeration. He concludes that the agglomeration elasticity measures the amount in which production function is shifted outwards, given the volume of input use as the consequences of these externalities. My results support and confirm this conclusion.

REFERENCES


Asilis, C.M., and L. Rivera-Batiz (1994), "Geography, Trade Pattern and Economic Policy," *IMF Working Papers* 94/16, International Monetary Fund

Berck, P., E. Golan and B. Smith (1997), "State tax policy, labor, and tax revenue feedback effects." *Industrial Relation* 36: 399-418.

Borjas, G. J., Bronars, S. G and S. J Trejo (1992), "Assimilation and the Earnings of Young Internal Migrants," *The Review of Economics and Statistics* 74(1): 170-75

Burnett, P., Cutler, H., and S. Davies (2008), "Understanding the Unique Impacts of the Causes of Economic Growth," *Colorado State University Working Paper* (unpublished)

Ciccone, A. (2002), "Agglomeration effects in Europe," *European Economic Review* 46 (2): 213–228.

Ciccone, A., and R.E. Hall (1996), "Productivity and the density of economic activity." *American Economic Review* 86(1): 54–70

Combes, P. P., G. Duranton, and G. Gobillon (2004), "Spatial wage disparities: sorting matters!," *CEPR dp* 4240

DuMond, J.M., B.T Hirsch and, D.A MacPherson (1999), "Wage Differentials across labor markets and workers: Does cost of living matter?" *Economics Inquiry* 37: 577-598.

Fogarty, M. S., and G.A Garofalo (1988), "Urban Spatial Structure and Productivity Growth in the Manufacturing Sector of Cities." *Journal of Urban Economics* 23: 60-70

_________________, 1980. "Urban Size and Amenity Structure of Cities," *Journal of Urban Economics* VIII.

Fuchs, V. (1959), "Differential in hourly earnings by region and region size." *Occasional paper 101 NBER*, New York.

Fujita, M., and J. Thisse (2002), "The Economics of Agglomeration," Cambridge University Press, Cambridge

Glaeser, E.L. and G.C Maré (1994), "Cities and Skills." *Working paper No. 4728 NBER*, New York.

___________________(2001), "Cities and Skills," *Journal of Labor Economics* 19, 316-342.

Glaeser, E.L., and Gottlieb (2006), "Urban Resurgence and the Consumer City." *Urban Studies* 43(8): 1275-1299,

Goldfarb, R. S., and A. M. J. Yezer (1976), "Evaluating Alternative Theories of Intercity and Interregional Wage Differentials," *Journal of Regional Science* (XVI):345-63.

Graham, D. (2007), "Agglomeration, Productivity and Transport Investment," *Journal of Transport Economies and Policy* 41(3): 317-343,

Hanson, G. H. (1997), "Increasing Returns, Trade and the Regional Structure of Wages," *The Economic Journal* 107: 113-133.

Henderson, J.V**. (**1988**),** "Urban Development: Theory, Fact, and Illusion." New York: Oxford University Press.

Hoch, I. (1972), "Income and City Size," *Urban Studies* IX: 299-328

Kim, S. (1990), "Labor Heterogeneity, wage bargaining, and agglomeration economies," *Journal of Urban Economics* 28:160-177.

Kim, S. (1987), "Diversity in urban labor markets and agglomeration Economies," Papers of *Regional Science Association* 62: 57-70.

Krugman, P. (1991a), "Increasing Returns and Economic Geography," *Journal of Political Economy 99*: 483-499.

Lippman, S.H. and J.J. McCall (1976), "Job Search in a Dynamic Economy," J. *of Economic Theory* 12:365-390

Moomaw, R. L. (1983), "Is population scale a worthless surrogate for business agglomeration economies?," *Regional Science and Urban Economics* 13**(**4): 525-545

Mortensen, D. (1986), "Job search and labor market analysis." Ch. 15 of *Handbook of Labor Economics*, Vol. 2, O. Ashenfelter and R. Layard, eds., North-Holland.

Rauch, J.E.(1993), "Does History Matter Only When It Matters Little? The Case of City-Industry Location," *The Quarterly Journal of Economics* 108(3**):** 843-67.

Rosenthal, S. S. and W.C. Strange (2001), "The Determinants of Agglomeration," *Journal of Urban Economics* ***50***: 191-229.

____________________________(2004), "Evidence on the nature and sources of agglomeration economies." In: V. Henderson and J. Thisse, Editors, *Handbook of Urban and Regional Economi*, vol. 4.

Yankow, J.J. (2006.) "Why do Cities Pay More? An Empirical Examination of some competing Theories of the Urban Wage Premium," *Journal of Urban Economics* 60:139-161

Schwarm, W. and H. Cutler, H. (2003), "Building Small City and Town SAMs and CGE Models," *Review of Urban and Regional Development Studies* 15: 132–47

Segal, D**.** **(**1976**),** "Are There Returns to Scale in City Size?" *Review of Economics and Statistics* 58(3): 339-50.

Sveikauskas, L., 1975. "The productivity of cities," *Quarterly Journal of Economics* 89: 393–413.

Tabuchi, T., and A.Yoshida (2000), "Separating urban Agglomeration Economies in Consumption and Production**,"** *Journal of Urban Economics* 48: 70-84.

Wheaton, W.C. and M.J. Lewis, (2002), "Urban wages and labor market agglomeration", *Journal of Urban Economics* 51: 542–562.

Wheeler, C. H. (2001), "Search, Sorting and Urban Agglomeration," *Journal of Labor Economics* 19: 879-99.

Wing, I.S. (2007), "Computable General Equilibrium Models and Their Use in the Economy- Wide Policy Analysis: Everything you Ever Wanted to Know (But were afraid to Ask)," (Unpublished).

# 5. CONSUMPTION EXTERNALITIES: THEIR IMPACTS ON NOMINAL AND REAL WAGES IN NORTHERN COLORADO

## 5.1 INTRODUCTION

The literature claims that workers' productivity increases with city size thus, higher labor productivity tends to attract more people (especially skilled workers) into urban areas relative to non urban area. Puga (2009) argues that "skilled workers may also be drawn to urban areas, both because of higher urban wages, and also because of consumption externalities associated with urban life (e.g. theaters, restaurants, etc)."

A consumption externality is an externality generated by the consumption behavior of an economic actor who wants to maximize utility. Many regional economists have argued that people who prefer consuming a wide variety of goods may prefer living in large cities. They also argue that people who value product variety should be willing to work for lower wages in cities offering greater product variety [Gyourico and Tracy (1991), Blomqist et al (1987)]. The idea that workers would be willing to give up real wages to enjoy a city's consumption amenities is a central feature of a literature on the urban quality of life and its relationship to agglomeration economies. This argument indicates that the value that workers place on the opportunity to live in one city over another is measured by the difference in the real wage necessary for the worker to be indifferent between the two areas.

A study done by Tabuchi (1988) finds that indeed there is widespread evidence that a larger urban population (and increased population density) increases the variety of local goods and services available to consumers and that this explains why city density is sometimes correlated with lower wages; individuals tolerate a reduction in their real standard of living in denser cities if they are compensated by the existence of a wider array of local consumer services (restaurants, barbershops, theaters, etc) relative to less densely populated areas.

Glazer at el (2003) also find that consumer utility increases with the number of different goods available and increases more with an increase in the number of goods he prefers. They emphasize that, “such a preference can lead to urban agglomeration, a concentration of different types of consumers in different cities, an agglomeration of industries that use similar types of workers, and investment in facilities that attract customers of one type over another.” These authors’ observations suggest that when economies of scale limit the number of varieties of goods produced, an increase in the number of consumers who prefer the same class of goods can generate an externality.

They conclude that this cause of agglomeration has been analyzed theoretically and verified empirically.

A study by Mueser and Graves (1995) finds that locations that are attractive to households but unattractive to firms will have lower wages than elsewhere. They argues that, “ this follows from the fact that the labor supply to such a location would be greater than elsewhere, while the labor demand would be smaller than elsewhere. The net effect on population size and hence the demand for land is ambiguous in such locations.” They estimate a measure of the relative importance of job opportunity versus amenities in explaining migration patterns over the period 1950-1980 for U.S county aggregates. They find that the group coefficient for employment-related variables is between 0.13 and 0.28, while that for amenities is usually over 0.5. They therefore concluded that amenities play a more important role in explaining migration patterns.

Gehrig (1998) examines agglomeration economies which arise from economies of scope in consumer search. He argues that consumers prefer to search for product varieties in a large market where they are more likely to find their preferred variety. That in turn induces firms to locate next to their rivals. He explains that the concentration of the firms producing same or differentiated goods is the factor that brings about agglomeration. Agglomeration will come about because of more people and other firms will be attracted to this area.

Quigley (2006) argued that "theoretical models built along urban economies yield a remarkable conclusion that diversity and variety in consumer goods or in producer inputs can yield external scale economies. The size of the city and its labor force determine the number of specialized producer inputs, given the degree of substitutability among specialized inputs in production." He insists that, under reasonable assumptions, the utility of a household in the city will be positively related to the aggregate quantity of local goods it consumes and the number of types of these goods that are available in the economy. He stresses that "as long as the higher density of cities is associated with greater variety – in people, in goods, in services – there are some utility gains to those who value diversity. These gains compensate consumers for some or all of the increased location rents in cities." He concludes that a larger city will therefore have greater variety of consumer products and producer inputs. Since the greater variety adds to utility and to output, in these models larger cities are more productive, and therefore, the well-being of those living in cities increases with their size (also see Fujita and Thisse, 2002).

The literature on consumption externalities also looks at its effect on real wages. The literature argues that people who value product variety should be willing to work for lower wages in cities offering greater product variety. One example of such literature is the work by Getz and Huang (1978) who indeed find some evidence that increased availability of consumer goods reduces local wage rates. Furthermore, Tabuchi and Yoshida (2000) estimate economies of agglomeration arising when consumers can choose more suitable goods and services from a larger variety in 4 Japanese larger cities. They find that, in Japan, a doubling of a city's population reduces the real wage by 7 to 12 percent. Tabuchi and Yoshida (2000) conclude that urban agglomeration economies due to product varieties outweigh the agglomeration diseconomies due to congestion for households located in large cities.

Rosenthal and Strange (2002) examine the relationship between city size and wage, find that "if households prefer big cities because of amenities associated with big city life, this will work to raise rents and reduce wages in big cities. If firms find big city workers to be more productive, this works to raise wages and rents. If the household amenity effect is sufficiently large, this will lead to lower wages and higher rents in big cities, despite the existence of agglomeration economies. Of course, the empirical relevance of this point depends on the degree to which amenity and firm productivity effects are correlated."

The same argument about the relationship between consumer preference and lower wages in larger cities is supported by Blomqist et al (1987) who cite Rosen's fundamental insight that households will be attracted to areas where there are good buys, i.e. better combinations of amenities, wages and housing prices. Combinations will be more attractive the better the amenities, the higher the wages and the lower the housing prices. They continue to argue that households that choose to live in high amenity areas will pay for them with the combination of wages and housing prices that makes the high amenity areas more expensive. Households are forced to trade money for the better amenity bundles. The combination of lower wages and higher housing costs is an implicit premium, or the price households pay, for choosing an urban area with more attractive amenities. They conclude that, “it is this value of the local amenity bundle that economists call urban quality of life.”

Puga (2010) examines different methodologies that are used to quantify agglomeration economies. One of the methodologies he examines is the quantification of agglomeration economies through wages and rents. In looking at different approaches, he finds that a particular fruitful approach is to combine data on wages and rents following Roback’s 1982 work. He insists that the beauty of Roback’s framework is that it helps to disentangle the consumption amenities from the productive advantage of big cities. He argues that “for workers, higher wages make them better off, whereas higher rents make them worse off. Thus, greater consumption amenities in a city will make workers willing to accept lower wages and higher rents. For firms, both higher wages and higher rents means increased costs. Thus, localized productive advantages should be associated with higher rents.” He emphasizes that “consequently, both consumption amenities and productive advantages should be associated with higher rents. However, consumption amenities should be associated with lower wages, whereas productive advantages should be associated with higher rents. However this raises an additional concern when looking for agglomeration effects through wages. If big cities are associated with both better amenities and higher productivity, the net effect on wages may be ambiguous.”

This dissertation uses a Computable General Equilibrium (CGE) model to examine the economic impacts on the nominal and real wages and household income per capita when export demand and the level of consumption externalities (migration elasticity) are increased in two cities of different sizes in northern Colorado. The cities to be examined are Fort Collins (a thick labor market) and Loveland (a thin labor market).

I find that an increase in sector-specific export demand and level of migration elasticity increase nominal wages in all labor groups in each sector studied with only one exception. When the coefficient for migration elasticity is increased by 0.5, nominal wages decrease for labor group three in the retail sector in both cities. This study also finds that when the coefficient for migration elasticity is increased by 0.3, the real wage decreases for labor group two in the retail sector and when the coefficient for migration elasticity is increased by 0.5, the real wage decreases for labor groups two and three in the retail sector in Fort Collins. In Loveland (a thin labor market), when the coefficient for migration elasticity is increased by 0.3, real wages decrease for labor group three in all sectors. Real wages also decrease in all sectors when the coefficient for migration elasticity is increased by 0.5. Comparing the two cities, the results show that when the coefficient for migration elasticity is increased by 0.3 in the retail sector, the real wage results support consumption externalities theories in both cities.

## 5.2 MODEL SPECIFICATIONS

The second part of this study is to estimate the impact of consumption externalities on wages and household income. The study specially concentrates on the impacts on consumption externalities due to the fact that agglomeration literature emphasizes that the value that workers place on the opportunity to live in one city over another is measured by the difference in real wages necessary for the workers to be indifferent between the two areas.

In accomplishing this task, I am using different levels of migration elasticity to represent different levels of amenities in a city.  According to Glaeser et al (2000), there are four particularly critical urban amenities: (1) the presence of a rich variety of services and consumer goods (restaurants, theaters, and an attractive mix of social partners). These goods are hard to transport and are therefore local goods. (2) Aesthetics and physical setting: large cities may offer various aesthetic charms (i.e., the Los Angeles climate or Paris architecture). (3) Fiscal amenities: These are the results of state, local and federal government's actions. In large cities government may provide services such as roads and highway infrastructures, utilities, parks, recreation services and other services. Many government-provided goods and services require presence of consumption. In some cases, government or fiscal amenities may be related to agglomeration effect. (4) Speed: the range of services and jobs available in a metropolitan area is a function of the ease with which individuals can move around (social interactions).

In this study, amenities will represent the first type which is variety of services and goods. I regard migration elasticities that range from 0.5 to 1.0 to represent a high level of amenities in the city and migration elasticities that ranges from 0.4 and below to represent low amenities levels of a city.  In this study, I use two levels of migration elasticity. The first two levels are 0.1 and 0.3 that are considered low, and then I use 0.5 which I consider to be a high level of amenities. In the literature, consumption elasticities widely known are that of Tabuchi and Yoshida that ranges from 0.07 to 0.12.  I then compare how these different levels of amenities impact the nominal and real wages. The results are then compared across two cities. The analysis concentrates on the three productive sectors in each city. These sectors are manufacturing, high service and retail.

So far I am not aware of any studies that have examined impacts of agglomeration economies using micro data and the CGE model.

5.2.1 SETTING UP SIMULATIONS

A common way that has been used to try to understand agglomeration economies is to directly estimate the production function. However, the economists that use this method in estimating agglomeration economies are faced with a challenge concerning lack of input data especially capital.

Another approach of estimating agglomeration economies is to study wages. This approach utilizes the classical theory of income distribution that in a competitive market, inputs (labor and capital), are paid the value of their marginal products. The agglomeration literature argues that larger cities are more productive and therefore workers are paid higher wages [Glaeser and Mare (2001), Wheaton and Lewis (2002)].

In this study, when sector-specific export growth is increased, the sector's aggregate employment is expanded by 2.5 percent in both Fort Collins and Loveland. In the model, this is accomplished by increasing PWO in [equation (5-1) below] for a specific sector until aggregate employment increases by

$$CX_I = CX0_I * (PD_I (1 + \Sigma_{GK} TAUX_{GK,I}))/(PW0_I(1 + \Sigma_{GK} TAUQ_{GK,I})^{ETAE}{}_I; \quad (5\text{-}1)$$

Where sector export demand ($CX_I$) depends on the initial export demand ($CX_{0I}$), price movement relative to initial price (PD/PWO) and taxes charged on those exports (TAUX, TAUQ) and elasticity of export demand (ETAE). This increase in sales for exports shifts out the demand curve through the following equation in the factor market:

$$R_{F,I} * RA_F * (1 + \Sigma_{GF} TAUFX_{GF,F,I}) * FD_{F,I} = PVA_I * DS_I * ALPHA_{F,I}; \quad (5\text{-}2)$$

The above equation states that firms' expenditure on factors of production as the function of initial sector rental rate for factors ($R_{F,I}$), average rental rate ($RA_F$), labor taxes ($TAUFX_{GF,F,I}$) and factor demand ($FD_{F,I}$) should be equal to the revenue the firm gets from selling output domestically. Firm's revenue is determined by value added prices ($PVA_I$), sector's domestic supply (DSI) and relative share of factors ($ALPHA_{F,I}$).

Consumption externalities that are captured by migration elasticity are increased through the following equation:

$$\begin{aligned} HH_H = {} & HH0_H * NRPG_H * (DS/DS0)^{\pi} + MI0_H *[(YD_H / HH_H/(YD_{0H}/ HH_{0H}) \\ & / (CPI_H / CPI0_H)]^{ETAYD}{}_H * [(HN_H/ HH_H)/(HN_{0H}/ HH_{0H})]^{ETAU}{}_H \\ & - MO0_H *[(YD0_H/ HH0_H)/(YD_H/ HH_H))/ (CPI0H/CPI_H)]^{ETAYD}{}_H \\ & * (HN0_H/ HH0_H)/ (HN_H/HH_H)^{ETAU}{}_H; \qquad (5\text{-}3) \end{aligned}$$

Equation (5-3) above shows that the number of total households is determined by the base number of households in the city (HH0) times the natural rate of population growth (NRPGH) and real household income (YDH/CPIH). Also, total households are inversely related to the relative portion of non working households in the economy (HNH/HHH). Net migration and population growth in the model are the difference between changes in households after simulations and their base values. In the same equation, elasticities are presented by parameters ETAYD and ETAU. The migration elasticity is represented by in the equation. DS represents domestic supply of the consumer goods. We believe that as the values of increase, this will lead to more people being attracted to the city due to higher availability of consumer goods (amenities). In setting the simulations, the values of are then altered starting from 0.1, 0.3 and 0.5.

## 5.3 EMPIRICAL RESULTS

### 5.3.1 *FORT COLLINS*

Table 5.1 below represents the impacts of the consumption externalities on nominal and real wages in the city of Fort Collins. The results suggest that as the value of coefficient for migration elasticity increases, the nominal wages increase at a decreasing rate for the higher values (0.3, 0.5) compared to the lower value (0.1) in all three sectors. This can be explained by looking at the number of new households migrating into Fort Collins. Low level of migration elasticity leads to a smaller number of new households migrating to town. The numbers of households moving into town increases with the level of migration elasticity, implying more households are attracted to the city that has a higher level of amenities.

Within each sector, the nominal and real wage increases more for labor group one compared to the other two groups. In the manufacturing sector for example, when the coefficient for migration elasticity is increased by 0.1, the nominal wage for labor group one increases by 1.15 percent while it increases by 0.54 percent for the labor group three. The same pattern is observed when the coefficient of migration elasticity is increased by 0.3 and 0.5 respectively.

The results also show that real wages increase as the value for migration elasticity increases. However, the real wage increases more for labor group one compared to the other two groups. The real wage increases by 0.81 percent for labor group one when the coefficient for migration elasticity is increased by 0.1, while it increases by 0.64 and 0.21 percent for labor group two and three respectively. When the coefficient for migration elasticity is increased by 0.3, the same pattern is observed as when the migration elasticity was 0.1. The real wage for the labor group three decreases by 0.04 percent when the coefficient for migration elasticity is increased by 0.5. Results for labor group three support the agglomeration literature arguments that with higher amenities, workers are willing to accept lower real wages in order to enjoy the amenities that the city has to offer [see Tabuchi and Yoshida (2001, Rosenthal and Strange (2002), Blomqist (1987)]. The results for the high service sector show the same pattern as that observed in the manufacturing sector.

The results are a bit different in the retail sector. The nominal wage for labor group one increases significantly with an increase in the migration elasticity compared with other two groups. When the coefficient for migration elasticity is increased by 0.1, the nominal wage for labor group one increases by 1.55 percent, while increases by 0.07 and 0.03 percent for labor groups two and three respectively. When the coefficient for migration elasticity changes to 0.3, the nominal wage for labor group one increases to 1.52 percent, 0.04 percent for labor group two and does not increase for labor group three. When migration elasticity is increased to 0.5, the nominal wage for labor groups one and two increases by 1.48 and 0.02 percent, while it decreases by 0.04 percent for labor group three.

The real wage results show that when migration elasticity increases to 0.1, real wages increase only for labor group one. Real wages do not increase for labor group two and decrease for labor group three by 0.03 percent. When migration elasticity increases to

0.3, the real wage for labor group one increases by 1.45 percent and by 0.02 and 0.07 percent for labor group two and three respectively. The same pattern is observed when migration elasticity is increased by 0.5. The real wage for labor group two and three decreases supporting the agglomeration literature arguments that people are willing to accept lower wages in order to enjoy the amenities the city has to offer [Tabuchi and Yoshida (2000), Gehrig (1998), Getz and Huang(1978)].

The number of new households moving into town increases with the level of migration elasticity, indicating that as more goods and services (amenities) become available, more households move into the town [see Quigley (2006), Fujita and Thisse (2002)].

Table5.1: Impacts of different values of consumption externalities on nominal and real wages in Fort Collins

| *Sector* | *Variable* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | π=0.1 | 1.15% | 0.98% | 0.54% | 0.81% | 0.64% | 0.21% | 1.69% | 0.33% |
| | π=0.3 | 1.04% | 0.88% | 0.42% | 0.70% | 0.55% | 0.09% | 2.09% | 0.33% |
| | π=0.5 | 0�90% | 0.78% | 0.29% | 0.58% | 0.42 | -0.04% | 2.55% | 0.32% |
| High Service�s | π=0.1 | 0.80% | 0.49% | 0.48% | 0.62% | 0.31% | 0.31% | 0.96% | 0.17% |
| | π=0.3 | 0.76% | 0.46% | 0�45% | 0.59% | 0.29% | 0.27% | 1.07% | 0.17% |
| | π=0.5 | 0.72% | 0.43% | 0.41% | 0.55% | 0.26% | 0.23% | 1.20% | 0.17% |
| Retail | π=0.1 | 1.55% | 0.07% | 0�03% | 1.49% | 0.00% | -0.03% | 1.17% | 0.06% |
| | π=0.3 | 1.52% | 0.04% | 0.00 | 1.45% | -0.02% | -0.07% | 1.27% | 0.06% |
| | π=0.5 | 1.52% | 0.02% | -0.04% | 1.41% | -0.04% | -0.10 | 1.40% | 0.06% |

*5.3.2 LOVELAND RESULTS*

Table 5.2 represents the results on the impacts of consumption externalities on the nominal and real wage and household migration for the city of Loveland. The results show that when migration elasticity increases, nominal wages increase for all labor groups in the manufacturing and high service sectors. The increase in the nominal wage decreases with the level of migration elasticity. The nominal wage increases more for labor group one compared to groups two and three. In the manufacturing sector, when the coefficient for migration elasticity is set to 0.1 the nominal wage for labor group one increases by 1.10 percent, by 0.61 percent for labor group two and 0.34 for labor group three. The same pattern is observed in the high service sector.

The real wage also increases when the coefficient for migration elasticity is increased by 0.1 in all groups except labor group three. The real wage for all labor groups increases in the manufacturing and high services sectors, with that of labor group one increasing more. However, the real wage for the labor group three decreases with higher levels of migration elasticity ($\pi = 0.3$, $\pi = 0.5$) in the manufacturing sector and ($\pi = 0.5$) for the high services sector. The decrease in real wages after increase in migration elasticity supports the Tabuchi and Yoshida's (2000), Rosenthal and Strange's (2002), Blomiqist's (1987) findings. However,the percentage decrease is low in this study compared to other studies because the city size is increased by 2.5 percent instead of double the size.

In the retail sector, as the migration elasticity increases, the nominal wage increases for labor groups one and two but not for labor group three. The percentage increase in the nominal wages for labor groups one and two do not differ significantly. When they migration elasticity is increased by 10 percent, the nominal wage for labor group one increases by 0.78 percent while that of group two increases by 0.80 percent. However, the nominal wage for labor group three does not increase.

When migration elasticity is increased by 0.3, the nominal wage for labor group one increases by 0.76 percent and the nominal wage for labor group two increases by 0.77 percent. The nominal wage decreases by 0.02 percent for labor group three. An increase of migration elasticity from 0.3 to 0.5 does not change the results for the three labor groups.

Table 5.2 Impacts of different values of Consumption Externalities on the nominal and real wages in Loveland

| *Sector* | *Variable* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New HHs* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | π=0.1 | 1.10% | 0.61% | 0.34% | 0.88% | 0.39% | 0.12% | 0.68% | 0.20% |
| | π=0.3 | 0.99% | 0.50% | 0.20% | 0.78% | 0.29% | -0.01% | 1.03% | 0.20% |
| | π=0.5 | 0.86% | 0.38% | 0.04% | 0.66% | 0.17% | -0.16% | 1.44% | 0.20% |
| High Services | π=0.1 | 1.11% | 0.38% | 0.24% | 0.95% | 0.22% | 0.08% | 0.53% | 0.20% |
| | π=0.3 | 1.06% | 0.33% | 0.17% | 0.90% | 0.17% | 0.01% | 0.72% | 0.20% |
| | π=0.5 | 0.99% | 0.27% | 0.09% | 0.84% | 0.11% | -0.06% | 0.94% | 0.20% |
| Retail | π=0.1 | 0.78% | 0.80% | 0.00% | 0.62% | 0.63% | -0.16% | 0.35% | 0.20% |
| | π=0.3 | 0.76% | 0.77% | -0.02% | 0.60% | 0.61% | -0.19% | 0.42% | 0.20% |
| | π=0.5 | 0.73% | 0.75% | -0.06% | 0.57% | 0.58% | -0.22% | 0.52% | 0.20% |

The nominal wage for labor groups one and two increases by 0.73 and 0.75 percent respectively, while that of labor group three decreases by 0.06 percent. The group three's results indicate the increased labor supply of skilled workers relative to demand.

The fact that the increase in the nominal wages does not differ significantly from one level of migration elasticity to another in the retail sector, can be attributed to the migration pattern of households into Loveland when this sector is expanded. When the coefficient for migration elasticity is increased by 0.1, 0.35 percent of new households migrate to Loveland. When migration elasticity increases to 0.3, 0.42 percent of households move into town, and when the migration elasticity is increased to 0.5, 0.52 percent of new households move into town. The percentage of new households migrating to Loveland is therefore lower when the retail sector is expanded relative to manufacturing and high services sectors.

The real wage for labor groups one and two increases at almost the same proportion at each level of migration elasticity. However, the real wage for labor group three decreases in all levels of migration elasticity. The real wage for labor group three decreases by 0.16 percent when the migration elasticity increases by 0.1, and decrease by 0.19 percent when migration elasticity increases by 0.3. When migration elasticity increases by 0.5, this leads to a decrease of 0.22 in the real wages of labor group three. The labor three results support agglomeration literature argument that real wage decreases with the increase in amenities [Tabuchi and Yoshida (2000), Rosenthal and Strange (2002), Blomiqist (1987)].

## 5.4 CONCLUSION:

I find that an increase in sector-specific export demand and level of migration elasticity increases nominal wages in all labor groups in each sector studied with only one exception. When the coefficient of migration elasticity increases to 0.5, the nominal wage decreases for labor group three in the retail sector in both cities.

This study also finds that when migration elasticity increases to 0.3, real wages decrease for labor group two in the retail sector, and when migration elasticity increases to 0.5, the real wage decreases for labor groups two and three in the retail sector in Fort Collins. In Loveland, the thin labor market, when migration elasticity increases to 0.3, the real wage decreases for labor group three in all sectors. The real wages also decrease in all sectors when the coefficient for migration elasticity increases to 0.5. Comparing the two cities, nominal wages increases more in Fort Collins than in Loveland with very few exception of labor group two in the retail sector where the nominal wages seems to increase more in Loveland than in Fort Collins. The fact that the nominal wages increases more in Fort Collins than Loveland supports Quigley (2006) and Fujita and Thisse (2002) who argued that well being increase with the city size. The results also show that when the coefficient of migration elasticity increases to 0.3 in the retail sector, the real wage results support consumption externalities theories in both cities.

REFERENCES


de Groot, H.L.F., and R. Nahuis (1998**), "**Taste for diversity and the optimality of economic growth," *Economics Letters* 58: 291–295.

Gehrig, T. (1998), "Competing cities," *European Economic Review* 42: 277–310.

Getz, M., Huang, Y.(1978), "Consumer revealed preference for environmental Goods," *Review of Economics and Statistics* 60: 449–458.

Glazer, A., M Gradstein and P. Ranjan (2003), "Consumption variety and urban Agglomeration," *Regional Science and Urban Economics* 33: 653-661.

Ogawa, H. (1998), "Preference for product variety and city size," *Urban Studies* 35:45–51.

Quigley, J. (1998), "Urban diversity and economic growth," *Journal of Economic Perspectives* 12: 127–138.

Rivera-Batiz, F.L., 1988. Increasing returns, monopolistic competition, and agglomeration economies in consumption and production. *Regional Science and Urban Economics* 18: 125–153.

Stahl, K. (1983), "A note on the microeconomics of migration," *Journal of Urban Economics* 14: 318–326.

Tabuchi, T. (1998), "Urban agglomeration and dispersion: a synthesis of Alonso and Krugman," *Journal of Urban Economics* 44: 333–351.

Tabuchi, T. and A. Yoshida, (2000), "Separating urban agglomeration economies in consumption and production," *Journal of Urban Economics* 48: 70–84.

Rosenthal S.S and W.C. Strange (2002), "Evidence on the Nature and Sources of Agglomeration Economies," *The Handbook of Urban and Regional Economics*, Vol. 4.

Mueser P. and P. Graves (1995), "Examining the Role of Economic Opportunity and Amenities in Explaining Population and Redistribution," *Journal of Urban Economics,* 37: 176-200.

# 6. ECONOMIC IMPACTS OF PRODUCTION AND CONSUMPTION EXTERNALITIES ON NOMINAL AND REAL WAGES

## 6.1 INTRODUCTION

This study uses a computable general equilibrium model to explore the economic impacts of production and consumption externalities on wages in two cities of different sizes in northern Colorado. The cities explored are Fort Collins, which is larger with a thick labor market and Loveland which is smaller with a thin labor market.

Agglomeration economies are externalities in production and consumption which depend on population size, spatial structure and possibly the age of the city. Previous literature on agglomeration economies is divided into two sides. One strand of the literature attempts to study the presence and effects of production externalities and their relationship to either city or industry size [(Sveikauskas (1988), Nakamura (1985), Henderson (1986, 2003), Ciccone and Hall (1986) and Ciccone (2002), Graham (2007), etc].

On the other hand, very few studies have attempted to explore the presence and effects of consumption externalities and their relationship to the city and industry size [(Glazier et al (2002), Ogawa (1988), Getz and Huang (1978), Tabuchi (1998), Rivera-Batiz (1988) etc]. Carlino and Saiz (2008) argue that "past studies have provided only indirect evidence for the importance of consumer amenities. Typically, studies have relied on implicit valuations of urban amenities estimated using a Rosen-Roback reduced-form approach." They insist that "a number of other studies have calculated residuals in a rent-wage regression and related them to city size or growth [Tabuchi and Yoshida (2000), Asashi, Hikino and Kanemoto (2008)]. On balance, these studies suggest that, while productivity is higher in larger cities, peoples' taste for urban amenities and variety is an important factor accounting for the concentration of population in cities". Carlino and Saiz

(2008) stressed that “a greater variety of consumption amenities is especially attractive to households as their wealth increases.”

So far, only Tabuchi and Yoshida (2000), using a general equilibrium model, estimated the economies of agglomeration arising due to simultaneous consumption and production externalities in Japan. They find that in Japan, a doubling of a city’s population increases the nominal wage by approximately 10 percent but reduces the real wage by approximately 7 to 12 percent. They claimed that “the 10 percent increase in the nominal wage is attributed to the productivity increase in the production activities while the 7-12 percent decrease in the real wage is the compensation for the net agglomeration economies which are the benefit from the product variety minus the cost of congestion.” By doing that, they separated the net agglomeration economies on the production side from those on the consumption side.

The more recent study that incorporates both the production and consumption side is by Dalmazzo and deBlasio (2007), who did an empirical study to explore the impacts of production and consumption externalities on human capital in Italy. They argue that “production and consumption externalities have a positive effect on rents while having an ambiguous effect on local wages.” They claim that, “the reason is that local productivity and local utility have opposing effects on local wages. On one hand, human capital spillovers raise local wages by increasing local productivity. But on the other hand, local wages tend to fall when human capital has positive spillovers on utility.” They emphasize that, “the reason is that individuals may be willing to accept lower wages to live in areas where high-average education significantly improves the quality of life.” The difference between Dalmazzo and deBlasio’s (2007) work and this study is that, I was not able to collect human capital data although informally Fort Collins's population is said to be more educated than Loveland's. So their study basically suggests that consumption and production externalities tend to offset each other in local wage determination.

This paper proceeds as follows; the third section will discuss setting up the model, the fourth section will present simulation results and discussion and section five presents the conclusion.

## 6.2 SETTING THE MODEL:

Following previous studies on production externalities [Aberg (1973), Moomaw (1981, 1985), Segal (1976)], this study uses an approach that views production advantage as operating through the efficiency parameter of the production function. Fogarty and Garofalo (1988) explained that "usually the efficiency parameter is assumed to be a function of population size which is intended to capture urbanization economies or economies of agglomeration that are function of the urban scale."

Following Fogarty and Garofalo's (1988) approach to measure the production externalities, this paper uses following equation:

$$DS_I = DELTA_I * \sum_H (HH_H / HH0_H)^{\beta} * \Pi F(FD_{F,I}{}^{ALPHA_{F,I}}) \qquad (6\text{-}1)$$

In the above equation, DS represents domestic supply which, depends on DELTA; the production function scale. The term $\sum_H (HH_H/HH0_H)^{\beta}$ represents how the number of households changes when productivity increases and $\beta$ represents productivity externalities. When the value of $\beta$ is altered, productivity externalities are either increased or decreased depending on the direction of the change in $\beta$. $\Pi_F$ is the function that represents factor demands (FD) and ALPHA is the relative share of the factors.

In this paper, the values of $\beta$ are altered between 0.1 and 0.3. These elasticities are chosen following Graham (2007) who conducted a meta-analysis on the various studies that were done to estimate agglomeration economies. He finds that "the estimates of urbanization economies on manufacturing industries range from 0.01 and 0.2 but the majority of values are under 0.1". He concluded that those results indicate that a doubling of city size is typically associated with an increase in productivity of somewhere between 1 percent and 10 percent. The weighted average elasticity for the service sector is 0.186 which indicates that a doubling of a population is associated with an increase in productivity of just under 20 percent. The value of 0.3 is chosen to extend Graham's range and see if there will be any significant impacts on nominal and real wages and household income per capita.

On the other hand, the consumption externalities are represented in the model by the following migration equation:

$$HH_H = HH0_H * NRPG_H * (DS/DS0)^{\pi} + MI0_H *[(YD_H / HH_H/(YD_{0H}/ HH_{0H}) / (CPI_H / CPI0_H)]^{ETAYD}{}_H * [(HN_H/ HH_H)/(HN_{0H}/ HH_{0H})]^{ETAU}{}_H - MO0_H *[(YD0_H/ HH0_H)/(YD_H/ HH_H))/ (CPI0H/CPI_H)]^{ETAYD}{}_H * (HN0_H/ HH0_H)/ (HN_H/HH_H)^{ETAU}{}_H; \qquad (6\text{-}2)$$

Equation (6-2) above is the household migration equation. The equation shows that the number of households depends on the natural rate of population growth (NRPG) and domestic supply of goods and services (DS), we know that generally a larger population leads to a higher level of demand for goods and services. Household migration also depends on workers that are commuting in (MI0) and commuting out (MO0). The equation also shows that household migration is a function of the real household income (YD) and HN, which is the symbol for non-working households. CPI is the price index and $\pi$ is migration elasticity with respect to amenities. The simulation is set to reflect the importance of domestic supply on migration. The change in the level of migration elasticity reflects the change in domestic supply of goods. The increased domestic supply indicates that there is an increase in demand for a variety of goods and services offered domestically. The increase in variety attracts more people to migrate into the town.

In order to capture the consumption externalities, the coefficient for migration elasticity ($\pi$) is set first at 0.07 and then increased to 0.12. The value of migration elasticity follows Tabuchi and Yoshida's (2000) argument that doubling the city size causes the real wage in Japan to decrease by 7 to 12 percent due to consumption externalities. Their study also finds that doubling the city size leads to a 10 percent increase in the nominal wage due to increased production externalities. When the values to capture production and consumption externalities are set, then the export demand function of each sector is expanded individually from the normalized value of 1 until the aggregate city employment increases by 2.5 percent (1000 workers in Fort Collins and 422 in Loveland). The results of each city are analyzed first, and then those results are compared across the two cities.

Employment growth can be divided into two types: export growth and local growth (capital migration). Employment growth through exports results from an increase in external demand that shifts out the sector's demand curve. The sector increases its factors of production, including land and labor, in order to meet demand for the increased production. This type of growth not only increases quantity of goods to be exported, but also puts upward pressure on prices of outputs and that of factors of production.

In this study, sector specific export demand is also increased simultaneously with consumption and production externalities. When sector-specific export growth is increased, the sector's aggregate employment is expanded by 2.5 percent in both cities of Fort Collins and Loveland. In the model, this is accomplished by increasing PWO in [equation (6-3) below] for a specific sector until aggregate employment increases by 1,000 additional workers in Fort Collins and 422 in Loveland.

$$CX_I = CX0_I * (PD_I (1 + \Sigma_{GK} TAUX_{GK,I}))/(PW0_I(1 + \Sigma_{GK} TAUQ_{GK,I})^{ETAE}{}_I; \quad (6\text{-}3)$$

Where sector export demand ($CX_I$) depends on the initial export demand ($CX_{0I}$), price movement relative to initial price (PD/PWO), taxes charged on exports (TAUX, TAUQ) and elasticity of export demand (ETAE). This increase in sales for exports shifts out the factor demand curve through the following equation in the factor market:

$$R_{F,I} * RA_F * (1 + \Sigma_{GF} TAUFX_{GF,F,I}) * FD_{F,I} = PVA_I * DS_I * ALPHA_{F,I}; \quad (6\text{-}4)$$

This equation states that firms' expenditure on factors of production as the function of initial sector rental rate for factors ($R_{F,I}$), average rental rate ($RA_F$), labor taxes ($TAUFX_{GF,F,I}$) and factor demand ($FD_{F,I}$) should be equal to the revenue the firm gets from selling output domestically which is the function of value added prices ($PVA_I$), sector's domestic supply (DSI) and relative share of factors ($ALPHA_{F,I}$).

## 6.3 EMPIRICAL RESULTS

### 6.3.1 *FORT COLLINS RESULTS*

#### *6.3.1.1 PRODUCTIVITY COEFFIENT INCREASES BY 0.1*

Table 6.1 presents the results on a simultaneous increase on production and consumption externalities on nominal and real wages for three sectors in the city of Fort Collins. The results show that, when the coefficient for production externalities increases by 0.1 and the consumption externalities coefficient increases by 0.07 simultaneously, nominal and real wages increase for all labor groups in Fort Collins. The increase in the nominal wages supports Tabuchi and Yoshida's findings, while those of real wages do not support their findings which argue that the real wage tends to decrease with the increase in the city size and amenities.

The results for the retail sector are a bit different from other two sectors. The nominal wage increases by 1.54 percent for labor group one and increases by 0.08 percent and 0.06 percent for labor groups two and three, respectively. There is no significant difference between the percentage change in the nominal wage and the real wage in the retail sector due to a small change in the CPI. The real wage increases by 1.52 percent for labor group one; it increases by 0.06 percent for labor group two and 0.04 percent for labor group three. Increasing production and consumption externalities in the retail sector leads to a 0.02 percent increase in the CPI. About 1.35 percent of new households migrate to Fort Collins.

When the coefficient of consumption externalities increases by 0.12, the nominal and real wages increase, but at a decreasing rate compared to when the coefficient of consumption externalities increases by 7 percent. In all three sectors, the results show that the number of new households increases with the level of consumption externalities supporting the agglomeration economies theories [Fujita and Thiesse (2002), Quigley (2006)]. As an example in the manufacturing sector, the number of new households increases by 2.34 percent when the coefficient for consumption externalities increases by 0.12, compared to 1.94 percent when consumption externalities are increased by 0.07. The higher percentage increase in new households migrating into the city reflects the fact that, as a city's amenities increase, more people will be attracted to the city.

Table 6.1: Impacts of Sector-Specific export demand expansion, Production and Consumption Externalities on nominal and real wages in Fort Collins.

| *Sector* | *Production Externalities* | *Consumption Externalities* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | β=0.1 | π=0.07 | 1.16% | 0.99% | 0.60% | 0.88% | 0.72% | 0.32% | 1.94% | 0.27% |
| | | π=0.12 | 1.09% | 0.90% | 0.48% | 0.83% | 0.64% | 0.23% | 2.34% | 0.25% |
| High Service | β=0.1 | π=0.17 | 0.80% | 0.49% | 0.50% | 0.66% | 0.35% | 0.36% | 1.09% | 0.14% |
| | | π=0.12 | 0.78% | 0.47% | 0.46% | 0.64% | 0.34% | 0.32% | 1.21% | 0.13% |
| Retail | β=0.1 | π=0.07 | 1.54% | 0.08% | 0.06% | 1.52% | 0.06% | 0.04% | 1.35% | 0.02% |
| | | π=0.12 | 1.50% | 0.06% | 0.03% | 1.48% | 0.05% | 0.01% | 1.49% | 0.01% |

The results show that when the coefficient of production externalities (0.1) is higher than that of consumption externalities (0.07), the nominal and real wages increase. This shows that higher productivity outweighs the consumption externalities effect. Increased productivity means that firms are also producing more output at lower cost, and this can contribute to lower output price. Real wages depend on the level of the general prices. Results show that the general price level (measured by the CPI) increases (for example 0.2 percent for the manufacturing sector), but relatively less compared to the increase in nominal wages; this can contribute to the increase in real wages.

When the coefficient for production externalities (0.1) is almost at the same level as that of consumption externalities (0.12), nominal and real wages increase, indicating that the productivity effect outweighs the consumption effect. However, the percentage change in wages is lower compared to when the consumption externalities were lower. The number of new households increases with the level of consumption externalities, supporting the agglomeration literature.

#### *6.3.1.2 PRODUCTION EXTERNALITIES INCREASE BY 0.2*

In order to explore further the effect of increased productivity, the coefficient for production externalities is increased by 0.2, while that for consumption externalities is increased by 0.07. Table 6.2 below presents the results. The results show that nominal and real wages increase in all three sectors. The percentage change in nominal and real wages is not significantly different compared to when the coefficient for production externalities is increased by 0.1. In the manufacturing sector for example, when the coefficient for production externalities is increased by 0.2 and that of consumption externalities increased by 0.07, the nominal wage for labor group one increases by 1.14 percent (compared to 1.16 percent when the coefficient of production externalities is set at 0.07). The nominal wage increases by 0.99 percent (the same as when the coefficient for production externalities is set at 0.1) and 0.65 percent (compared to 0.60 percent) for labor groups two and three respectively. This increase in production and consumption externalities attracts about 2.43 percent of new households to Fort Collins, while it increases prices by 0.2 percent. Real wages increase a bit more compared to when the coefficient for production externalities is increased by 0.1. The pattern of results for the high services sector is not different from that of the manufacturing sector.

In the retail sector, the nominal wage increases by 1.50 percent for labor group one and does not increase much for labor groups two (0.09 percent) and three (0.10 percent). The real wage in the retail sector increases more than the nominal wage due to decreases in the CPI. The real wage increases by 1.55 percent for labor group one, 0.14 percent for the labor group two and increases by 0.15 percent for labor group three. About 1.66 percent of new households migrate into town following an increase in production and consumption externalities, and prices decrease by 0.1 percent.

When the coefficient for consumption externalities increases by 0.12 while the coefficient of production externalities is fixed at 0.2, nominal and real wages and prices increase in all sectors but the increase was less with the increased level of consumption externalities. In the manufacturing sector, the nominal wage for labor group one increases by 1.11 percent, it increases by 0.96 percent for labor group two and by 0.62 percent for labor group three. The real wage increases by 0.94 percent for labor group one, while it increases by 0.80 percent and 0.46 percent for labor groups two and three respectively.

Increased productivity and amenities attracts about 2.62 percent of new households, causing prices to increase by 0.2 percent.

The results show that nominal and real wages increase because of the increased productivity. According to the classical theory of income distribution, real wage is equal to marginal productivity of labor. As the productivity increases, the marginal productivity of labor also increases leads to an increase in the real wage. However according to the agglomeration literature, the real wage declines with the increased amenities, in this case the productivity effect outweighs the amenity effect, and therefore the net agglomeration effect is higher nominal and real wages in all sectors of the economy.  In the retail sector, real wages increase more than nominal wages. This is due to the fact that in the retail sector, when productivity increases, excess supply of output might have caused a downward pressure on output prices and this leads to a fall in the CPI. The fall in the CPI causes the real wages to increase more than the nominal wages.

Table 6.2: Impacts of Sector-Specific export demand expansion, Production and Consumption Externalities on nominal and real wages in Fort Collins.

| *Sector* | *Production Externalities* | *Consumption Externalities* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | β=0.2 | π=0.07 | 1.14% | 0.99% | 0.65% | 0.96% | 0.80% | 0.48% | 2.43% | 0.20% |
| | | π=0.12 | 1.11% | 0.96% | 0.62% | 0.94% | 0.81% | 0.46% | 2.26% | 0.20% |
| High Service | β=0.2 | π=0.17 | 0.80% | 0.50% | 0.52% | 0.71% | 0.40% | 0.43% | 1.31% | 0.10% |
| | | π=0.12 | 0.78% | 0.49% | 0.51% | 0.70% | 0.40% | 0.15% | 1.37% | 0.10% |
| Retail | β=0.2 | π=0.07 | 1.50% | 0.09% | 0.10% | 1.55% | 0.14% | 0.14% | 1.69% | -0.10% |
| | | π=0.12 | 1.49% | 0.08% | 0.09% | 1.54% | 0.13% | 0.13% | 1.73% | -0.10% |

6.3.1.3 *PRODUCTIVITY COEFFIENT INCREASES BY 0.3*

Table 6.3 presents the results when the coefficient for production externalities increases by 0.3 and the coefficient for consumption externalities increases by 0.07. The results showed mixed impacts on the three sectors. In the manufacturing sector, the nominal wage for labor group one increases by 1.05 percent. The nominal wage increases by 0.97 percent for labor group two and that of labor group three increases by 0.78 percent. The real wage increases more for all labor groups compared to the nominal wage. The real wage increases by 1.08 for labor group one; by 1.00 percent for labor group two and 0.81 percent for labor group three. About 3.59 percent new households migrate into town, while prices decrease by 0.03 percent. The real wage increases more than the nominal wage due to the fact that as productivity increases, the domestic supply of goods and services increases. The increased supply causes a downward pressure on prices of domestically produced goods and services, which leads to increased purchasing power in the economy and therefore higher real wages than nominal wages. The same pattern is observed in the retail sector where real wage increases more due to decreased price level.

In the high service sector, the nominal wage increases by 0.79 percent for labor group one, 0.50 percent and 0.56 percent for labor groups two and three respectively. The real wage increases by 0.77 percent for labor group one and 0.48 percent for labor group two. For labor group three, the real wage increases by 0.55 percent. About 1.67 percent of new households are attracted into Fort Collins, while prices increase by 0.01 percent. Comparing the percentage change in the nominal wage and real wage, results observed show no significant difference between the two wages because of a smaller change in prices.

Table 6.3: Impacts of Sector-Specific export demand expansion, Production and Consumption Externalities on nominal and real wages in Fort Collins.

| *Sector* | *Production Externalities* | *Consumption Externalities* | *Nominal Wage 1* | *Nominal Wage2* | *Nominal Wage3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | β=0.3 | π=0.07 | 1.05% | 0.97% | 0.78% | 1.08% | 1.00% | 0.81% | 3.59% | -0.03% |
| | | π=0.12 | 1.00% | 0.93% | 0.76% | 1.08% | 1.01% | 0.84% | 4.04% | -0.10% |
| High Service | β=0.3 | π=0.07 | 0.79% | 0.50% | 0.56% | 0.77% | 0.48% | 0.55% | 1.67% | 0.10% |
| | | π=0.12 | 0.77% | 0.48% | 0.54% | 0.77% | 0.48% | 0.54% | 1.77% | 0.01% |
| Retail | β=0.3 | π=0.07 | 1.43% | 0.10% | 0.17% | 1.60% | 0.27% | 0.34% | 2.23% | -0.17% |
| | | π=0.12 | 1.40% | 0.09% | 0.16% | 1.59% | 0.27% | 0.35% | 0.37% | -0.20% |

When the coefficient for consumption externalities is increased by 0.12 that for production externalities increased by 0.3, nominal wages for all labor groups increase by a smaller amount compared to previous levels of production and consumption externalities. In the manufacturing sector, however, the difference is insignificant. The nominal wage increases by 1.00 percent for labor group one and 0.93 percent for labor group two. The nominal wage increases by 0.76 percent for labor group three in the manufacturing sector.

The real wage increases more than the nominal wage due to the fact that an increase in productivity and amenities leads to the fall in price by 0.1 percent. The nominal wage for labor group one increases by 1.08 percent, by 1.01 percent for labor group two and 0.84 percent for labor group three. The number of new households migrating into town increases by 4.04 percent.

In the high service sector, the nominal wage for all labor groups increases at a decreasing rate with the increased level of consumption externalities. The real wage increases at the same level as nominal wage due to the fact that the price level did not change with the increased level of amenities. New households migrating into town increase by 1.77 percent.

The nominal wage increases by 1.40 percent for labor group one in the retail sector. For labor group two, the nominal wage increases by 0.09 percent, while it increases by 0.16 percent for labor group three. The real wage in the retail sector increases by 1.59 percent for labor group one while increases 0.27 percent for labor group two and 0.35 percent for labor group three. The new households migrating into town increase by 2.37 percent, while the price decreases by 0.2 percent. Compared with other sectors, this drop in prices is the highest, causing real wages to increase more than nominal wages. The decrease of the CPI indicates that production externalities outweigh the consumption externalities effect and therefore cause the price level to decrease due to increased supply of output.

### *6.3.2 LOVELAND RESULTS*

The results for Loveland followed the same pattern as those observed for Fort Collins. When the production externalities coefficient increases by 0.1 and the consumption externalities coefficient increases by 0.07, the nominal and real wages increase in all sectors, with the exception of the real wage for labor group three in the retail sector. The real wage results in Loveland support Carlino and Saiz (2008) who argue that “a greater variety of consumption amenities is especially attractive to household as their wealth increases”.

In the manufacturing sector, the nominal wage increases by 1.10 percent for labor group one; 0.60 percent for labor group two and 0.34 percent for labor group three. The real wage also followed the same pattern as the nominal wage, with that of group one increasing more than that of the other two groups. The real wage for labor group one increases by 0.91 percent, 0.40 percent and 0.15 percent for labor groups two and three respectively. Increased productivity and amenities attract about 0.70 percent of new households into Loveland, while prices increase by 0.19 percent.

In the high services sector, the nominal wage for labor group one increases by 1.12 percent, 0.37 percent for labor group two and increases by 0.24 percent for labor group three. The real wage increased by 0.97 percent for labor group one, by 0.23 percent for labor group two, and by 0.10 percent for labor group three. This expansion of the high service sector attracts 0.57 percent of the new households into town, and prices as measured by CPI increase by 0.14 percent.

In the retail sector, the nominal wage for labor groups one and two increases by the same percentage (0.79) and does not increase at all for labor group three (0.00 percent). The real wage increases by 0.63 percent for labor group one while it increases by 0.64 percent for labor group two. The real wage decreases for labor group three by 0.15 percent. Results for the labor group three support what the agglomeration literature suggests: when production and consumption externalities are increased simultaneously, the net agglomeration results show that the real wage decreases. The skilled workers are willing to sacrifice their wages for the amenities the city has to offer. As the result of increased agglomeration economies, about 0.38 percent of new households are attracted to town.

When the consumption externalities level increases from 7 percent to 12 percent while maintaining the level of production of 0.1, the nominal and real wages increase in all sectors, with exception of the real wage for labor group three in the retail sector which decreases. However, the increase in wages is less relative to the wage increase when the coefficient for consumption externalities increases by 7 percent.

In the manufacturing sector, the nominal wage increases by 1.08 percent for labor group one, while it increases by 0.57 percent and 0.30 percent for labor groups two and three respectively. The real wage increases by 0.89 percent by labor group one, by 0.38 percent for labor group two and by 0.12 percent for labor group three. The number of new households migrating into the city increases by 0.80 percent, and prices increase by the same percentage as when the coefficient for consumption externalities increases by 7 percent.

In the high service sector, the nominal wage increases by 0.79 percent for labor group one, while it increases by 0.36 percent for labor group two and 0.22 percent for labor group three. The real wage results follow the same pattern as nominal wage results, with that of labor group one increasing by 0.96 percent, while it increases by 0.22 percent and 0.08 percent for labor groups two and three respectively. New households attracted to the city increase by 0.67 percent, and the prices increase at the same percentage as when the level of consumption externalities increases by 7 percent.

In the retail sector, the nominal wage increases by 0.78 percent for labor groups one and two, while it decreases by 0.01 percent for labor group three which is insignificant. The same pattern is observed for the real wage results, where the real wages of labor groups one and two increase at the same percentage (0.63), while they decrease for labor group three by 0.16 percent. The decrease in real wage for labor group three supports the agglomeration literature; some workers are willing to accept low real wages for the amenities in a city. About 0.40 percent of new households are attracted to the city, and the price index (CPI) increases by 0.15 percent.

Table 6.4: Impacts of Sector-Specific export demand expansion, Production and Consumption Externalities on nominal and real wages in Loveland.

| *Sector* | *Production Externalities* | *Consumption Externalities* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | β=0.1 | π=0.07 | 1.10% | 0.60% | 0.34% | 0.91% | 0.40% | 0.15% | 0.70% | 0.10% |
| | | π=0.12 | 1.08% | 0.57% | 0.30% | 0.89% | 0.38% | 0.12% | 0.80% | 0.10% |
| High Service | β=0.1 | π=0.07 | 1.12% | 0.37% | 0.24% | 0.97% | 0.23% | 0.10% | 0.57% | 0.10% |
| | | π=0.12 | 1.10% | 0.36% | 0.22% | 0.96% | 0.22% | 0.08% | 0.62% | 0.10% |
| Retail | β=0.1 | π=0.07 | 0.79% | 0.79% | 0.00% | 0.63% | 0.64% | -0.15% | 0.38% | 0.10% |
| | | π=0.12 | 0.78% | 0.78% | -0.01% | 0.63% | 0.63% | -0.16% | 0.40% | 0.10% |

*6.3.2.2 PRODUCTIVITY COEFFIENT INCREASES BY 0.2*

Table 6.5 below presents the effects of production and consumption externalities on nominal and real wages when production externalities are set at 0.2 and consumption externalities is set at 0.07 and at 0.12.

When the coefficient for production externalities increases by 0.2, while that of consumption externalities increases by 0.07, the nominal and real wages increase for all labor groups in the manufacturing and high services sectors in Loveland. The nominal and real wage also increases in the retail sectors, but those of labor group three decreases.

I will discuss the results for the retail sector in detail. In the retail sector, the nominal wages for labor groups one and two increases, while that of labor group three decreases. The nominal wage increases by 0.79 percent for labor group one and by 0.78 percent for labor group two. The nominal wage decreases by 0.01 percent for labor group three. The percentage change for the real wage follows the nominal wage's pattern. The real wage for labor group one increases by 0.65 percent and increases by 0.64 percent for labor group two. However, the real wage for labor group three decreases by 0.14 percent. Results for labor group three's real wage support the agglomeration economies literature arguments. Increased productivity and amenities lead to a 0.43 percent increase in new households into town. The prices increase by 0.1 percent.

The mixed results between nominal and real wages support Dalmazzo and DeBlasio (2007), who argues that production and consumption externalities have positive effects on rents while having an ambiguous effect on local wages due to the fact that local productivity and local utility have opposing effects on local wages.

When the level of consumption externalities is increased by 0.12 and production externalities coefficient remains at 0.2, the nominal wage increases a bit less than when the consumption externalities coefficient was 0.07 for all labor groups in all three sectors. The real wage also follows the same pattern as the nominal wage.

Table 6.5: Impacts of Production and Consumption Externalities on Nominal and Real Wages in Loveland

| *Sector* | *Production Externalities* | *Consumption Externalities* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | β=0.2 | π=0.07 | 1.09% | 0.57% | 0.32% | 0.93% | 0.41% | 0.16% | 0.79% | 0.20% |
| | | π=0.12 | 1.06% | 0.53% | 0.28% | 0.91% | 0.38% | 0.13% | 0.91% | 0.10% |
| High Service | β=0.2 | π=0.07 | 1.11% | 0.35% | 0.23% | 0.99% | 0.24% | 0.11% | 0.65% | 0.10% |
| | | π=0.12 | 1.10% | 0.33% | 0.20% | 0.99% | 0.22% | 0.09% | 0.72% | 0.10% |
| Retail | β=0.2 | π=0.07 | 0.79% | 0.78% | -0.01% | 0.65% | 0.64% | -0.14% | 0.43% | 0.10% |
| | | π=0.12 | 0.78% | 0.77% | -0.02% | 0.65% | 0.64% | -0.15% | 0.46% | 0.10% |

*6.3.2.3 PRODUCTIVITY COEFFIENT INCREASES BY 0.3*

When the coefficient for the production externalities increases by 0.3 and the coefficient for consumption externalities increases by 7 percent, the nominal and real wages increase in all labor groups for manufacturing and high service sectors. The nominal and real wages decrease for labor group three in the retail sector. The nominal wage increases more for labor group one than labor groups two and three.

The nominal wage increases by 1.08 percent for labor group one, while it increases by 0.53 percent and 0.29 percent for labor groups two and three respectively in the manufacturing sector. The real wage increases by 0.96 percent for labor group one, 0.41 percent for labor group two and 0.17 percent for labor group three. About 0.91 percent of new households migrate into the city, and prices increase by 0.1 percent.

In the high service sector, the nominal wage increases by 1.11 percent for labor group one, 0.32 percent for labor group two and 0.20 percent for labor group three. The real wage in the high service sector increases by 1.03 percent for labor group one, while it increases by 0.24 percent and 0.12 percent for labor group two and three respectively. About 0.76 percent of new households migrate into town, and the prices increase by 0.1 percent.

In the retail sector, the nominal wage increases by 0.79 percent for labor group one, 0.76 percent for labor group two and decreases by 0.02 percent for labor group three. The real wage increases by 0.68 percent for labor group one, increases by 0.65 percent for labor group two, and decreases by 0.13 percent for labor group three. This increase in productivity and amenities attracts 0.50 percent of new households, and prices increase by 0.1 percent. When the level of consumption externalities coefficient increases by 0.12, the nominal and real wage increases less than the previous level, but the difference is not significant.

Table 6.6: Impacts of Production and Consumption Externalities on Nominal and Real Wages in Loveland

| *Sector* | *Production Externalities* | *Consumption Externalities* | *Nominal Wage 1* | *Nominal Wage 2* | *Nominal Wage 3* | *Real Wage 1* | *Real Wage 2* | *Real Wage 3* | *New Households* | *CPI* |
|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturing | β=0.3 | π=0.07 | 1.08% | 0.53% | 0.29% | 0.96% | 0.41% | 0.17% | 0.91% | 0.10% |
| | | π=0.12 | 1.04% | 0.48% | 0.24% | 0.95% | 0.38% | 0.14% | 1.06% | 0.10% |
| High Service | β=0.3 | π=0.07 | 1.11% | 0.32% | 0.20% | 1.03% | 0.24% | 0.12% | 0.76% | 0.10% |
| | | π=0.12 | 1.09% | 0.30% | 0.17% | 1.02% | 0.23% | 0.11% | 0.85% | 0.10% |
| Retail | β=0.3 | π=0.07 | 0.79% | 0.76% | -0.02% | 0.68% | 0.65% | -0.13% | 0.50% | 0.10% |
| | | π=0.12 | 0.78% | 0.77% | -0.02% | 0.67% | 0.64% | -0.14% | 0.45% | 0.10% |

## 6.4 CONCLUSION

The results show that when production and consumption externalities are analyzed simultaneously, and the level of production externalities is higher than consumption externalities, nominal and real wages increase for all labor groups in manufacturing and high services sectors in both cities. The nominal and real wages increase more in the manufacturing sector in Fort Collins than in Loveland. At the higher level of production externalities (0.2 and 0.3), nominal and real wages increase less than when the coefficient of production externalities was 0.1. Interesting results are observed in the high service sector where the nominal and real wages increase more in Loveland than in Fort Collins. The percentage change in the nominal and real wage in this sector does not differ significantly with the change in the level of production and consumption externalities.

The results of the retail sector are a bit different than those of the other sectors. When the coefficient of production externalities is set at 0.1 and consumption externalities is set at 0.07, the nominal wage does not change while the real wage decreases. When the coefficient of consumption externalities increases to 0.12, the nominal wage and real wage decrease for labor group three. These results in the retail sector support the Carlino and Saiz's (2008) findings that people prefer consumption externalities as their wealth increases. The fact that the real wage for low income group increases more than the high and middle income groups also supports Carlino and Saiz's findings. The real wages results also support Tabuchi and Yoshida's (2000) perspective that the real wage decreases with increasing consumption externalities especially for the higher income households, and the fact that the nominal wage increases with production externalities also supports Tabuchi and Yoshida (2000) findings.

The nominal and real wages also decrease in Loveland when the coefficient of production externalities increases to 0.2 and 0.3 in the retail sector. In Fort Collins' retail sector, the CPI decreases with increasing productivity, making real wages increase more than nominal wages. This is an indication of an increase in domestic supply of goods that causes a downward pressure on prices. In general, I can say that the major portion of my results supports Dalmazzo and deBlasio's findings (2007) that consumption and production externalities have ambiguous effects on local wages. The results depend mainly on model used, the level of data collected and variables used.

REFERENCES

Dalmazzo and Deblasio, (2007), "Production and Consumption externalities of Human Capital" *Journal of population Economics*, 20: 359-387

Fogarty, M.S. and G.A. Garofalo, (1988), "Urban spatial structure and productivity growth in the manufacturing sector of cities," *Journal of Urban Economics* 23: 60-70.

Fujita, M. and J.-F., Thisse, (1996), "Economics of agglomeration," *Journal of the Japanese and International Economics* 10: 339-78.

Fujita, M., P. Krugman and A.J. Venables, (1999) "The Spatial Economy*" The MIT Press,* Cambridge, MA.

Moomaw, R.L (1981). "Productivity and City Size? A critique of the evidence," *Quarterly Journal Of Economics* 96(4): 675-688

Sveikauskas, L., 1975. "The productivity of cities" *Quarterly Journal of Economics* 89: 393–413.

Tabuchi, T. and A. Yoshida (2000), "Separating urban Agglomeration Economies In Consumption and Production," *Journal of Urban Economics,* 48: 70-84.

Getz, M., Y. Huang (1978), Consumer revealed preference for environmental goods. Review of Economics and Statistics 60, 449–458.

Glazer, A., M. Gradstein and P. Ranjan (2003), "Consumption variety and urban Agglomeration" *Regional Science and Urban Economics* 33: 653-661.

Ogawa, H.(1998), "Preference for product variety and city size" *Urban Studies* 35: 45–51.

Rivera-Batiz, F.L. (1988) "Increasing returns, monopolistic competition, and Agglomeration economies in consumption and production," *Regional Science and Urban Economics* 18: 125–153.