DISSERTATION

TWO ESSAYS ON REGIONAL LABOR MARKETS FOR THE DENVER AREA

Submitted by

Chiung-Hsia (Doris) Wang

Department of Economics

In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Summer 2011

Doctoral Committee:

Advisor: Harvey Cutler

David Mushinski
Martin Shields
Stephan Weiler
Stephan Kroll

Copyright by Chiung-Hsia (Doris) Wang 2011

All Rights Reserved

ABSTRACT

TWO ESSAYS ON REGIONAL LABOR MARKETS

FOR THE DENVER AREA

Borts and Stein (1964) and Mathur and Song (2000) presented a general theoretical framework regional growth model, which shows regional growth based on labor demand and supply simultaneously. However, most previous empirical work estimated only either the regional demand curve or regional supply curve due to limited data availability, and nearly all of these empirical works use a reduced form model.

The first goal is to build a more inclusive data set, including cost of production, output, demographic data, and dynamic externality indices, so a complete structural regional labor market model can be estimated. The second goal is to use this dataset in two applied studies. The first applied study is the impact of building a new stadium in the Denver area, and the second is a dynamic externality study on regional growth in the Denver area.

The results show building a stadium in the Denver area had a positive impact on employment on labor demand in the Construction and Professional, Scientific and Technical Services sectors and had a positive impact on labor supply in the Professional, Scientific and Technical, and Accommodation and Food Services sectors.   These results differ from previous research.

The next chapter examines the various diversity indices and econometric techniques that have been used in previous studies in determining the local economic growth for the Denver area. This study compares the dynamic externality results directly across different econometric specifications in order to shed light on the issues of possibly omitted variables bias, endogeneity, and simultaneous bias issues. In addition, comparing the various diversity indices could show a sensitivity of index choice which may affect policy makers' decisions regarding regional development policy.

The results of this study indicate that the choice of diversity index does affect empirical results. Moreover, different econometric techniques provide mixed results for most diversity indices.

TABLE OF CONTENTS

CAPTER 1: INTRODUCTION

The number of studies examining the effect of public policy on regional labor market development has increased in recent years. Typically, these studies measure the relationship between employment growth or personal income, and public policy change or regional economic environmental change. However, most theoretical models, including export-base models and neo-classical growth models, only focus on regional labor demand effects on regional growth, which implies a perfectly elastic regional labor supply curve. Borts and Stein (1964) and Mathur and Song (2000) presented a general theoretical framework regional growth model which shows regional growth based on labor demand and supply simultaneously. In other words, regional growth is actually based on the determinants of both demand and supply and the slope (or elasticity) of the regional labor demand and supply curves. Most previous empirical work estimated only either the regional demand curve or regional supply curve due to limited data availability, and nearly all of these empirical works use a reduced form model.[1]

This study has two goals. The first goal is to build a more inclusive data set, including cost of production, output, demographic data, and dynamic externality indices, so a complete structural regional labor market model can be estimated. The second goal is to use this dataset for two applied studies. The first applied study is the impact of building a new stadium in the Denver area, and the second is a dynamic externality study on regional growth in the Denver area. A summary of each chapter follows:

[1] Except Combes et al.'s (2004) framework. For more details, see Chapter 5.

First, Chapter 2 is based on Roback (1982) and Ottaviano and Peri's (2006) spatial equilibrium framework and a detailed theoretical labor demand and supply model for the region is derived. The model assumes: (i) that individuals and firms have perfect mobility, (ii) that each individual selects a city in the economy to live and work in, thus maximizing utility, and (iii) each firm picks a location to produce a single good to maximize profits. At equilibrium, each individual enjoys the same utility level and each firm obtains the same profit across cities, and wages and rent clear the land and labor markets (Fujita, 1989, and Fujita and Thisse, 2002). Finally, by aggregating across individuals and land for a city, aggregate regional labor demand and supply curves will be represented. Previous studies have analyzed how local condition changes (e.g., amenities, taxes, dynamic externalities, or investment environment) impact the city's labor market. These changes affect both individuals' labor supply and firms' labor demand decisions in that city. In this dissertation, two regional condition changes in the spatial equilibrium framework are included. Chapter 4 discusses the effects of building three new stadiums (i.e., amenity change), Invesco Field at Mile High (professional football), Coors Field (professional baseball), and the Pepsi Center (professional basketball and hockey), on the Denver area regional labor market. Chapter 5 analyzes the effects of changes in dynamic externalities (e.g., specialization, diversity and competition for a specific industry) on the Denver area regional labor market.

Previous studies on regional labor market research typically faced data limitation issues, and thus this issue is addressed in Chapter 3. The first part describes in detail how this study combines multiple datasets consistently over time. The data used in this study includes the Quarterly Census of Employment and Wages (QCEW), the Current

Population Survey (CPS), IMpact analysis for PLANning (IMPLAN) from the Minnesota IMPLAN Group, Inc. (MIG), the Federal Reserve Economic Data (FRED), and the Office of Federal Housing Enterprise Oversight (OFHEO) to build a more complete dataset to specify a labor market. The second part of Chapter 3 calculates various dynamic externality indices (such as specialization, diversity and competition) based on the dataset built in the previous part.

Specifically, this research focuses on Denver County, for which this study constructs consistent quarterly data between 1991 and 2008. Most importantly, most previous studies do not include material costs or output in labor demand curves, leading to data limitations. One contribution of first part of Chapter 3 is to provide a way to approximate estimated output and estimated material costs by using QCEW and IMPLAN data. The logic for calculating estimated output and estimated material costs is that in a perfect competition market, at equilibrium, the input price (including human capital value added) is a fixed proportion of the output price. From this perspective, average wage from QCEW and input proportion from IMPLAN, are used to estimate material costs and calculate estimated output.

Another contribution of Chapter 3 is to examine different dynamic externality (specialization, diversity and competition) indices over time. The goal is to calculate the various indices for the Denver area, and examine the pattern of main indices for dynamic externalities. Previous studies have used various formulas to define each dynamic index[2]; however, doing so produces inconsistent results. Further, the effect of formula choice for estimating each index on empirical outcome had not been examined. In order to compare these formulas, this chapter calculates a wide range of formulas for each index by using

[2] Beaudry and Schiffauerova (2009) summarize various dynamic externalities indies.

Denver area data. The preliminary results show that the Glaeser Diversity Index and Krugman Diversity Index show different results in a region over time. The results depend heavily on whether the index accounts for relative industry structural change in a region and change in surrounding regions.

Next, based on the dataset and theoretical model, two applied studies are carried out in Chapters 4 and 5. The purpose of Chapter 4 is to examine the economic impact of the addition of Invesco Field at Mile High (professional football), Coors Field (professional baseball), and the Pepsi Center (professional basketball and hockey) on Denver by estimating labor demand and supply equations simultaneously, based on the theoretical model built in Chapter 2. Estimating the relationship between building a new stadium and regional growth is typically measured by growth in employment or personal income, estimated by the reduced form model. Previous research had not estimated labor demand and supply equations simultaneously with a structural model. The advantage of estimating a structural model is that it allows the impact of a stadium on labor demand and supply to be examined separately. Also, it allows for estimation of a well-specified structural labor market by including estimated material costs and output. The simultaneous equations method is also used to estimate many sector-specific regional labor markets in this chapter. The results show building a stadium in the Denver area had a positive impact on employment in labor demand in the Construction and Professional, Scientific and Technical Services sectors, and a positive impact on labor supply in the Professional, Scientific and Technical, and Accommodation and Food Services sectors. These results differ from previous research.

Chapter 5 uses the dataset built in Chapter 3 to examine the effect of dynamic externalities on regional growth for the Denver area. Over the last twenty years, there has been a strong debate over which type of dynamic externalities (specialization, diversity, or competition), would foster more local economic growth. Previous studies arbitrarily chose one of various formulas for each index and obtain mixed results. Beaudry and Schiffauerova (2009) summarize the literature and conclude that results may depend heavily on the choice of industry sector, industrial aggregate level, geographical area, geographical level and the time period. This chapter examines the various diversity indices and econometric techniques that have been used in previous studies in determining the local economic growth for the Denver area. Comparing the dynamic externality results directly across different econometric specifications would shed light on the possible omitted variables bias, endogeneity, and simultaneous bias issues. Also, comparing the various diversity indices would show the sensitivity of index choice which may affect policy makers' decisions regarding regional development policy. The results show that the choice of a diversity index does affect empirical results. Also, different econometric techniques provide mixed results for most diversity indices.

In sum, this dissertation adopts a spatial equilibrium model to examine the effects of two regional condition changes (i.e., building a new stadium and dynamic externality) on the Denver labor market. This was accomplished through developing a more complete data set and then estimating the effects of these changes with a structural model. In addition to estimating these effects, this study analyzes how the use of various econometric techniques and dynamic externalities formulas affect the econometric results of regional growth studies.

CHAPTER 2: SPATIAL EQUILIBRIUM MODEL

This chapter presents a theoretical spatial equilibrium framework model that is based on work by Mills (1967), Ottaviano and Peri (2006), Rosen (1979), and Roback (1982). The spatial equilibrium model has been applied to explain regional growth in many different dimensions. For example, in analyzing housing prices, wage premiums, income growth, city growth, migration, and population density literature due to positive or negative amenity, productivity, agglomeration or transportation costs.[3] A Spatial equilibrium model is adopted is because this theoretical model provides a well-presented of derivation of regional labor demand and supply equations. In general, a spatial equilibrium model has the spatial component, i.e., individual's and firm's movement across regions. When a regional factor change occurs, this model shows how this factor shifts regional labor demand and supply. This model will be adopted in this study; however, from only one region view point, i.e., the Denver area. Instead of analyzing the equilibrium across regions, this study will focus only on the Denver area.

Within the amenity literature, Black (1999) applied the spatial equilibrium concept to measure the value of school quality. He found parents do care about school quality and they would be willing to pay 2.1% more for homes located in areas with higher Massachusetts Educational Assessment Program (MEAP) testing scores. The disamenity of neighborhoods with higher crime rates, lowers housing values (Buck and Hakim, 1989; Schwartz et al., 2003; Thaler, 1978; Tita et al., 2006). Spatial equilibrium

[3] Glaeser and Gottlieb (2009) summarized the majority of empirical work on spatial equilibrium model.

concepts have also been broadly adopted in other topics, such as regional economic environment change (e.g., sales tax rate, market size, and transportation improvement in a region), and regional natural environment changes (e.g., sunny days, temperature, or pollution) (Blien et al., 2006; Deller et al., 2001; Knapp and Graves, 1989; Ottaviano and Peri, 2005; Mathur and Stein, 1993).

In the agglomeration literature, spatial equilibrium techniques address cities becoming the center of idea transmission (Glaeser and Gottlieb, 2009). Most previous research in dynamic externalities literature further separates the effects of how cities separate innovation into three groups: Marshall, Arrow and Romer (MAR) suggest the same industrial concentration in a regional will be more innovative; Jacobs (1969) argues that urban diversity is the main force of innovation; and Porter (1990) argues that competition within the same industry in a region is a vital force of innovation.

This spatial equilibrium concept will be applied to two main categories: amenity shock (Chapter 4), and agglomeration in productivity, i.e., dynamic externalities (Chapter 5). This model assumes that individuals and firms are allowed to have perfect mobility, and each individual selects a city in the economy to live and work in, to maximize utility, and each firm picks a location to produce a single good to maximize profits. When there is a local condition change in a city, it will affect not only individuals but also firms in that city.

In Chapter 4, one key explanatory variable, a stadium, i.e., the addition of Invesco Field at Mile High (professional football), Coors Field (professional baseball), and the Pepsi Center (professional basketball and hockey) in the Denver area, is used to represent the local condition change over time. A new stadium may benefit firms in a city because they have to produce more to meet higher demands, and individuals in a city also benefit from being able to attend games, or enjoy the amenity even without going to the games.

In Chapter 5, key explanatory variables of dynamic externalities, specialization, diversity and competition, are used as to capture the local condition in the Denver Area. The Marshall-Arrow-Romer (MAR) theory states that a specialization externality runs through a specific industry in a region, Jacobs's diversity externality works across industrial sectors in a region, and Porter's competition externality arises from competition between the same types of firms within a region (Beaudry and Schiffauerove, 2009; (Glaser et al., 1992).

If individuals or firms prefer a certain regional condition, they will have to locate to a city that offers it. At equilibrium, each individual enjoys the same utility level and each firm obtains the same profit across cities, and wages and rent clear the land and labor markets (Fujita, 1989, and Fujita and Thisse, 2002). Therefore, no individual or firm will have an incentive to migrate.

2.1 Model of Individual and Firm Equilibrium

Several assumptions are needed for modeling the regional labor demand and supply equations. Consider first an economy that contains a large number of non-overlapping cities, (c=1,2,3,…, N). Each city's land endowment is fixed, and the geographic area will not change over time. The land will be used for either residential housing or business use, and transformation costs between these two uses is set at zero. A single good, Y, is produced in each city and can be traded to other cities at no additional cost. There are many firms *j*, and each of them produces output in city *c*, $Y_{j,c}$, which requires only labor and land inputs that are homogeneous across the cities. Furthermore, since the tradable good can be bought and sold across cities with no transaction costs, then its price, P_c, at equilibrium is the same across all cities.

Another assumption is that individuals are identical in their preferences toward amenities.[4] The goal of this analysis is to focus on the impact of an amenity change on the regional labor market. For simplicity, individuals are assumed to be identical. This assumption avoids mixed impacts of amenities on individuals' preferences, wages and rents.

Furthermore, assume there are L identical individuals, of which, a subset L_c live and work in city *c*. Therefore, $L = \sum_{c=1\sim C} L_c$. Each of these individuals acts as a worker and supplies one unit of labor and chooses a living location freely between and within cities. Following Roback's assumption, the commuting cost between cities is prohibitive, so people work in the region where they live. The total amount of homogeneous land available in an economy is assumed to be constant at *H*, and the amount of land in city *c* is denoted H_c, giving $H = \sum_{c=1\sim C} H_c$. For simplicity, land in city *c* is assumed to be owned by a local resident landlord, and other individuals pay rent for the land they use. In this way, the rental income of individuals is independent of location, and does not affect migration choice.[5]

---

[4] A relaxation of this assumption allows individuals to have different preferences and thus different reactions toward amenities, i.e., a new football stadium might attract football fans but not individuals that prefer quiet life. At equilibrium, individuals and firms will sort themselves out across cities, based on amenities, such as a club good. Consequently, a change in amenities of a city could impact local labor markets through wages, rents, and individual preferences toward amenities (Combes, et al, 2004).

[5] There are only two uses of land – commercial or residential. The transformation of land from one use to another is free of charge and can be done immediately.

Finally, local conditions in city c, s_c, are assumed to have effects on its firms and individuals, and it is assumed there are no spillover effects on other cities. This condition implies that if an individual or firm prefers a certain regional local condition, they will have to locate in the city with that condition to enjoy it. This regional condition may produce positive or negative effects. While making migration decisions, a firm or an individual has full information on all the conditions in each city and chooses a city with the bundle of amenities that maximizes profits or the individual's own utility.

2.1.1 Individuals

An individual maximizes utility subject to budget constraints by choosing which city *c* to live in and the amount of tradable goods to consume in city *c*, $Y_{i,c}$. Specifically, a typical individual *i* in city *c* will maximize utility with a limited budget:

$$\underset{Y_{i,c} H_{i,c}}{Max}\, U_{i,c}(Y_{i,c}, H_{i,c}, s_c) = A_u(s_c) H_{i,c}^{\alpha_1} Y_{i,c}^{\alpha_2} \quad \text{with } 0 < \alpha_1, \alpha_2 < 1 \tag{2-1}$$

$$s.t.\ E_{i,c} = P_c Y_{i,c} + r_{i,c} H_{i,c} \tag{2-2}$$

where $H_{i,c}$ denotes the amount of land rented by individual *i* in city *c*; $Y_{i,c}$ denotes the amount of consumption by individual *i* in *c*; $E_{i,c}$ denotes the individual's labor income from work which is used for renting land and consuming goods; P_c denotes the price of good Y, and r_c denotes the rental price of land in city *c*. Also, the individual is assumed not to save any income, and $A_u(s_c)$ captures a utility effect of the bundle of local conditions in city *c*, where s_c represents amenity, and quality characteristics of local public services (Henderson, 1988). If $\frac{\partial A_u(s_c)}{\partial s_c} > 0$, it implies this s_c has positive effects on utility. If $\frac{\partial A_u(s_c)}{\partial s_c} < 0$, it implies a negative regional condition bundle.

According to the above, the Lagrangian expression for individual is

$\theta = A_u(s_c)H_{i,c}^{1-\alpha}Y_{i,c}^{\alpha} + \lambda\left(E_{i,c} - P_c Y_{i,c} - r_{i,c}H_{i,c}\right)$ where λ is the Lagrangian multiplier.

The first order conditions are

$$\frac{\partial\theta}{\partial H_{i,c}} = A_u\left(s_c\right)\alpha_1 H_{i,c}^{\alpha_1-1}Y_{i,c}^{\alpha_2} - \lambda r_c = 0 \quad (2\text{-}3)$$

$$\frac{\partial\theta}{\partial Y_{i,c}} = A_u\left(s_c\right)\alpha_2 H_{i,c}^{\alpha_1}Y_{i,c}^{\alpha_2-1} - \lambda P_c = 0 \quad (2\text{-}4)$$

$$\frac{\theta}{\partial\lambda} = E_{i,c} - P_c Y_{i,c} - r_{i,c}H_{i,c}$$

From equations (2-3) and (2-4), the following is derived:

$$Y_{i,c} = \frac{r_c}{P_c}\left(\frac{\alpha_2}{\alpha_1}\right)H_{i,c} \quad (2\text{-}5)$$

From equation (2-5) and equation (2-2), the demand for $H_{i,c}$ and $Y_{i,c}$ can be expressed as the following:

$$H_{i,c}(r_c, E_{i,c}) = \left(\frac{\alpha_1}{\alpha_1+\alpha_2}\right)\frac{E_{i,c}}{r_c} \quad (2\text{-}6)$$

$$Y_{i,c}(P_c, E_{i,c}) = \left(\frac{\alpha_2}{\alpha_1+\alpha_2}\right)\frac{E_{i,c}}{P_c} \quad (2\text{-}7)$$

From above, equation (2-5) can be represented as $r_c H_{i,c} = \frac{\alpha_1}{(\alpha_1+\alpha_2)} E_{i,c}$, which implies that individual *i* spends $\frac{\alpha_1}{(\alpha_1+\alpha_2)}$ of labor income on housing, and $\frac{\alpha_2}{(\alpha_1+\alpha_2)}$ of income on tradable good $Y_{i,c}$.

Consequently, an individual's indirect utility in city c, $V_{i,c}$, is written as

$$V_{i,c}(r_c, P_c, E_{i,c}; S_c) = A_u(S_c) H_{i,c}^{1-\alpha} Y_{i,c}^{\alpha}$$

$$= A_u(s_c)\left(\frac{\alpha_1}{\alpha_1+\alpha_2}\right)^{\alpha_1}\left(\frac{\alpha_2}{\alpha_1+\alpha_2}\right)^{\alpha_2} E_{i,c} {r_{i,c}}^{-\alpha_1} P_c^{-\alpha_2} \qquad \text{(2-8)}$$

2.1.2 Firms

In perfect competition, firm *j*'s objective is to maximize profits by choosing the amount to produce and the city where it locates. Specifically, a typical firm *j*, in city *c*, has the following production function:

$$Y_{j,c} = f\left(H_{j,c}, L_{j,c}; S_c\right) = A_Y(S_c) H_{j,c}^{\beta_1} L_{j,c}^{\beta_2} \qquad \text{with} \quad 0 < \beta_1, \beta_2 < 0 \qquad \text{(2-9)}$$

Where $Y_{j,c}$ denotes the production from firm *j* in city *c*; $H_{j,c}$ denotes the amount of land rented by firm *j* in city *c*, and $L_{j,c}$ denotes the amount of labor employed by firm *j* in city *c*. $A_Y(s_c)$ is a general term that captures the regional effect due to local condition changes in the city, *c*. This local condition, s_c, could be a amenity factor, such as weather, landscape, air quality and educational environment, or traditional production externality, i.e., specialization, diversity and competition.[6] If $\frac{\partial A_Y(s_c)}{\partial s_c} > 0$, then this s_c has a positive effect on production.

The firm *j*'s total expenditure is $(w_c L_{j,c} + r_c H_{j,c})$, with the average wage in city *c*, w_c and rental price for land, r_c. The profit function for a typical firm *j* in city *c* is:

$$\underset{H_{j,c} L_{j,c}}{Max}\ \pi_{j,c} = P_c Y_{j,c} - r_c H_{j,c} - w_c L_{j,c}$$

$$= P_c A_Y(s_c) H_{j,c}^{\beta_1} L_{j,c}^{\beta_2} - r_c H_{j,c} - w_c L_{j,c} \qquad (2\text{-}10)$$

The first order conditions are

$$\frac{\partial \pi}{\partial H_{j,c}} = P_c A_Y(s_c) \beta_1 H_{j,c}^{\beta_1 - 1} L_{j,c}^{\beta_2} - r_c = 0 \qquad (2\text{-}11)$$

and

$$\frac{\partial \pi}{\partial L_{j,c}} = P_c A_Y(s_c) \beta_2 H_{j,c}^{\beta_1} L_{j,c}^{\beta_2 - 1} - w_c = 0 \qquad (2\text{-}12)$$

Again, from equations (2-11) and (2-12), the relationship between $L_{j,c}$ and $H_{j,c}$ can be expressed as

$$L_{j,c} = \frac{r_c}{w_c}\left(\frac{\beta_2}{\beta_1}\right) H_{j,c} \qquad (2\text{-}13)$$

With a perfect competition assumption, at equilibrium profit will be equal to zero, where $\pi_{j,c} = P_c Y_{j,c} - r_c H_{j,c} - w_c L_{j,c} = 0$. Then, the input demand for $H_{j,c}$ and $L_{j,c}$ can be expressed as the following:

[6] Detailed explanations and summary please see Deller et al. (2001) and Waltert and Schlapfer (2010).

$$H_{j,c}(P_c, r_c, w_c) = \left(\frac{w_c^{\beta_2} \beta_1^{\beta_2 - 1}}{P_c A_Y(s_c) r_c^{\beta_2 - 1} \beta_2^2} \right)^{\frac{1}{\beta_1 + \beta_2 - 1}} \tag{2-14}$$

$$L_{j,c}(P_c, r_c, w_c) = \left(\frac{r_c}{w_c} \frac{\beta_2}{\beta_1} \right) \left(\frac{w_c^{\beta_2} \beta_1^{\beta_2 - 1}}{P_c A_Y(s_c) r_c^{\beta_2 - 1} \beta_2^2} \right)^{\frac{1}{\beta_1 + \beta_2 - 1}} \tag{2-15}$$

Furthermore, in the long run at the equilibrium where $\pi_{j,c} = 0$, the identical firm's long run technology is a constant-returns-to-scale (CRTS), i.e., $\beta_1 + \beta_2 = 1$. For CRTS technology[7], by plugging equation (2-13) into equation (2-10) and setting it equal to zero, we can get

$$r_c H_{j,c} = \left(\frac{\beta_1}{\beta_1 + \beta_2} \right) P_c Y_{j,c} = \beta_1 P_c Y_{j,c} \tag{2-16}$$

$$w_c L_{j,c} = \left(\frac{\beta_2}{\beta_1 + \beta_2} \right) P_c Y_{j,c} = \beta_2 P_c Y_{j,c} \tag{2-17}$$

where equations (2-16) and (2-17) represent the total cost of $H_{j,c}$ and $L_{j,c}$ in terms of P_c and $Y_{j,c}$. Also, bringing equation (2-16) and (2-17) into equation (10), the yield is

$$P_c = \frac{w_c^{\beta_2} r_1^{\beta_1}}{A_Y(s_c) \beta_2^{\beta_2} \beta_1^{\beta_1}} \tag{2-18}$$

where P_c also equals to the marginal cost price at equilibrium.[8]

Before going to the spatial equilibrium section, $A_Y(S_c)$ and $A_u(S_c)$ will need to be explained, first. In this dissertation, for simplicity, $A_Y(S_c)$ and $A_u(S_c)$ will be interpreted

[7] There could be another market structure, such as Cournot competition, which has been discussed in Combes' (1997) work.
[8] In a perfect competition market in the long run, at equilibrium where P=minAC=MR=MC, and in the long run where the production function is CRTS, making equations (2-14) and (2-15) undefined, However, they can still be represented as input expenditures for each input and marginal cost.

and presented in a more general way in Chapter 2. More specific interpretations will be defined later in the next section and Chapters 4 and 5.

2.1.2.1 Regarding S_c in Production Function

When a regional condition changes, it may affect a producer's location decision as well as stimulate an existing firm's demand for labor. This change could have a positive or negative impact on production. For example, if a city receives a theme-park, some new firms might like to locate either in or near the park to take advantage of the higher demand of final goods. Other firms might want to locate near the theme-park in anticipation of additional new firms, with which to interact and exchange ideas or business. However, there could also be a negative impact on the production side as a result of a new theme park, such as greater traffic congestion due to increased population. This would increase not only transportation costs but also pollution and the crime rate. Furthermore, Gottlieb (1995) showed that employers evaluate some residential amenities for their location decision.[9]

In early '90s, the Denver government had a series of plans to redevelop the Denver area, and building Coors Field, Pepsi Center and Invesco Field are the three main projects in the series. When the three stadiums were built in the Denver Area, they changed the regional condition and affected its regional labor market in many ways which will be examined in Chapter 4. From the labor supply perspective, three stadiums attracted more new firms, not only due to the proximity of the larger final goods market,

---

[9] Also, some studies have shown that business executives consider residential amenities as they chose a firms' location (Schmenner, 1982 and Lyne, 1988).

but also the proximity to other firms and the opportunity to exchange ideas in order to increase productivity. Of course, these three new stadiums could also have other impacts on the regional growth, such as increase traffic congestion and higher population density in the region, which could affect production. In other words, this amenity change is shown as $A_Y(\ ; S_c)$.

The other competition theory of regional growth is explained in the dynamic externalities literature, i.e., by examining the employment composition of the Denver area, which will be examined in Chapter 5. Cites are the center of idea transmission and innovation (Glaeser and Gottlieb, 2009). Over the last twenty years, there has been a strong debate about which type of externality, specifically specialization or diversity, would foster more local economic growth. According to Glaeser et al. (1992), dynamic externalities can be differed into three main types: Marshall-Arror-Romer (MAR), Jacobs, and Porter externalities. Marshall (1890) first observed that the higher the concentration of an industry's employment within a region, the higher the chance for people to interact, which may increase opportunities to exchange idea flow between firms. Arrow (1962) and Romer (1986) then formalized Marshall's idea as specialization externalities, usually called the Marshall-Arrow-Romer (MAR) theorem. This theorem claims that specialization of an industry within a region will promote knowledge spillovers between firms, which will further enhance regional growth. However, Jacobs (1969) argues that the most important knowledge spillover actually comes from outside the industry within a region. Knowledge spillovers across industry sectors are recognized as diversity externalities. Furthermore, Porter (1990) points out that the knowledge spillover arises from competition between the same types of firms within a region, which stimulates firms to innovate for survival in the market. This competitive force is known as a competition externality. Porter agrees with Jacobs' theory that a local competition environment is better for growth than a monopoly market; however, he also agrees with MAR that specialization externalities in a region promote growth (Beaudry and Schiffauerove, 2009; Glaeser et al., 1992).

According the above description, most previous researchers, such as Combes et al. (2000), Dekle (2002) and Glaeser et al., (1992), $A_Y(s_c)$ is assumed that productivity shocks which will depend on local characteristics, s_c, such as specialization, diversity, competition, industry size or total regional market size. In order to determine the impact of those local characteristics on growth, $A_Y(s_c)$ can be rewritten as $A_Y(s_c) = A_Y$ *(specialization, diversity, competition, size).*

2.1.2.2 Regarding S_c in Utility Function

When a regional condition changes, it will not only affect the producer's decision, but also the individual's decision. For example, a negative amenity (i.e., heavy traffic, air pollution, etc.) for a region may affect happiness or satisfaction with living in a region, which will also shift the regional labor supply curve inward (Fujita, 1989). In other words, this amenity change will be shown as $A_u(\ ; S_c)$.

Furthermore, Simon (1988) showed that in a city with a higher specialization sector, workers have a higher incentive to move somewhere else for decreased unemployment opportunity. This suggests that a city with a higher specialization industry may shift its regional labor demand curve outward; however, this specialized force may also shift the regional labor supply curve inward. Therefore, in order to get a more accurate estimation, labor supply side factors will also be included in the model. Similar to the firm's perspective, in order to determine the impact of those local characteristics on growth, $A_u(s_c)$ in Chapter 5 can be rewritten as $A_u(s_c) = A_u$*(specialization, diversity, competition, size)*.

2.2 Spatial Equilibrium

Since each individual and firm has perfect mobility within and between cities, each individual finds a city that maximizes utility, and each firm moves to a city that maximizes profit. Consequently, a set of prices, w_c and r_c, that clear factor and product markets is reached at equilibrium where no firm and no individual has the incentive to enter or exit the market.

Keep in mind that since Y can be traded anywhere in a perfect competition economy, this implies that P_c will be the same cross cities, $P_c = P_k = \cdots = \bar{P}$, and no firm will have incentive to move. Equation (2-18) can be therefore restated as

$$r_c^{\beta_1} w_c^{\beta_2} = \bar{P} A_Y(s_c) \beta_2^{\beta_2} \beta_1^{\beta_1} \qquad (2\text{-}19)$$

Equation (2-19) will be referred to as the *free entry condition* for a firm.

In addition, since individuals do not have an incentive to migrate to another city at equilibrium, the indirect utility for an individual should also be common across the cities. That is,

$$V_{i,c}(r_c,P_c,E_i;s_c)=V_{i,k}(r_k,P_{k,}E_{i,k};s_k) \quad \forall c, k = 1, \dots . N$$

$$= A_u(s_c)\left(\frac{\alpha_1}{\alpha_1+\alpha_2}\right)^{\alpha_1}\left(\frac{\alpha_2}{\alpha_1+\alpha_2}\right)^{\alpha_2}\frac{E_{i,c}}{r_c^{\alpha_1}\overline{P}^{\alpha_2}}$$

$$= A_u(s_k)\left(\frac{\alpha_1}{\alpha_1+\alpha_2}\right)^{\alpha_1}\left(\frac{\alpha_2}{\alpha_1+\alpha_2}\right)^{\alpha_2}\frac{E_{i,k}}{r_c^{\alpha_1}\overline{P}^{\alpha_2}} \qquad (2\text{-}20)$$

Equation (20) will be referred as the *free migration condition* for an individual.

In sum, spatial equilibrium can be written as the free entry condition for a firm (equation 2-19) and the free migration condition for an individual (equation 2-20).

2.3 Regional Labor Demand and Labor Supply

Since the focus of this analysis is on the regional labor market, the following section will show the steps to obtaining aggregate regional labor supply from an individual's indirect utility equation, equation (2-8), and aggregate regional labor demand marginal cost curve, equation (2-18).

2.3.1 Aggregation

At equilibrium, the total amount of labor for city *c*, L_c, is the aggregate amount of labor hired by each firm *j* in the city *c*, i.e. $L_c = \sum_j L_{j,c}$. The total tradable output in city *c*, Y_c, is the sum of production of each firm *j* in city *c*, i.e. $Y_c = \sum_j Y_{j,c}$. By adding equation (2-16) across the firm *j* for city *c*, we can get

$$\sum_j w_c L_{jc} = \sum_j \beta_2 \overline{P} Y_{j,c}$$

Pulling the constant coefficients, w_c, β_2, and P_c to the front, we can get

$$w_c \sum_j L_{j,c} = \beta_2 \overline{P} \sum_j Y_{j,c}$$

$$w_c L_c = \beta_2 \overline{P} Y_c \tag{2-21}$$

Equation (2-19) shows that the total wage payment is equal to the proportion of the total output value in city *c*.

Moreover, the amount of land in a city *c* is fixed, H_c, and it is used either for residential or for commercial purposes.[10] Hence, $H_c = \sum_i H_{i,c} + \sum_j H_{j,c}$. By aggregating equation (2-6) across individuals and aggregating equation (16) across firms for city *c*, H_c can be represented as

$$H_c = \sum_i H_{i,c} + \sum_j H_{j,c} = \sum_i \left(\frac{\alpha_1}{\alpha_1 + \alpha_2} \right) \frac{E_{i,c}}{r_c} + \sum_j \beta_1 \frac{\overline{P} Y_{j,c}}{r_c}$$

Multiply r_c on both sides, then

$$r_c H_c = r_c \sum_i H_{i,c} + r_c \sum_j H_{j,c} = \frac{\alpha_1}{\alpha_1 + \alpha_2} \sum_i E_{i,c} + \beta_2 \overline{P} \sum_j Y_{j,c} \tag{2-22}$$

Also, from equation (2-7), $E_{i,c} = Y_{i,c} P_c \left(\frac{\alpha_1 + \alpha_2}{\alpha_1} \right)$. Then,

$$r_c H_c = \left(\frac{\alpha_1}{\alpha_1 + \alpha_2} \right) \overline{P} \left(\frac{\alpha_1 + \alpha_2}{\alpha_1} \right) \sum_i Y_{i,c} + \beta_2 \overline{P} \sum_j Y_{j,c} \tag{2-23}$$

[10] This assumption is made for analytical convenience. Also, the official geographic area of Denver area did not change much from 1991-2005.

At equilibrium, the total amount of Y_c produced in city c should be consumed totally in c at equilibrium, i.e., $\sum_i Y_{i,c} = \sum_j Y_{j,c} = Y_c$.

This simplifies equation (2-23) into

$$r_c H_c = \left(\frac{\alpha_1 + \alpha_2 \beta_1}{\alpha_2}\right) \overline{P} Y_c \tag{2-24}$$

Equation (2-24) shows that the total rent payment is equal to the proportion of the total output value in city *c*.

2.3.2 Aggregate Demand and Aggregate Supply

Remember that each individual is identical and the indirect utility level is indistinguishable between cities at equilibrium, i.e., $V_{i,c} = V_{i,k} = ... = \overline{V}$. Given the assumption of the local landlords, the aggregated expenditure in city c will be equal to the aggregate income, i.e., $\sum_i E_{i,c} = \sum_i w_c$.[11]

From equation (2-8) and equation (2-5)

$$\overline{V} = V_{i,c}\left(r_c, P_c, E_{i,c}\right) = V_c(r_c, \overline{P}, w_c) = A_u\left(s_c\right)\left(\frac{\alpha_1}{\alpha_1 + \alpha_2}\right)^{\alpha_1}\left(\frac{\alpha_2}{\alpha_1 + \alpha_2}\right)^{\alpha_2} \frac{w_c}{r_c^{\alpha_1} \overline{P}^{\alpha_2}} \tag{2-25}$$

Furthermore, equations (2-21) and (2-23) can be rewritten as

$$r_c H_c = \left(\frac{\alpha_1 + \alpha_2 \beta_1}{\alpha_2}\right) \frac{w_c L_c}{\beta_2} \tag{2-26}$$

[11] For simplification, assume there are no savings in this analysis. Total expenditures will be equal to total factor income (including wage and rent revenues.)

Plug equation (2-26) into the free migration equation, then

$$\overline{V}_c = \Theta A_u(s_c) w_c^{\alpha_2} \left(\frac{H_c}{L_c}\right)^{\alpha_1} \overline{P}^{-\alpha_2} \tag{2-27}$$

where $\Theta = \left(\frac{\alpha_1}{\alpha_1+\alpha_2}\right)^{\alpha_1} \left(\frac{\alpha_2}{\alpha_1+\alpha_2}\right)^{\alpha_2} \left(\frac{\alpha_2\beta_2}{\alpha_1+\alpha_2\beta_1}\right)^{\alpha_1} > 0$ [12]

Rearranging equation (2-27) gives

$$L_c = A_u(s_c)^{\alpha_1^{-1}} \Theta^{\alpha_1^{-1}} \overline{V}^{\alpha_1^{-1}} w_c^{\frac{\alpha_2}{\alpha_1}} H_c \overline{P}^{\frac{-\alpha_2}{\alpha_1}} \tag{2-28}$$

$$\frac{\partial L_c}{\partial w_c} = \frac{\alpha_2}{\alpha_1} A_u(s_c)^{\alpha_1^{-1}} \Theta^{\alpha_1^{-1}} \overline{V}^{\alpha_1^{-1}} w_c^{\frac{\alpha_2}{\alpha_1}-1} H_c \overline{P}_c^{-\frac{\alpha_2}{\alpha_1}} > 0 \tag{2-29}$$

With $0 < \Theta < 1$ and $0 < \alpha_1, \alpha_2, \beta_1, \beta_2 < 1$, equations (2-28) and (2-29) show that when w_c increases, L_c also increases, resulting in an upward sloping *aggregate regional labor supply curve*. In addition, equation (2-28) has derivatives of the labor supply with respect to $A_u(s_c)$as

$$\frac{\partial L_c}{\partial s_c} = \frac{1}{\alpha_1} A_u(s_c)^{\alpha_1^{-1}-1} \Theta^{\alpha_1^{-1}} \overline{V}^{\alpha_1^{-1}} w_c^{\frac{\alpha_2}{\alpha_1}-1} H_c \overline{P}_c^{-\frac{\alpha_2}{\alpha_1}} \gtrless 0 \tag{2-30}$$

Equation (30) shows that if a local condition has a positive effect on utility, i.e., $\frac{\partial A_u(s_c)}{\partial s_c} > 0$, the labor supply will increase, and if a negative effect, i.e., $\frac{\partial A_u(s_c)}{\partial s_c} < 0$, the labor supply will shift inward.

---

[12] With the assumptions: $0 < \alpha_1, \alpha_2, \beta_1, \beta_2 < 1$

The derivation of labor demand is similar to that of labor supply. When replacing r_c with equation (2-26), then the free entry equation can be rewritten as

$$\left(\frac{\alpha_1 + \alpha_2\beta_1}{\alpha_2\beta_2}\right)^{\beta_1}\left(\frac{L_c}{H_c}\right)^{\beta_1} w_c = \overline{P} A_Y(s_c)\beta_1^{\beta_1}\beta_2^{\beta_2}$$

$$\overline{P} = \Delta\, A_Y(s_c)^{-1}\, w_c \left(\frac{L_c}{H_c}\right)^{\alpha_1} \tag{2-31}$$

where $\Delta = \left(\frac{\alpha_1 + \alpha_2\beta_1}{\alpha_2\beta_2}\right)^{\beta_1} \beta_1^{-\beta_1}\beta_2^{-\beta_2}$

Rearranging the equation (2-31) gives

$$L_c = A_Y(s_c)^{\beta_1^{-1}}\Delta^{-\beta_1^{-1}}\overline{P}^{\beta_1^{-1}} w_c^{-\beta_1^{-1}} H_c \tag{2-32}$$

$$\frac{\partial L_c}{\partial w_c} = -\frac{1}{\beta_1} A_Y(s_c)^{\beta_1^{-1}}\Delta^{-\beta_1^{-1}}\overline{P}^{\beta_1^{-1}} w_c^{-\beta_1^{-1}-1} H_c < 0 \tag{2-33}$$

With $0 < \Delta < 1$ and $0 < \alpha_1, \alpha_2, \beta_1, \beta_2 < 1$, equation (2-32) and (2-33) show that when w_c increases, L_c will decrease, giving a downward sloping *aggregate regional labor demand curve*. In addition, equation (2-32) has derivatives of the labor demand with respect to s_c as

$$\frac{\partial L_c}{\partial s_c} = \frac{1}{\beta_1} A_Y(s_c)^{\beta_1^{-1}-1}\Delta^{-\beta_1^{-1}}\overline{P}^{\beta_1^{-1}} w_c^{-\beta_1^{-1}-1} H_c \gtrless 0 \tag{2-34}$$

Equation (2-34) shows that if a local condition has a positive effect on total productivity, i.e., $\frac{\partial A_Y(s_c)}{\partial s_c} > 0$, the labor demand will increase, and if a negative effect on total productivity, i.e., $\frac{\partial A_Y(s_c)}{\partial s_c} < 0$, the labor demand will shift inward.

Figure 2-1 illustrates the equilibrium from equations (2-30) and (2-34) and can be used to identify the impacts of local condition change to the regional labor market. The interaction of the regional labor demand curve, equation (2-30), and the regional labor supply curve, equation (2-34), for city c endogenously determines w_c and L_c simultaneously, given the profit, $\bar{\pi}$, and utility level, $\bar{V}$.

In sum, this chapter provides a detailed description of a spatial equilibrium model set up from an individual's and a firm's decision to get aggregate regional labor demand and supply. Based on the theoretical model presented previously, Chapter 3 will provide a detailed description of each variable that will be used in Chapter 4 and 5. Chapter 4, will consider a local condition change, specifically an amenity change in the Denver area. In Chapter 5, dynamic externalities indices, specialization, diversity and competition, are used to measure the local condition for a specific industry in a region (Glaser et al., 1992).

CHAPTER 3: DATA ANALYSIS

"One of the first tasks of a regional analyst or planner, when he begins to study an area, is to glean as much as information as possible from readily available resources."
Paul Polzin (1970)

The goal of this chapter is to construct a complete dataset for the Denver Area over time in order to specify a structural labor market estimation. In the last decade, a huge interest in regional development has focused on employment growth. According to Hamermesh (1996) and Mathur and Song (2000), data used for estimating a regional labor market include wage rates, employment, environmental factors, education levels, input costs, output levels, etc. For estimating a labor supply curve, wage rate, employment, demographic characteristics, environmental factors, etc. are needed. Wage rate and employment are usually available at either the micro-level (e.g., EC202 data) or macro-level (e.g., Quarterly Census of Employment and Wages, QCEW), demographic characteristics are also available at individual levels (e.g., Current Population Survey, CPS), and regional environmental factors are usually available in various geographic areas (e.g., American Community Survey). The other two important factors for estimating labor demand are output and material costs; however, those data are not usually available either at the micro level or the aggregated levels for the different industry sectors over time.

Chapter 3 is divided into two main parts. The first part describes in detail how this study combines multiple datasets consistently over time. This will include two elements:

first, a detailed description of each variable used for estimation from various data resources, and second, a proposed method for calculating the cost of production, such as estimated material costs and estimated output at a higher aggregated industrial geographic level. The second part calculates various dynamic externality indices (such as specialization, diversity and competition) based on the dataset built in the previous part.

3.1 Data Sources

The data consists of 60 quarterly observations across time from 1991.1 to 2005.4 for twenty different 2-digit NAICS sectors (Table 3-1) to estimate the aggregate labor demand and supply for the Denver area. Data used in this analysis come from several different sources, including the Quarterly Census of Employment and Wages (QCEW), the Current Population Survey (CPS), IMpact analysis for PLANning (IMPLAN) from the Minnesota IMPLAN Group, Inc. (MIG), the Federal Reserve Economic Data (FRED), and the Office of Federal Housing Enterprise Oversight (OFHEO). To my knowledge, this is the first study combining QCEW and IMpact analysis for PLANning (IMPLAN) datasets to estimate material costs and output at the county level.

The QCEW dataset comes from the U.S. Census Bureau. The QCEW includes monthly employment, quarterly total payroll, number of establishments, the North American Industry Classification System (NAICS) code and geographic information (i.e., FIPS code). These data were originally collected from the Colorado Demographic of Labor and Employment for workers who are covered by State unemployment insurance law and Unemployment Compensation for Federal Employees (UCFE). The dataset includes individual corporations with paid employees, which covers about 98% of nonfarm employment[13] (Bureau of Labor Statistics, BLS, 2008). The Colorado Demographic of Labor and Employment office provides various aggregate level information by different industrial digit levels (from 2-digits to 6-digits) and by different geographic areas, i.e., a five-digit Federal Information Processing Standard (FIPS). This data is published on the BLS website for public use.

The QCEW dataset contains various NAICS and FIPS level data and allows researchers to manipulate the data at higher industry levels in different geographic areas. For consistency, to merge the data across the various datasets over time for Denver County, a 2-digit level of NAICS is chosen. Average wages, average employment, and number of establishments were aggregated from QCEW; estimated output and estimated material costs were generated from IMPLAN and QCEW, and education, gender, age and race were aggregated from CPS.

The following section provides a detailed description of the manipulation for each variable for the regression analysis. The sources of data used in this research are described first. Then the analysis of the descriptive statistics and graphs for variables for labor demand and supply are explained.

Table 3-1 2-Digit NAICS Codes and Titles

Codes	Industry Title
11	Agriculture, Forestry, Fishing and Hunting
21	Mining
22	Utilities
23	Construction
31-33	Manufacturing

[13]This dataset only includes corporation employment; it does not include proprietor employment or self-employment.

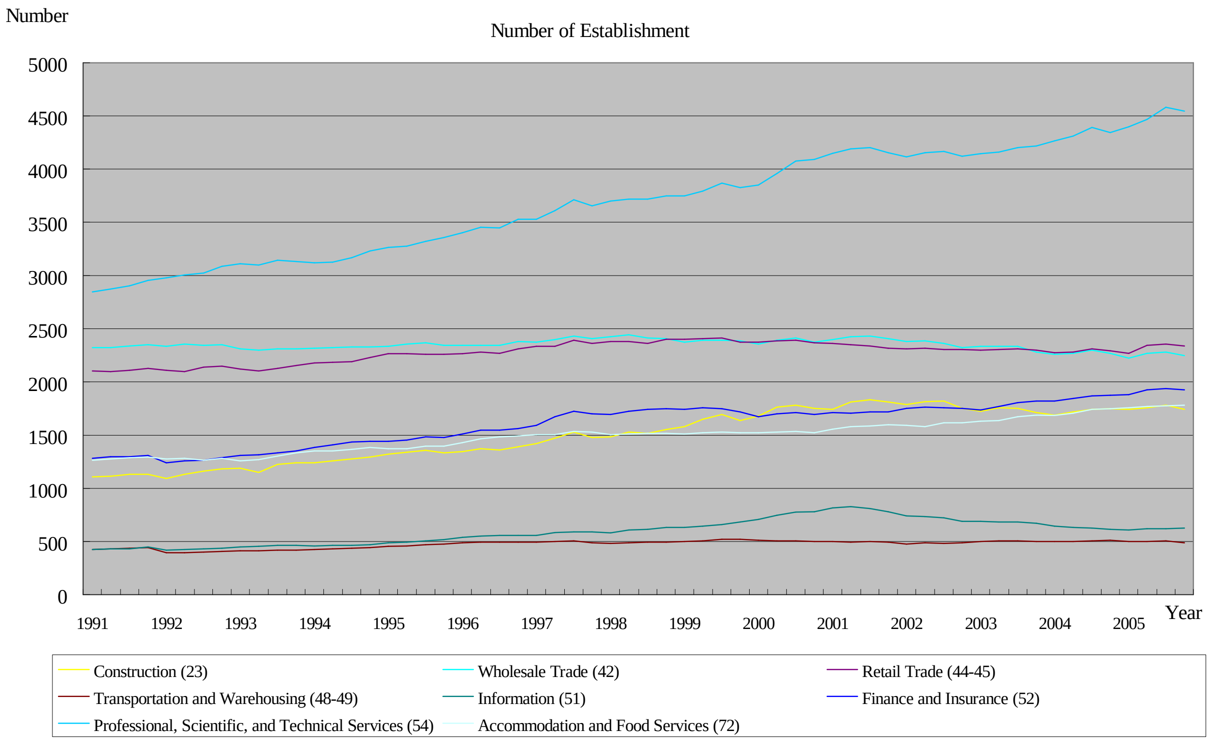
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

Resource: U.S. Census Bureau (http://www.census.gov/epcd/naics02/)

3.2 Variable Constructions for Labor Demand Side

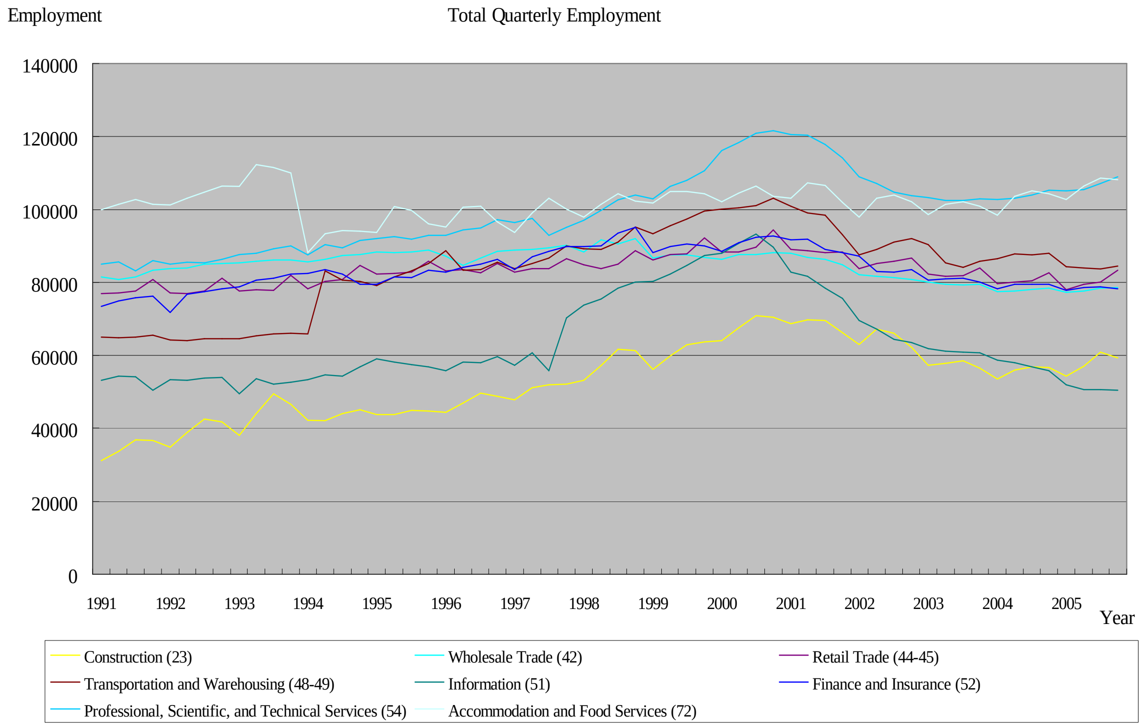
3.2.1 Number of Establishments

The number of establishments reflects the sum of establishments in Denver County. The number of establishments shows different patterns for different industry sectors (Figure 3-2). In 1997, *Fortune Magazine* ranked Denver as the 2nd most improved city for business climate and quality of life in the nation, which attracted some major companies, such as Grayline, Inc., Texaco, and the Pavilions to locate there. The Denver economic environment change also encouraged more entrepreneurs to open businesses in the region. Including the number of establishments controls for the attractiveness of the Denver area, and it is also a shifter for the regional labor demand curve.



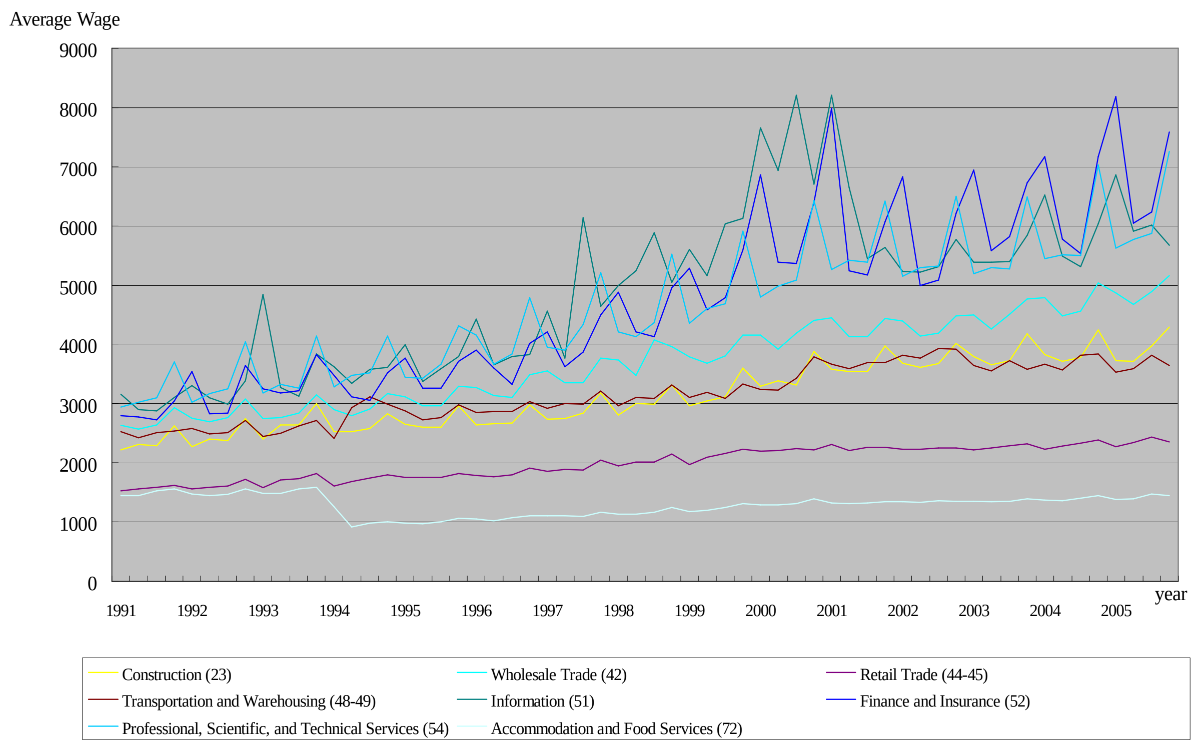
3.2.2 Quarterly Average Employment

In the QCEW, monthly employment in different NAICS industries is reported. For quarterly average employment, the three months of employment for each quarter are summed. For most industry sectors, quarterly employment shows seasonal fluctuations (Figure 3-3). Quarterly average employment is included in the model as an endogenous variable for estimation.



3.2.3 Quarterly Average Wage

The quarterly average wage is calculated by quarterly total payroll, divided by total quarterly employment. The nominal quarterly average wage grew over time for most industry sectors with some seasonal patterns (Figure 3-4). Quarterly average wage is included in the model as an endogenous variable for estimation.



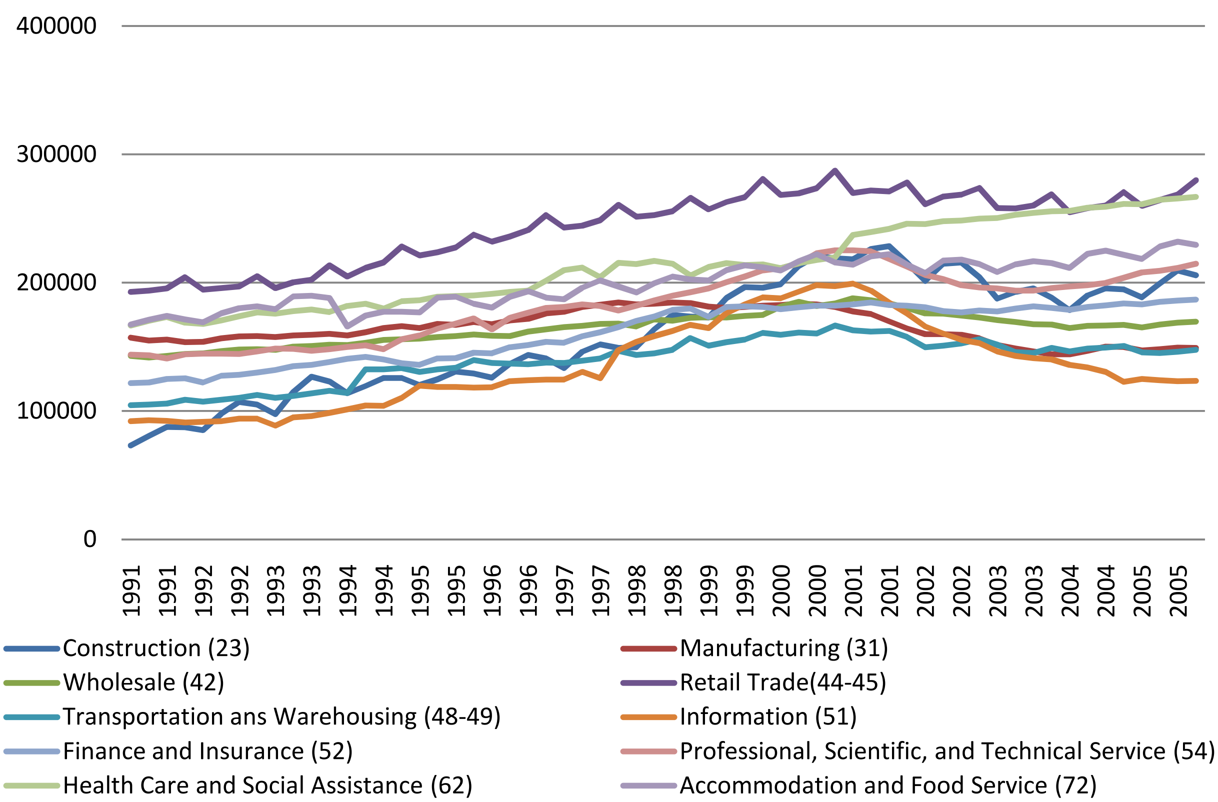
3.2.4 Aggregate Quarterly Employment

QCEW provides county monthly employment data from 1-digit NAICS to 6-digit NAICS. The aggregate quarterly employment data in this analysis were obtained by adding quarterly employment data for the surrounding four counties, Adams, Arapahoe, Douglas and Jefferson.[14] Figure 3-4 shows a general growth pattern in the total employment in Denver County for most industry sectors, but it shows a decreasing pattern after 2001 (except for the Accommodation and Food Service sector). Also, total employment will be used to control for an approximation of the labor pool in the Denver area, which is also a shifter of the regional labor supply curve.

---

[14] Broomfield county has been separated from Adams, Jefferson and Weld counties since 2002.

Figure 3-4 Aggregate Employment by Sector



3.2.5 Estimated Output and Estimated Material costs

Estimated output and estimated material costs can be estimated by industry sector by generating the regional production absorption coefficients from IMPLAN first and then multiplying that by the quarterly sector average wage. The logic for calculating material costs this way is that in a perfect competition market, the firm will choose the output level where $P = MR = MC = \min AC$ for maximizing profits in the long run. Furthermore, at equilibrium, the input price is a fixed proportion of the output price.

The regional absorption matrix comes from IMPLAN for 1991-2005,[15] and it

[15] Owing to data limitations, only 1992, 1994, 1999, 2001, 2002 and 2004 regional absorption matrices from IMPLAN are available. For the other years (1991, 1993, 1995, 1996, 1997, 1998, 2003 and 2005), the

provides the cost structures in different industries. Since IMPLAN provides 506 by 506 industry sectors' absorption index matrices, the aggregate of the absorption can be calculated up to different levels, such as a 1- or 2-digit SIC and a 2- or 3-digit NAICS. In this research, 2-digit NAICS was chosen as the aggregate level because it allows for a merger of estimated material costs and estimated output consistent with the other datasets. Each absorption coefficient ($a_{i,j}$) in the matrix provides the proportion of input *j* used for a particular per unit of output *i* (Table 3-2).[16] For instance, $a_{i,j} = 0.15$ means that for producing one-dollar's worth of *i*, the firm will buy 0.15 dollar's worth of input from sector *j*. Summing the absorption index vertically ($\sum_{j=1\sim n} a_{i,j}$), will result in all inputs' worth, i.e., *material costs*, per one-dollar's worth of output. Then, the *value-added* of output *i*, V_{ij}, will be equal to $(1 - \sum_{j=1\sim n} a_{i,j})$ which also equals the labor capital proportion per one-dollar's worth of output for industry *i*. In sum, per one-dollar's worth output can be separated into two categories, material costs and value-added. For example, if $\sum_{i=1\sim n} a_{i,j} = 0.75$, then producing one-dollar's worth of output *i*, the total input cost would be 0.75 dollars and the labor capital cost, is 0.25 dollars.

regional absorption coefficients are estimated from the yearly production absorption matrix by weighted average.

[16] $a_{i,j}$ is sometimes called the technical coefficient.

Table 3-2 Regional Production Absorption Coefficients Table

Input j \ Output i	Sector 1	Sector 2	…….	Sector n
Sector 1	a_{11}	a_{21}	$a_{.1}$	a_{n1}
Sector 2	a_{12}	a_{22}	$a_{.2}$	a_{n2}
: :	: :	: :	a_{ij}	: :
Sector n	a_{1n}	a_{2n}	$a_{.n}$	a_{nn}
Sum of Absorption	$\sum_{j=1\sim n} a_{1j}$	$\sum_{j=1\sim n} a_{2j}$	$\sum_{j=1\sim n} a_{.j}$	$\sum_{j=1\sim n} a_{nj}$
Value Added	V_1	V_2	$V_.$	V_n
Total (Sum of Absorption + Value Added)	1	1	1	1

As just described above, the absorption coefficient matrix provides the information regarding cost structure per dollar output. In IMPLAN, the absorption coefficients do not include the value-added costs. So it is reasonable to assume the labor input cost proportion can be represented as $(1 - \sum_I a_{ij})$= (value-added from labor input). Then, the output value and labor capital input ratio can be rewritten as

$$1: \left(1 - \sum_I a_{ij}\right) = PQ: \text{(Total Payroll)} \quad (3\text{-}1)$$

By controlling for the consumer price index, *P*, over time, we can calculate the estimated output, Q, for each sector over time. The detailed steps for estimating estimated output and estimated material costs were estimated as follows:

3.2.5.1 Estimated Output

The estimated output is included in the model because the greater the output, the higher the labor demand. Since QCEW provides the average wages, then the estimated output can be estimated from the absorption matrix by the following:

$$1:\left(1-\sum_j a_{ij}\right) = 1:(value-added)$$

$$= (total\ output\ value):(average\ wage) \qquad (3\text{-}2)$$

The estimated output was calculated by using the following steps:

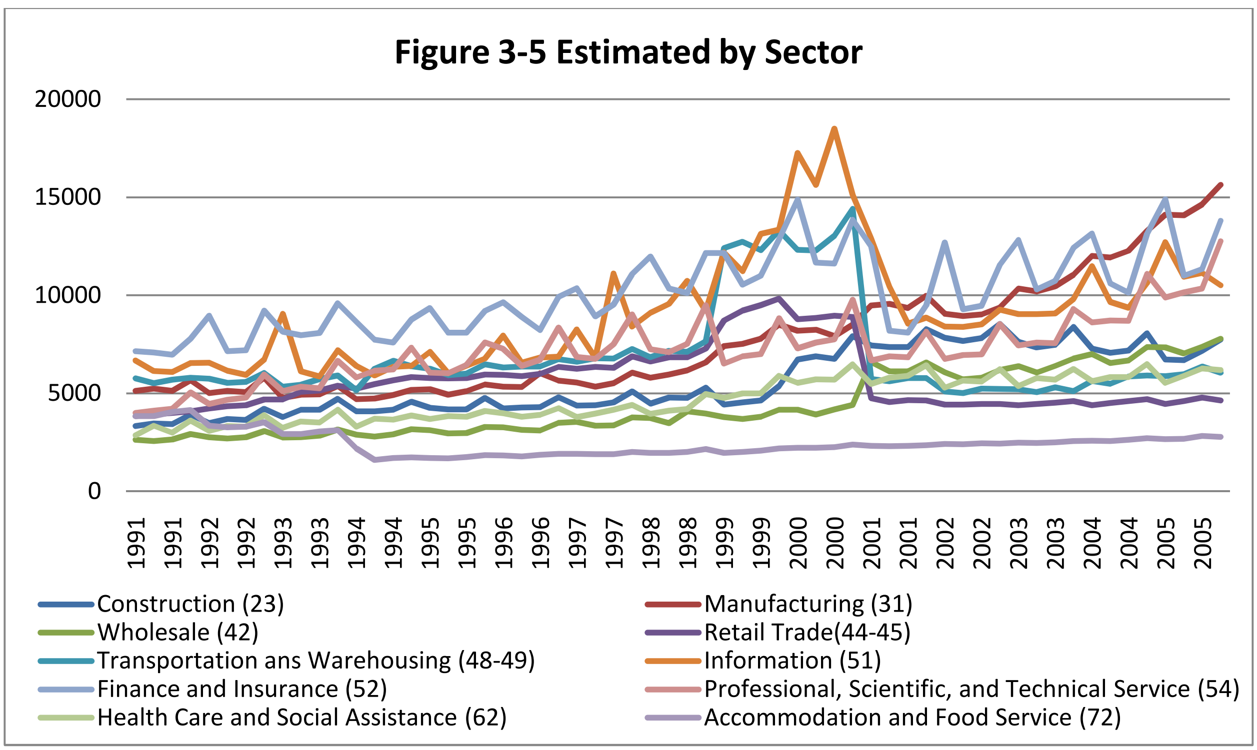
Step 1: Pull out yearly absorption coefficients from IMPLAN.

Step 2: Sum output sector *i* by *j*, $\sum_i a_{ij}$, and calculate value-added as

$$(1-\sum_{j=1\sim n} a_{ij})$$

Step 3: Estimate estimated output by $Q = \frac{Total\ Output\ Value}{1-\sum_i a_{ij}}$

For the estimated output, the growth pattern is similar to the total employment for most sectors. The higher the output level, the higher the employment. For example, the total employment in Wholesale Trade decreased after 2000 because of migration out to the suburban areas, and the total output value decreased in the Denver area, too (Figure 3-5).



3.2.5.2 Estimated Material Costs

Since the absorption index provides the input proportion per dollar output, the estimated material costs can be approximated from the average wage, using the following steps:

Step 1: Calculate quarterly average wages ($\overline{wage_i}$) by 2-digit NAICS industry sector from QCEW.

Step 2: Multiply the absorption index (a_{ij}) by the average wage for output sector i to get estimated material costs by input sector for a specific output sector ($a_{ij} \times \overline{wage_i}$).

Step 3: Sum total material costs for output sector i by $\sum_j a_{ij} \times \overline{wage_i}$

Furthermore, by looking at the absorption index for each sector, the combination of input for each sector, $a_{i,j}$, did not change much across the years. The pattern of material costs typically moved upward, and they moved in the same direction as average wages, with some seasonal adjustments.[17] For material costs, the pattern typically moved upward, and in the same direction as average wages across time with some seasonal adjustments.

[17] Of course, above calculation for estimated materials cost and output is accurate only under a perfect competition assumption. If not, then profit proportion per worth output needs to be considered.

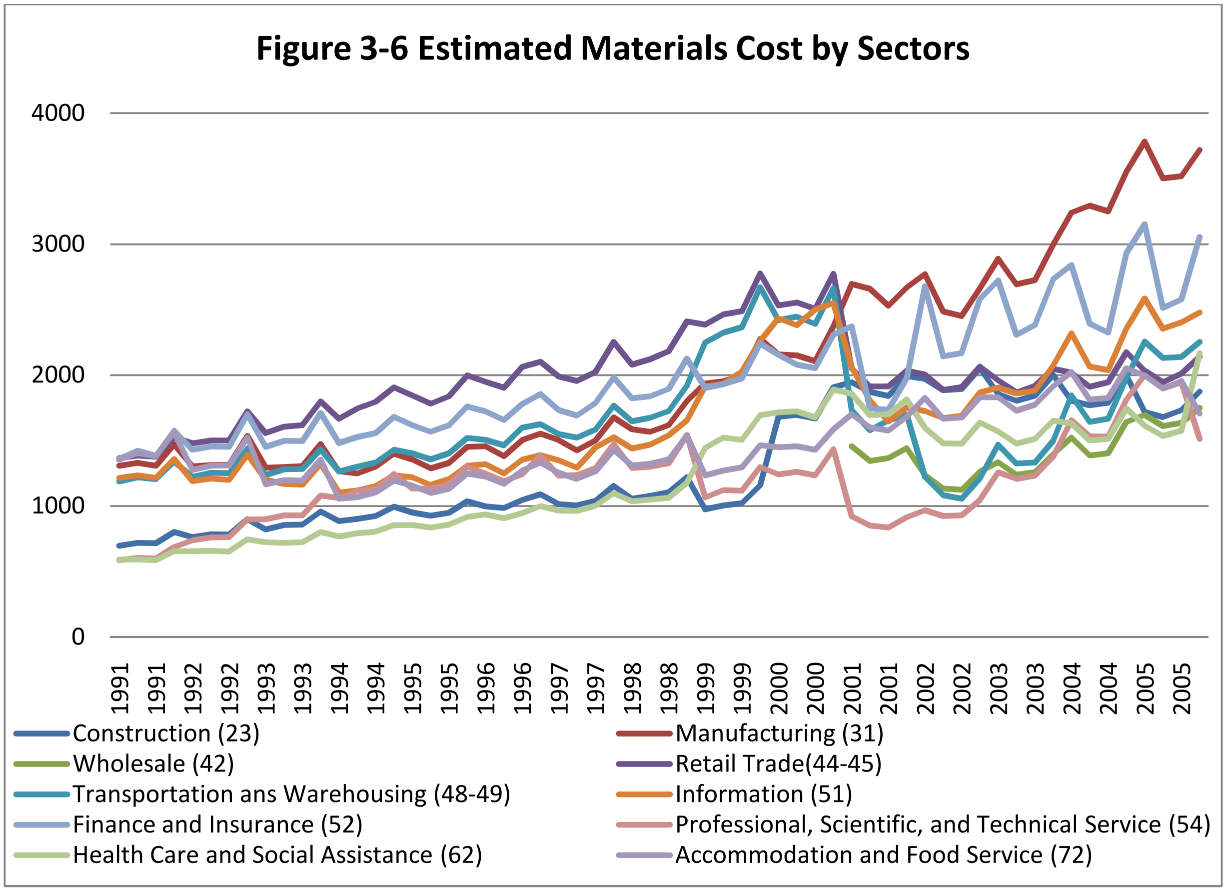


Figure 3-6 Estimated Materials Cost by Sectors

3.2.5.3 Comparison of Various Sources of Estimated Material Costs and Estimated Output

There are various techniques to measure material costs and output: either collecting data from individual firms or directly estimating material costs and output at aggregate regional levels through second hand data sources, such as IMPLAN. Typically, obtaining material costs by industry in a region is really challenging, unless a detailed individual industrial cost structure survey has been done. IMPLAN adopts input-output tables from the Bureau of Economic Analysis (BEA). BEA surveys representative 6-digit NAICS manufacturers for detailed cost structure at the national level every five years, and creates a national representative input-output table accordingly. This benchmark input-output table shows the detailed interactions among industrial sectors. However, these indices, $a_{i,j}$, generated from input-output tables are unadjusted, which may not be ideal to describe the industrial structure at the regional level. To obtain a more accurate table on the regional level structure, IMPLAN includes an adjusted input-output index at the regional level accordingly.[18]

However, there is still a weakness in adopting material costs and output from IMPLAN directly. IMPLAN provides total industrial output value for a region, instead of dollars per worker. Of course, output per worker can be calculated by dividing the total output value by the total employment in a region from IMPLAN; however, this total employment is calculated through multipliers, instead of actual total industrial employment. In other words, this estimated output per worker in IMPLAN will be under-estimated.[19] For estimated material costs per worker, IMPLAN does not provide this information directly. To get more accurate county level industrial material costs, the steps listed in the previous section become necessary. The methodology for calculating estimated material costs and output provided in this study, not only considers regional structure over time (i.e., regional absorption table at the regional level in IMPLAN), but also uses actual average wage per worker (i.e., from QCEW). Again, this may provide a convenient way to estimate material costs and output.

3.2.6 Interest Rate

The quarterly interest rate was obtained from the Federal Reserve Economic Data

---

[18] IMPLAN staff estimates regional input-output tables by considering regional employment structure. This data comes from EC202. Also, to ensure consistency across various regional levels, IMPLAN also controls for the higher geographic aggregated level. For example, when state level data is generated, national totals will be controlled for.
[19] Multipliers are always greater than one.

(FRED). Interest rate is used as the approximated cost of capital.

3.2.7 Education

Education level is used to approximate labor productivity and human capital spillovers of an industry within a region. According to human capital theory, the higher the education or training investment, the higher the expected earnings. Furthermore, human capital externalities can affect production into two different ways: direct technological spillovers (i.e., specialization) and complementary knowledge between different industries (i.e., diversity) (Moretti, 2004 and Bline et al., 2006). Typically, human capital is difficult to measure. Duranton and Puga (2004) argued this type of externality usually goes through the communication of educated workers more efficiently.

From the time series perspective, the education level increases overall across whole industries in the Denver area; however, the variations in education levels for different industries may vary. Controlling for education level such as human capital spillovers and productivity will allow to check the impact of diversity and specialization of an industry in a region.

The education level variable in CPS is a categorical variable. Before 1992, the coding for education level was based on the number of years of education, but after 1993, the coding for education attainment changed, reflecting 10 different education levels. Since before 1992, the coding reflects the years of education, in order to merge the data consistently across time, 1991 to 1992 education attainment was recoded to match the 1993 education levels.

3.2.8 Producer Price index (PPI)

The producer price index for finished consumer goods was obtained from the Federal Reserve Bank of St. Louis website.[20] Producer Price Index is used to convert the nominal value to real value for average wages, estimated material costs, and estimated output.

3.2.9 Housing Price Index

A quarterly housing price index for the Denver-Aurora-Broomfield Metropolitan area was obtained from the Office of Federal Housing Enterprise Oversight (OFHEO).[21] This index measures the average price change from the repeated sales of the same properties. The housing price index is then used to control for the aggregate housing and land price growth patterns in the Denver area. Furthermore, Glaeser (2009) also pointed out housing price is an important factor for individuals' migration decisions. Not including this variable may create biased results.

3.2.10 Time Trend Variables

In this analysis, several different time trend variables are used. They include a simple time trend, Denver Metropolitan geographical population (including Adams, Arapahoe, Denver, Douglas, and Jefferson counties), and Colorado's total population. A simple time trend is created from the first quarter of 1991, where T=1, to the fourth quarter of 2005, where T=60. The other two time trend variables, Denver Metropolitan geographical population and Colorado's total population, are used to control for the

[20] Detailed information can be found at http://research.stlouisfed.org/fred2/categories/31.
[21] Fourth quarter 2008 Manipulatable Data for the Metropolitan Statistical Areas (MSAs) was downloaded from http://www.ofheo.gov/hpi_download.aspx.

general growth pattern from the larger geographic area, such as surrounding counties or the entire state. Also, a time trend variable is used to control for the general influences of omitted variables that were not included in the model over time.

3.2.11 Seasonal Dummy

There are also three seasonal dummy variables. *Sesaon1* represents the 1st quarter; *Season2* represents the 2nd quarter, and *Season3* represents the 3rd quarter. These dummy variables are created to account for seasonal patterns in several industry sectors, such as Construction, Manufacture, Retail Sales, and Accommodations and Food Services due to weather and the holiday shopping season. For example, during the 4th quarter, the retail sector hired more workers for the holiday shopping season; then, hiring dropped dramatically in the 1st quarter of the next year. This type of pattern can also be seen in the estimated output.

3.2.12 Stadium Dummy

For estimating the impact of building a new stadium, three stadium dummy variables were created for Coors Field (*Coors*), Pepsi Center (*Pepsi*) and Invesco Field (*Invesco*). The dummy variable equals 1 at the beginning of stadium construction. Also, according to previous literature, such as Baade (1996) and Coates and Humphreys (1999), the novelty of building a new stadium wears off in about 10 years. Since our analysis covers the years from 1991 to 2005, the three dummy variables are generated as follows: the beginning of construction of Coors Field in October 1992, then *Coors*=1 after 1992, 4th quarter, where T=8; *Pepsi*=1 after 1998, 1st quarter, where T=29; and *Invesco*=1 after

1999, 3rd quarter, where T=35.

3.2.13 Structure Dummy

The Structure dummy variable is created to control for the whole economy structural change after 2001, 3rd quarter, as described previously. So *Structure* = 1 after T = 44, and *Structure* = 0 before that.

3.3 Other Labor Supply Equation Variables

Previous labor supply literature shows the labor supply depends heavily on occupation, education, work experience, age, and gender. The next section provides a detailed description of each variable used in the empirical work.

Demographic data from 1991 to 2005 were obtained from the monthly Current Population Survey (CPS), which is conducted by the Bureau of Census for the Bureau of Labor Statistics. CPS reports demographic data on a monthly basis, and it provides comprehensive data for education, age, gender, race and income. Furthermore, CPS reported respondents' primary job industry by SIC (Standard Industrial Classification) before 2002, but by NAICS after 2003. To calculate average demographic values consistently from 1991 to 2005, a crosswalk from SIC to NAICS is required for the data from 1991 to 2002. The SIC to NAICS reference table was obtained from the Economics Census.[22] However, a crosswalk from 4-digit SIC to 6-digit NAICS is not an exclusively one-to-one relationship. That is possible only at a higher aggregated level, such as at the 2-digit level. Before 2002, CPS aggregated 4-digit SIC into 51 categories, and this

[22] Detailed information can be referenced from http://www.census.gov/epcd/ec97brdg/.

classification allows a crosswalk from SIC to 20 main 2-digit NAICS sectors. Also, to my knowledge, this is the first of this type of research to use an NAICS basis for analyzing the impact of building a stadium on the labor market.[23]

Table 3-3 shows the average for the demographic data, including educational level, gender, age, race, and family income in seven industry sectors.

Table 3-3 Mean of Each Variable used in the Labor Supply Regression

Industry (NAICS)	Education Level	Gender	Age	Race	Family Income
Construction (23)	12.28	0.88	38.75	0.42	10.45
Wholesale Trade (42)	13.50	0.68	41.52	0.75	11.14
Retail Trade (44-45)	13.95	0.66	40.90	0.64	11.30
Transportation and Warehousing (48-49)	13.02	0.50	35.55	0.93	9.91
Information (51)	13.44	0.72	42.92	0.64	11.05
Finance and Insurance (52)	14.77	0.55	39.08	0.59	11.99
Professional, Scientific, and Technical Services (54)	13.98	0.47	37.88	0.61	11.19
Accommodation and Food Services (72)	12.33	0.53	34.26	0.91	9.68

3.3.1 Education Attainment

For the definition and detailed discussion of this variable please see section *3.2.7*. From a labor supply perspective, the higher the education level, the higher the expected earnings.

3.3.2 Gender

Gender is one important factor that affects the labor supply. Including this variable controls for gender differences. Gender = 1 is recoded for males, and Gender = 0 for females. Furthermore, calculating the average gender index, which is also the gender proportion, for each industry demonstrates gender combination changes over time for

[23] Some sectors of the 4-digit SIC cannot completely crosswalk to 6-digit NAICS, so I chose to crosswalk the major sectors of 2-digit SIC to major 2-digit NAICS sectors.

each industry. For example, if Gender = 0.45, 45% of the population working in a specific industry sector is female.

3.3.3 Age

CPS reports the respondents' age. Calculating the average age by industry over time will show age fluctuation for each industry sector. This variable is included to control for potential work experience.

3.3.4 Race

Before 1992, there were only five categories for race: White, Black, American Indian, Asian and other. After 1993, twenty-one categories for Race were included. To merge this data consistently over time, data after 1993 had to be recoded to conform to the original 5 categories. Usually, for a labor supply equation, researchers use dummy variables for estimating the differences between racial groups. However, this research uses aggregate level data, so it is not reasonable to use four race dummies to represent the different groups. Variance of race is used for presenting the variety of races employed in a specific industry. The higher the variance, the greater the diversity of races in that industry.

3.3.5 Family Income

Family income is coded into 15 different groups by CPS from the lowest category, less than $5000 per year, to the highest category, more than $75,000 per year. Individual's work decisions depend on their wealth. However, because data for wealth is not available, family income is used as the indicator of total wealth since they are highly correlated.

Other variables that are used in the labor supply equation have been explained in the foregoing labor demand side factors section.

3.3.6 Summary of Variables for Stadium Research

The main contribution of this chapter is to combine QCEW, CPS, FRED, and OFHEO datasets in order to calculate aggregate variables, such as, average employment, average wage, material costs, estimated output, etc., and aggregate indices, such as, education and gender, and specialization, competition, and diversity indices. As in most regional development literature, the unit of observation in this research is 2-digit NAICS in Denver County from 1991.1 to 2005.4. This dataset contains 60 observations for each industry sector, and those variables are used to calculate dynamic externalities in Chapter 3, the impact of building a new stadium in the Denver area in Chapter 4, and dynamic externalities and regional growth in Chapter 5.

3.4 Dynamic Externality Indices for Specialization, Diversity, and Competition

Previous empirical works use various indices for measuring specialization, diversity and competition for determining the impact of these characteristics on growth. Beaudry and Schiffauerova (2009) summarize the majority of literature, and conclude that results depend heavily on the choice of industry sector, industrial aggregate level, geographic area, geographic level and the time period.[24] The following section will

[24] Ellison and Glaeser (1997) show specialization and diversity indices may be randomly distributed across

provide the various indices for calculating specialization, competition and diversity. And although there are many ways to measure each index, only the indices for which data are available (Table 3-1) are listed. Those indices can be categorized into three groups: size, share and others. Size indicates the absolute size of the industry in the county. Share represents the relative size of the industry in the county compared to the whole economy. Others include all other measurements.

This analysis uses the same data set presented in the first part of Chapter 3. Each variable used for calculating specialization, diversity and competition indices is defined in Table 3-4.

Table 3-4 Variable List

$Emp_{s,z,t}$= the industry *s* employment in county *z* at time *t*
$Emp_{z,t} = \sum_{s=1}^{S} Emp_{s,z,t}$= the total employment in county *z* at time *t*
$Emp_{s,t} = \sum_{z=1}^{Z} Emp_{s,z,t}$= the total industrial *s* employment in Colorado at time *t*
$Emp_{t} = \sum_{s=1}^{S} \sum_{z=1}^{Z} Emp_{s,z,t}$= the total employment of Colorado at time *t*
$n_{s,z,t}$= the number of industry *s* firms in county *z* at time *t*
$n_{z,t} = \sum_{s=1}^{S} n_{s,z,t}$= the total number of firms in county *z* at time *t*
$n_{s,t} = \sum_{z=1}^{Z} n_{s,z,t}$= the total number of industrial *s* firms in Colorado at time *t*
$n_{t} = \sum_{s=1}^{S} \sum_{z=1}^{Z} n_{s,z,t}$= the total number of firms in Colorado at time *t*
g_z = effective geographic size of county *z*

cities at 4-digit industrial sectors.

$g = \sum_{z=1}^{Z} g_z =$ effective geographic size of Colorado

where *s* represents the industry sector; *z* represents the county; and *t* represents time

3.4.1 Specialization/Concentration Index

3.4.1.1 Employment Within Industries

The employment within industries is defined as follows:

$Emps, z, t$= industry *s* employment in county *z* at time *t*

$Emp_{s,z,t}$ is used for controlling for the pure size effect of the region, and is also typically used for controlling for the regional fixed effect (Glaeser et al, 1992; Bline et al, 2006). The higher the $Emp_{s,z,t}$, the larger the industry in the region, and it also may be interpreted as the higher the specialization. However, $Emp_{s,z,t}$ does not consider the geographic size, so the interpretation may be misleading because $Emp_{s,z,t}$ is more likely larger when the region size is larger.

3.4.1.2 Number of Industry Firms

Number of industry firms is defined as follows:

$n_{s,z,t}$= the number of industry *s* firms in county *z* at time *t* (3-3)

Similar to $Emp_{s,z,t}$, $n_{s,z,t}$ is used for controlling for pure size effect of the region and regional fixed effect. The higher the $n_{s,z,t}$, the larger the industry in the region, and it also may be interpreted as the higher the specialization. However, it may be confusing because $n_{s,z,t}$ is more likely larger when the region size is larger.

3.4.1.3 Employment Density

The employment density is defined as follows:

$$Densitys, z, t = \frac{Emp_{s,z,t}}{g_z} \tag{3-4}$$

$Density_{s,z,t}$ is calculated by dividing employment within industries by the affected geographic size. This index takes geographic size into consideration for better interpretation of concentration because sometimes there is a natural geographic limitation in a region, and only certain areas can be used for production. Considering only the affected geographic area, $Density_{s,z,t}$, provides a better indicator of opportunities for people to interact. However, sometimes the affected geographic area is not easy to define and can change with time.

3.4.1.4 Employment Share

The employment share is defined as follows:

$$Share_{s,z\,,t} = \frac{Emp_{s,z,t}}{Emp_{z,t}} \tag{3-5}$$

In this formula, area industry employment is compared to the total employment in the region. The higher the $Share_{s,z\,,t}$, the higher the specialization of the industry focus. Furthermore, this index can be used for identifying the structural change within a region by comparing this index across time by industry. For example, the manufacturing sector's employment has been decreasing and the service sector's employment has been increasing over recent decades. $Share_{s,z\,,t}$ will show a decreasing pattern for the manufacturing sector, and $Share_{s,z\,,t}$ will show an increasing pattern for the service sector. However, this index is misleading when there is a structural change in the whole economy. For example, for industry *s* in region *z*, the employment share is still relatively higher than in other regions over time, but this index does not indicate that clearly because $Share_{s,z,t}$ represents a decreasing trend, even though industry *s* in region *z* is highly concentrated.

3.4.1.5 Relative Employment Share

The relative employment share is defined as follows:

$$Speci_{s,z,t} = \frac{\frac{Emp_{s,z,t}}{Emp_{z,t}}}{\frac{Emp_{s,t}}{Emp_t}} \quad (3\text{-}6)$$

Relative employment share index is measured by the ratio of industrial employment share in that county, relative to the share of industrial employment in Colorado as a whole. This measures the relative industrial share employment and also can be interpreted as the degree of a region's specialized employment. The advantage of this index is it considers the structural change of the whole economy. If the index is greater than one, the region has a relatively higher industrial concentration in the region compared to the entire state of Colorado. Also, according to the MAR theorem, the larger the index, the higher the specialization of an industry in the region.

3.4.1.6 Relative Density Employment Share

The relative density employment share is defined as follows:

$$Rel\ Sepci_{s,z,t} = \frac{\frac{Emp_{s,z,t}/g_z}{Emp_{z,t}/g_z}}{\frac{Emp_{s,t}/g}{Emp_t/g}} \quad (3\text{-}7)$$

This index is similar to relative employment share, but it also considers the geographic size. This index gives the same results as relative employment share, but it provides a better interpretation of specialization.

The summary of the definition, expected sign, and categories of each variable included in calculating specialization are listed in Table 3-5. Definitions and categories for each variable have been discussed above. Also, according to MAR theory, the expected sign column shows the sign when a higher specialization of industry occurs in a region.

Table 3-5 Definitions and Expected Signs for Specialization and Concentration Index

Determinants	Expected Sign	Category	Definition
Specialization or Concentration Index			
a. Employment Within Industries	+	Size	$Emp_{s,z,t}$ is calculated for each industry *s* employment in county *z* at time *t*
b. Number of Industry Plants	+	Size	$n_{s,z,t}$ is calculated for the number of industry *s* firms in the county *z* at time *t*
c. Employment Density	+	Size	$Density_{s,z,t}$ is measured by dividing industry employment by the effected geographic size for county *z*. $\text{Density}_{s,z,t} = \frac{Emp_{s,z,t}}{g_z}$
d. Employment Share (Simple Location Quotient)	+	Share	$\text{Share}_{s,z,t}$ is calculated by dividing each industry *s* employment by the total employment in county *z* during time *t*. $\text{Share}_{s,z,t} = \frac{\text{Emp}_{s,z,t}}{\text{Emp}_{z,t}}$
e. Relative Employment Share	+	Relative Share	It is measured by the ratio of industry *s* employment share in county *z* relative to the share of industrial *s* employment in the whole region during time *t*. $\text{Speci}_{s,z,t} = \frac{\frac{Emp_{s,z,t}}{Emp_{z,t}}}{\frac{Emp_{s,t}}{Emp_t}}$
f. Relative Density Employment Share	+	Relative Share	This measures the ratio of industry *s* employment density share in county *z* relative to the share of industry *s* employment density in the whole region

			during time *t* $$Rel\ Speci_{s,z,t} = \frac{\frac{Emp_{s,z,t}/g_z}{Emp_{z,t}/g_z}}{\frac{Emp_{s,t}/g}{Emp_t/g}}$$

3.4.2 *Diversity*

3.4.2.1 Glaeser's Diversity

Glaeser's diversity is defined as follows:

$$Glaser\_Div_{s,z,t} = \frac{\sum_{s' \neq s} Top\ 5\ ind\ Emp_{s'z,t}}{Emp_{z,t} - Emp_{s,z,t}} \qquad (3\text{-}8)$$

Following Glaeser's (1992) paper, the diversity index presents the fraction of employment in a city's top five industries compared to the total employment in the region, excluding the industry specific employment being calculated. The numerator is the summation of employment in the top five industries, excluding the industry measured. In other words, if industry *s* is one of the top five employment industries in the city *c* at time *t*, then the employment of this sector will not be included, but the sixth largest industry employment will replace it. However, if industry *s* is not one of the top five employment industries in the region, then its employment will not change the numerator for the region when the index is calculated. The denominator calculates the total employment excluding the industry specific employment being calculated. This index changes across regions, industries, and time. Also, this index is usually between 0 and 1.[25] If this index is relatively close to one, it implies these five industries represent a large share of the overall employment, meaning there is low diversity in that region. Lower values indicate

[25] However, if there are fewer sectors in the region, then the index maybe greater than 1.

industry *s* in the region faces a higher diversity environment. However, this index is only reasonable for use in larger geographic areas with higher levels of industry classification. When the geographic area is small, there may be only a few industry sectors (perhaps only 5), in the region. In this case, the index could be greater than one. Furthermore, another drawback of this index is that new and small industries may have potential growth in a region in the future, but these groups of data are not considered in diversity index, which may create biased results.

The Hirschman-Herfindahl Index (HHI) is the most popular index for diversity, and HHI has been used in several different styles in previous studies.

3.4.2.2 Simple HHI

The simple HHI is defined as follows:

$$HHIz,t = \sum_{s=1}^{S} \left(\frac{Emp_{s,z,t}}{Emp_{z,t}}\right)^2 \tag{3-9}$$

This simple HHI index calculates the summation of the share of industry *s* employment in the region *z* during time *t*. This index changes across cities over time, and is always between 0 and 1. If a city's employment is highly concentrated in only one type of industry, this index will be approximately one. The smaller the number of the Simple HHI, the higher the diversity in a city. Furthermore, some previous researchers used the inverse simple HHI to measure diversity for easier interpretation. The higher the inverse simple HHI, the greater the diversity. When the inverse HHI equals one, employment in a region is highly concentrated in one industry only, and when this index reaches its minimum value, local employment is uniform in the region.

3.4.2.3 Improved HHI

The improved HHI is defined as follows:

$$HHIs,z,t = -\sum_{s'=1}^{S}\left(\frac{Emp_{s',z,t}}{Emp_{z,t}-Emp_{s,z,t}}\right)^2 \quad (3\text{-}10)$$

The improved HHI is similar to the previous simple HHI. It measures the diversity for industry *s* by the surrounding industrial environment in the region *z* over time *t*. As industry s faces a more even industrial employment distribution in region *z*, the lower the HHI will be, which indicates the greater the diversity. In other words, when HHI is higher (approaching one), the distribution of the employment in region *z* faced by industry *s* is more concentrated in several industrial sectors, which indicates less diversity. This index varies across industry and region over time, and the index is usually between 0 and 1. However, when the geographic area is smaller (such as Gilpin county) or there are too few industrial sectors in that region (such as Rio Blanco County), then the index maybe greater than 1. Furthermore, some previous researchers may have used the inverse improved HHI to measure diversity for easier interpretation. This inverse improved HHI, with a higher index value implies the environment faced by industry s in region *z* is almost identical to other industries, which indicates higher diversity. When the inverse HHI is closer to one, employment in a region is highly concentrated in one industry. Finally, when using this type of index, either improved HHI or inverse improved HHI for estimating employment growth in logs, there is an identification issue because of perfect collinearity when $Emp_{z,t}$ is also included (Combes, 2000a; Bline et al. 2006).

3.4.2.4 Relative HHI

The relative HHI is defined as follows:

$$HHIs,z,t = \frac{1 \Big/ \sum_{\substack{s'=1 \\ s' \neq s}}^{S} \left(\frac{Emp_{s',z,t}}{Emp_{z,t} - Emp_{s,z,t}}\right)^2}{1 \Big/ \sum_{\substack{s'=1 \\ s' \neq s}}^{S} \left(\frac{Emp_{s',t}}{Emp_{t} - Emp_{s,t}}\right)^2} \tag{3-11}$$

This index represents the relative diversity faced by industry *s* in region *z* at time *t* compared with the diversity faced by industry *s* elsewhere in Colorado. If this index is greater than one, it implies the diversity environment faced by the industry in the region is greater than the environment in the state of Colorado. The advantage of using this index is relative HHI is not necessarily directly collinear with its own industrial employment for the region, which also avoids the perfect collinearity issue (Combes, 2000b).

3.4.2.5 Krugman HHI

Krugman HHI is defined as follows:

$$Krugman\_divs,z,t = -\sum_{s'=1,s'\neq s}^{S} \left|\frac{Emp_{z,s',t}}{Emp_{z,t}} - \frac{Emp_{s',t}}{Emp_{t}}\right| \tag{3-12}$$

The other diversity index is Krugman diversity index, which sums the absolute values of differences between regional employment share and national employment share for all industries except the industry that is under consideration. The basic concept of this index is to measure the local economic structure compared to the average whole economic structure. If this index equals zero, it implies the surrounding economic environment of industry *s* in region *z* is the same as the whole economic environment.

However, if the index is extremely small (with a negative sign in front of it), it implies the surrounding economic environment of industry *s* in region *z* is a lot different compared to the whole economy, which also implies the industry *s* faces a more concentrated environment, indicating less diversification. The other advantage for using this index for measuring diversity is it avoids perfect collinearity as described earlier.

Table 3-6 summarizes the definition, expected sign, and categories of each variable for calculating diversity indices.

Table 3-6 Definitions and Expected Signs for Diversity Index

Determinants	Expected Sign	Category	Definition
Diversity Index			
a. Glaeser Diversity	+	Size	It measures the fraction of employment in a city's top five industries compared to the total employment in the region, excluding the industry specific employment being calculated in the region *z* during time *t*. $Glaeser\_Div_{s,z,t} = \frac{\sum_{s' \neq s} Top\ 5\ ind\ Emp_{s'z,t}}{Emp_{z,t} - Emp_{s,z,t}}$
b. Simple HHI	-	Size	Calculates the summation of the share of industry *s* employment in region *z* during time *t*. $HHI_{z,t} = \sum_{s=1}^{S} \left(\frac{Emp_{s,z,t}}{Emp_{z,t}} \right)^2$
c. Improved HHI	-	Size	Measures the diversity for industry *s* by the surrounding industrial environment in region *z* over time *t*. $HHI_{s,z,t} = \sum_{s'=1}^{S} \left(\frac{Emp_{s',z,t}}{Emp_{z,t} - Emp_{s,z,t}} \right)^2$
d. Relative HHI	+	Relative Share	Represents the relative diversity in industry *s* in region *z* at time *t* compared with the diversity faced by an industry *s* in the whole region.

			$HHI_{s,z,t} = \frac{1 \Big/ \sum_{\substack{s'=1 \\ s' \neq s}}^{S} \left(\frac{Emp_{s',z,t}}{Emp_{z,t} - Emp_{s,z,t}} \right)^2}{1 \Big/ \sum_{\substack{s'=1 \\ s' \neq s}}^{S} \left(\frac{Emp_{s',t}}{Emp_t - Emp_{s,t}} \right)^2}$
e. Krugman HHI	+	Size	This index sums the absolute value of the difference between regional employment share and national employment share for all industries except the industry *s* under consideration during time *t*. $Krugman\_div_{s,z,t} = -\sum_{s'=1, s' \neq s}^{S} \left| \frac{Emp_{z,s',t}}{Emp_{z,t}} - \frac{Emp_{s',t}}{Emp_t} \right|$

3.4.3 Local Competition

3.4.3.1 Local Competition

The local competition is defined as follows:

$$Comps,z,t = \frac{\frac{n_{s,z,t}}{Emp_{s,z,t}}}{\frac{n_{s,t}}{Emp_{s,t}}} \tag{3-13}$$

Glaeser's (1992) local competition measurement focuses on the local competition of industry *s* in region *z* at time *t* is measured by the number of firms per industrial worker in the region, relative to the number of firms per worker throughout Colorado. If this index is greater than one, it means the number of local firms in that industry available for each industrial worker in that region is greater than elsewhere in Colorado. The higher the index, the greater the local competition among the firms in a region. According to Jacob's and Porter's theorems, the higher the local competition index, the greater the chance of externality knowledge spillover between employees, which creates a higher regional growth rate.

3.4.3.2 Inverse Local Competition

The inverse local competition is defined as follows:

$$Inv\_Comp_{s,z,t} = \frac{\frac{Emp_{s,z,t}}{n_{s,z,t}}}{\frac{Emp_{s,t}}{n_{s,t}}} \tag{3-14}$$

Inverse local competition is similar to the above. It measures the relative number of industrial employment per firm in region *z* to the number of industrial employees per firm in all of Colorado. Industrial employment per firm in industry *s* can also be interpreted as the average size of firms in the industry in the region. The average size of firms is relatively smaller in a perfect competition market than in a monopoly. In other words, employment per firm is lower in a perfect competition market than in a monopoly. If this inverse local competition index is greater than one, it implies the average size of the industrial firm is relatively greater than the average size of firms in the whole of Colorado, and also implies less local competition. According to Jacob's and Porter's theorems, the higher the inverse local competition index, the higher chance of externality knowledge spillover between employees within an industry, which creates a higher regional growth rate. However, according to the MAR theorem, monopoly power will internalize the externality knowledge spillover, enhancing growth. The higher the inverse local competition index, the greater the chance of externality knowledge spillover between employees in the same industry, and the higher the growth rate.

3.4.3.3 Relative Local Competition

The relative local competition is defined as follows:

$$Comps,z,t = \frac{1 \Big/ \sum_{i=1}^{I} \left(\frac{Emp_{i,s,z,t}}{Emp_{s,z,t}} \right)^2}{1 \Big/ \sum_{i=1}^{I} \left(\frac{Emp_{i,s,t}}{Emp_{s,t}} \right)^2} \tag{3-15}$$

where *i* represents the individual firm in the region.

The relative local competition index is measured by the sum of industrial employment share squared in the region, divided by the sum of the industrial employment share squared in Colorado. The formula is similar to the simple HHI (which indicates industry employment share at an individual firm). For the numerator, the industrial employment share of each firm in the region can also be interpreted as the size of each firm. The larger the market share of a firm, the higher the monopoly power. The greater the sum of all the firms' shares, the more the industrial firms are behaving like a monopoly. So in the inverse of this summation, the smaller the number, the greater the monopoly power for each firm. In terms of competition, the higher the number, the greater the local competition. Finally, if the relative local competition index is greater than one, there is higher local industrial competition in the region, relative to the whole region. In terms of regional growth, the sign of the relative local competition coefficient helps to determine whether perfect competition or monopoly will enhance growth more. The positive coefficient more favors Jacob's externality; the negative coefficient more favors the MAR externality.

The definition, expected sign, and category for each variable for calculating competition indices are listed in Table 3-7.

Table 3-7 Definitions and Expected Signs for Competition Index

Determinants	Expected Sign	Category	Definition
Competition Index			
a. Local Competition	+	Size	Measures the number of firms per industry *s* worker in region *z* relative to the number of firms per worker in the whole region. $Comp_{s,z,t} = \frac{\frac{n_{s,z,t}}{Emp_{s,z,t}}}{\frac{n_{s,t}}{Emp_{s,t}}}$
b. Inverse Local Competition	-	Size	$Inv\_Comp_{s,z,t} = \frac{\frac{Emp_{s,z,t}}{n_{s,z,t}}}{\frac{Emp_{s,t}}{n_{s,t}}}$
c. Relative Local Competition	+	Size	Measured by the sum of industry *s* employment shares squared in the region, divided by the sum of industrial *s* employment shares squared in the whole region. $Comp_{s,z,t} = \frac{1 \Big/ \sum_{i=1}^{I}\left(\frac{Emp_{i,s,z,t}}{Emp_{s,z,t}}\right)^2}{1 \Big/ \sum_{i=1}^{I}\left(\frac{Emp_{i,s,t}}{Emp_{s,t}}\right)^2}$

The aforementioned sections described the most popular indices for measuring specialization, diversity and local competition. The following section will use Denver and Larimer County data as examples for showing how different diversity indices may provide different interpretations for environmental change over time.

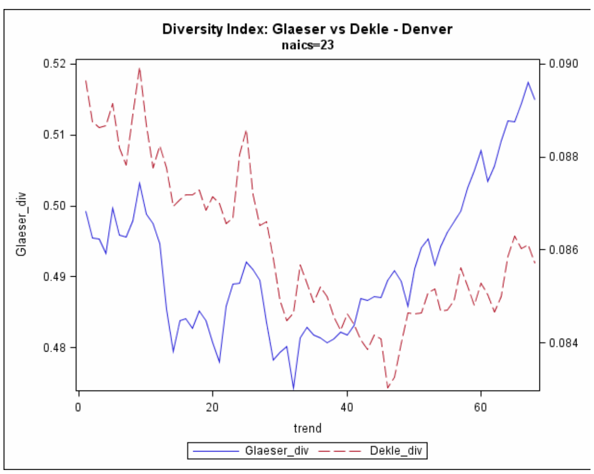
3.5 *Brief Look at Various Diversity Indices and Timing Issue*

3.5.1 *Diversity Index: Glaeser Diversity and Dekle HHI*

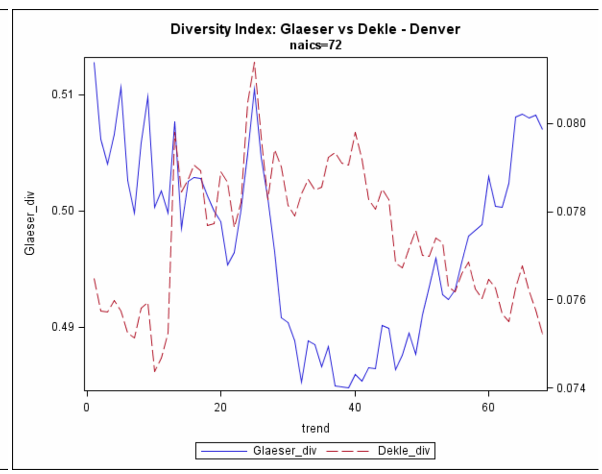
By comparing Glaeser Diversity and Dekle HHI, Figure 3-7, shows that these two indices do not confirm the same information across industries for Denver County. For example, for the Accommodations and Food Services sector, Glaeser's Diversity shows more diversity at the beginning and less diversity later, but Dekle HHI gives the opposite results. However, these two diversity indices confirm the same information for Larimer County (for complete industrial sectors).

Figure 3-7 Diversity Index Comparison for Glaeser and Dekle

Consistent Pattern



Inconsistent Pattern



Furthermore, for most other industry sectors in Denver, the results show that most industries face a greater diversity environment over time, except Professional, Scientific and Technical (NAICS54), Administrative and Support, Waste Mangement and Remediation Services (NAICS56), Health Care and Social Assistance (NAICS62) and Accommodation and Food Services (NAICS72) sectors (Appendix A). The reason the results are different is because the Glaeser Diversity only includes the sum of the top 5 industries' employment in the numerator, but the Dekle HHI includes all industry sectors excluding the one in question. When calculating the Glaeser Diversity index, if the industries are not one of the top 5 in a region during time *t*, the numerator is a constant, but with Dekle HHI the numerator changes as industry sectors change[26]. Another reason may be the industry ranking. Larimer County is stable, but Denver County changes over time, resulting in different consequences for these two indices.

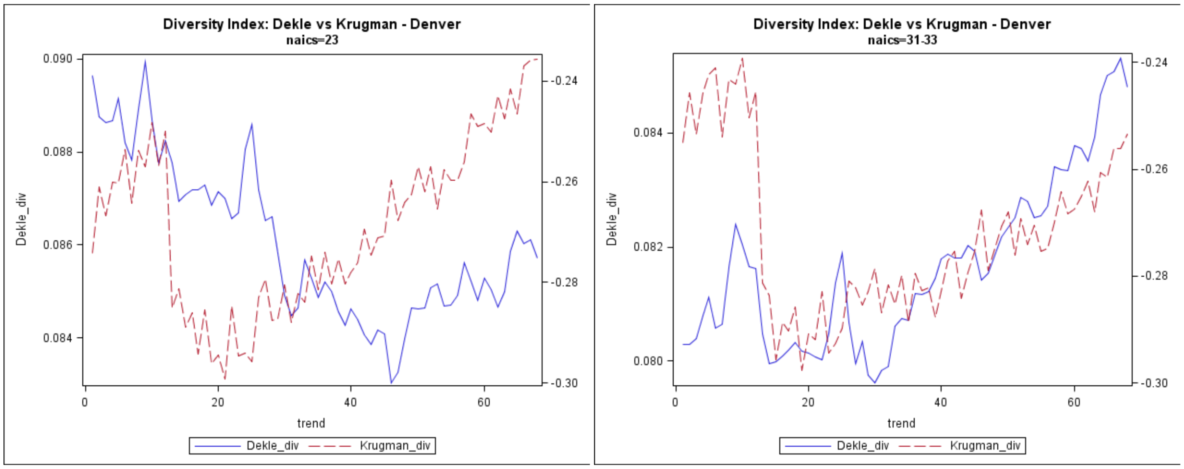
3.5.2 Diversity Index: Dekle HHI and Krugman HHI

Furthermore, comparing the results of the Dekle HHI and Krugman HHI indices, when an environment becomes more diverse, the Dekle HHI is lower and the Krugman HHI is greater. Figure 3-8 shows the inconsistent results of Dekle HHI and Krugman HHI indices for the Manufacturing Sector of Denver County. These two diversity indices do not have stable results across time, and 50% of the industries show different results when comparing these two indices (Appendix A).

[26] If the industry is one of the top 5 in the region, the sixth industry will replace it. If industry *s* is not one of the top five employment industries in the region, then its employment will not change the numerator for the region when the index is calculated. The denominator calculates total employment, excluding the industry specific employment being calculated.

Figure 3-8 Diversity Index Comparison for Dekle and Krugman

Consistent Pattern | Inconsistent Pattern



The reason for the different results is the Krugman HHI considers the relative environment change, from the local environment to the whole economy, but the Dekle HHI only considers the local economy. Also, Krugman HHI index calculates the difference between the local economy and whole economy, which means this index acts more like a random effects index (by removing the structural effect); however, the Dekle HHI includes the local economy which makes this index more likely to consider structural change effects. When employment share for an industry sector changes relatively more than the whole economy, the Dekle HHI and Krugman HHI would logically provide different results.

Appendix A shows the results of Improved HHI and Krugman HHI indices for Larimer county. Most industry sectors show a greater local diversity environment faced by industry *s* over time, except in the Manufacturing sector (NAICS 31-33). The Improved HHI shows a higher diversity environment faced by NAICS 31-33 (the lower the index, the higher the diversity); however, Krugman HHI shows a lower diversity environment (the higher the index, the higher the diversity).

3.5.3 Timing

Another interesting point is the importance of the time periods chosen. Glaeser (1992), Dekle (2002), Cingano and Schivardi (2004) use only two-point time periods for estimating regional growth, which ignore the historical and current pattern of dynamic externalities. For example, for the Construction sector (NAICS 23), the general pattern of Dekle HHI first decreases from 1991.1 to 1999.4 and then increases from 2000.1 to 2007.4. However, if the researcher chooses only two time points in time, say 1991.1 and 2007.4, then the general pattern of Dekle HHI decreases over time. In other words, randomly choosing two time points to calculate the growth rate and the diversity indies does not truly reflect the whole process of regional growth because dynamic externalities change over time, and the results may be biased.

Given the above indices comparison, several important themes should be considered when choosing indices. In sum, it depends heavily on if the index considers the local region's economy or the whole economy, and the time period chosen. These will not only affect the empirical results but also interpretation and conclusions.

3.5.4 Simple Three Industries Examples

For simplification and only to highlight the different conclusions between Improved HHI and Krugman HHI, Table 3-5 presents a simple comparison of three sample industries for City A in 1991 and 2000. Both Improved HHI and Krugman HHI are calculated and the results are as follows:

Table 3-5 Employment Share for City A in 1991 and 2002 Example

	City A	Whole Economy structure is Fixed	Whole Economy Structural changes
Year=1991			
Industry 1	0.3	0.3	0.3
Industry 2	0.2	0.3	0.3
Industry 3	0.5	0.4	0.4
Year=2000			
Industry 1	0.3	0.3	0.3
Industry 2	0.4	0.3	0.15
Industry 3	0.5	0.4	0.55

For example, in 1991 the employment share in City A for industry 1 is 0.3, for industry 2 is 0.2 and for industry 3 is 0.5. Then, Improved HHI for industry 1 in City A is $\frac{29}{7}$ for 1991 and is $\frac{25}{7}$ for 2000, indicating industry 1 experienced a higher diversity environment in 2000. From the Krugman Index perspective, if the whole economy structure does not change in 1991 and 2000, i.e., the employment share for each industry is constant, Krugman HHI is -0.3 for 1991 and -0.2 for 2000. It presents the same results as the Improved HHI.[27] However, if whole economy also changes, and the industry structure at the whole economy level changes more than the local economy (3rd column), the Krugman HHI is -0.45 for 2000. This would mean, according to the Krugman Index, industry 1 in City A is becoming less diverse, which indicates a different conclusion from that of the Improved HHI's.

[27] If we assume the employment share for the whole economy does not change, then second term, $\frac{Emp_{s',t}}{Emp_t}$, is a constant, and the results will depend only on the first term, $\frac{Emp_{z,s',t}}{Emp_{z,t}}$. Calculating the Krugman Index for industry 1 in City A for 1991 results in -0.3 and for 2000, -0.2. According to the Krugman Index, there was a greater diversity environment for industry 1 in city A in 2000.

3.6 Summary for Dynamic Externalities and Future Research

There are various indices for measuring specialization, localization, and competition; however, it has not yet been examined which indices are most accurate for capturing regional growth using the same dataset. Furthermore, work by Beaudry and Schiffauerova (2009) suggest that dynamic externality indices are heavily dependent on industrial sectors and the geographic area chosen. The questions I hope to address through this research in Chapter 5 are (i.) which dynamic externality indices provide the best better explanation, estimation and predictions for regional employment growth, and (ii.) which indices are most stable across varying industrial sectors and geographic areas. So far, I have compared Glaeser Diversity, Improved HHI and Krugman HHI, and further comparison between specialization and competition indices will be performed. Finally, the results from this chapter will be used in Chapter 5 for estimating the dynamic externality and regional growth for the Denver area using different econometrics estimation techniques.

CHAPTER 4: FIRST APPLIED STUDY: THE IMPACT OF BUILDING THREE STADIUMS IN THE DENVER AREA ON ITS REGIONAL LABOR MARKET

The sports industry is an important sector of the U.S. economy. In 1997, the sports industry, with annual expenditures of $152 billion, ranked 11th among America's largest industries (Meek, 1997; Pitts and Stotlar, 2002). Since 1961, the total investment in stadiums and arenas used by professional leagues was $23.8 billion (in 2003 dollars). Various public funding supported approximately 64% of the total expenditures, about $15.2 billion. Since 1990, thirty-five new stadiums or arenas have been built in the United States for professional sports teams (Siegfried and Zimbalist, 2000). The total cost of these facilities was about $7.2 billion, of which $5 billion came from public sources (Howard and Crompton, 2004). The debate surrounding stadium construction with public funding has a long history.

4.1 Pros vs. Cons of Building Stadiums with Public Funding

Those in favor of public funding for sports stadiums emphasize their positive impacts on the local community and economy. Those impacts can be categorized as follows. First, attracting a professional sports franchise to a city or building a new stadium or arena, is a catalyst for growth in the local economy, increasing sales, creating new jobs, attracting new businesses, raising income per capita, and enlarging tax revenues. Secondly, it also creates *nonpecuniary* benefits for the community. Pappaport and Wilkerson (2001) point out several reasons why a sports franchise might make a metro area a more attractive place to live. For example, happiness is enhanced for sports fans when they are able to attend home games, and root for a local team. In addition, the team's performance is often at the top of daily conversation among friends. Furthermore, sport franchises improve the happiness of the non-sports fans by facilitating civic pride. According to Johnson, Groothusi and Whitehead (2001), 72% of residents in Pittsburgh identify themselves as Penguins fans, even though more than 40% of them never attend games. Proponents further claim that since stadiums and franchises have public good characteristics, it is reasonable for state and local governments to subsidize stadium construction.

However, opponents argue that public funding does not have the impacts identified by proponents. First, major direct expenditures related to attending a game only occur within the stadium itself, such as luxury box, food, and souvenir purchases, and the impact is limited to the small stadium economy. It is very unlikely that spending in those direct sectors can increase aggregate spending in the entire region in which they are located. Also, since players, coaches and managers usually do not spend their money in the same region, their large salaries will have a limited indirect impact on the region. (Baade, 1994 and 1996; Noll and Zimbalist, 1997; Zimbalist, 1998 and 2006). Second, Noll and Zimbalist (1997) argue public subsidies for stadiums takes funding away from other public construction or economic development projects, such as for education and local infrastructure. Opponents insist those public funds should actually go to sectors with a higher impact for the whole economy. However, Coates and Humphreys (1999) show that compared to cities without stadiums, the quality of a stadium city is not actually lower, and Richmond's (1997) observation about Baltimore supports that viewpoint.

"The city is full of ruined houses, the jails are overcrowded, the dome is falling off City Hall, there are potholes in the streets, crippled children cannot get to school, taxes are up and services are going down – but we are going to have a sports complex (163)."

Third, some economists argue that stadium subsidies might decrease local development because professional sports and stadiums directly create only unskilled and labor-intensive jobs, which are low-wage and seasonal. Furthermore, most of the money spent on attending to a game is simply substituted from other local entertainment options (Baade and Dye, 1990; Hudson, 1999; Rosentraub et al., 1994). In addition, opponents suggest the sports environment may make workers less productive because of time spent discussing local teams at work (Carlion and Coulson, 2004; Noll and Zimbalist, 1997). Finally, they point out that building a new stadium will bring traffic congestion, noise, pollution, and increased criminal activities around that facility, which will cause housing prices to decline in the areas surrounding construction, and employers may need to pay more to compensate for these negative amenities (Coates and Humphreys, 1999; Nelson (2002); Noll and Zimbalist, 1997; Johnson, et al., 2001; Tu, 2004).

However, both proponents and opponents aknowledge the cultural value created by sports franchises and stadiums, and they all agree that the cultural benefit of having a sports franchise and stadium may be more important than its business success (Noll and Zimbalist, 1997, 2001, and Johnson et al., 2001).

4.1.1 The Bright Lights Hypothesis

Most stadium proponents, including most governors, agree with the Bright Lights Hypothesis, which states that building a stadium will make the city more attractive, so one should expect more firms would like to locate near a stadium and more people would like to move to a stadium city for better job opportunities (Borts and Stein, 1964) and a better quality of life resulting from the positive amenity factors.

When the building of Coors Field in Denver was first announced in 1990, the external environment of the region changed along with the structure of the local economy. Business managers already in the Denver area reacted to this change. For example, restaurant and hotel managers interpreted this change as a new market that would attract more customers and provide better accessibility. They might open a new business, enlarge the scale of their original business, or hire more employees to be able meet the anticipated increase in market demand. Those reactions will create higher labor demand, and therefore more jobs. Likewise, this was anticipated that this change would attract more people to live in the Denver area due to greater job availability or to enjoy the sports amenities in the city. The goal of this research is to analyze the economic impact of the three stadiums built in the Denver area on its regional labor market. The question this research will ask is “Did building new stadiums in the Denver area impact its regional labor market?”

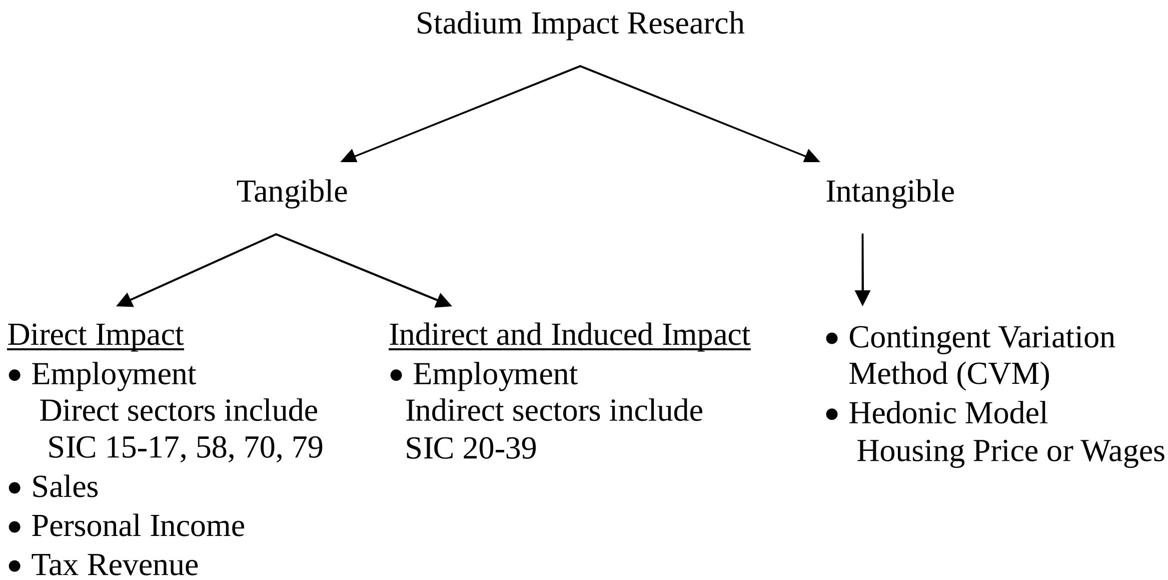
4.2 Literature Review

Baade and Dye (1988) propose that if a stadium generates benefits for a local economy, those benefits should be apparent in four areas: (1) increased direct municipal revenues from the stadium; (2) increased income and sales in the area; (3) increased attraction of unrelated businesses; and (4) enlarged intangible benefits, such as the civic pride, and psychological identification or quality-of-life for a region's improvement.

Literature on stadium impact can be divided into two main categories as shown in Figure 4-1. (1) *Tangible* effects: those which focus on employment impacts or the impact on personal income for direct and induced impact industry sectors. The direct industry sectors include Construction (SIC 15-17), Eating and Drinking Establishments (SIC 58), Hotels and Other Lodging (SIC 70), and Amusement and Recreation (SIC 79), which are directly related to a stadium and associated with the initial injection of expenditure. The indirect and induced sectors include Manufacturing (SIC 20-39), Wholesale Trade (SIC 50-51), etc. These sectors represent the ripple effect of additional rounds of reinputting the initial expenditure. One direct way to analyze the impacts of building or renovating a stadium is to look at the impact on regional employment, local wage rates or real per capita income for direct and non-direct industry sectors. These studies use cross-section data, time-series data, or both to investigate whether the presence of a professional franchise or the construction or renovation of a stadium impacts the local economy. (2) *Intangible* effects: those which focus on *nonpecuniary* benefits, such as measuring of the quality-of-life improvement through the hedonic model. Individuals' choice of where to live depends on many factors. They take into account the presence of good jobs, a good housing market, nice weather, and the presence of supported professional franchises. Quality-of-life captures the happiness of residents due to sharing metro area attributes.

The following sections show tangible and intangible effects of building a new stadium in relevant research.

Figure 4-1 Stadium Impact Research



Note: SIC 15-17: Construction; SIC 20-39Manufacturing; SIC 58: Eating and Drinking Establishments; SIC 70: Hotels and Other Lodging; SIC 79: Amusement and Recreation Services

4.2.1 Tangible Effects

The main argument is that if a new stadium really does brighten metropolitan economic activity, then real per capita income growth should increase, compared to cities without a stadium because it either attracts new money from other cities, or the city can retain money previously spent outside the city. However, if the results do not show a statistically significant impact on aggregate employment or real per capita income growth, it may imply that consumer spending on stadium sports is simply replacing other leisure expenditures, rather than generating a new source of revenue.

4.2.1.1 Negative Results

Baade and Dye (1988) argue that if the impact of a stadium cannot be seen in whole categories, tangible as well as intangible areas, we should at least expect to see the impact on the direct municipal revenues from stadium activities, i.e., increased food, beverage, and retail sales; increased construction employment; and attraction of unrelated business activity, i.e., increased manufacturing employment. For testing this business attraction hypothesis, Baade and Dye chose eight different Standard Metropolitan Statistical Areas' (SMSA) manufacturing sectors as unrelated businesses from 1965-1978. [28] By controlling for population, stadium construction and other variables, they found the most SMSAs, except San Diego, showed no significant positive relationship between building a stadium and manufacturing employment. None of the SMSAs showed a statistically significant impact on total output value. Only Cincinnati and San Diego had a positive impact on new capital expenditures. Baade and Dye concluded that without intangible values, direct stadium revenue is not sufficient to cover the subsidy, nor is there a statistical increase in metropolitan economic activity for indirect sectors after building or renovating a stadium.

Baade and Dye (1990) undertook a similar analysis in their 1988 research, evaluating the influence of stadiums and professional sport teams on both levels of income and shared regional aggregate income for nine different metropolitan areas between 1965 and 1983.[29] By controlling for the population, stadium, franchise movement, and time trends, they found that building or renovating a stadium generally did not have a significant positive impact on the level of aggregate income, except in

[28] Buffalo, Cincinnati, Denver, Miami, New Orleans, San Diego, Seattle, and Tampa Bay
[29] Cincinnati, Denver, Detroit, Kansas City, New Orleans, Pittsburgh, San Diego, Seattle, and Tampa Bay

Seattle. They also found the same results on aggregate income due to gaining a new professional franchise. Furthermore, for the relative regional income, they also found that building or renovating a stadium may have a potentially negative impact on relative income, such as in Cincinnati, Detroit, Kansas City and Tampa Bay. Also, for the direct sectors, such as retail sales, having a new sports franchise or a new or renovated stadium in a city does not have a positive impact on the relative regional income. In sum, the results suggested a possible negative impact from a new or renovated stadium on the levels and share of personal income in an SMSA. However, at the end of the paper, the authors agree that intangible economic benefits such as civic pride or psychological identification do exist, but that they are not significant enough to compensate for large public subsidies.[30]

In a related work, Baade (1996) takes the additional step to enlarge the partial equilibrium model to a general equilibrium concept, since previous researchers assumed that spending on sports events would not affect the spending elsewhere. However, in reality, Baade found the sports expenditures were substituted from other leisure spending. He used a relative variable to consider the expenditure change in a relative manner.[31] If the relative personal income increase of a city has a significant positive impact on the relative employment in the Amusement and Recreation industry (SIC79) and Commercial Sports industry (SIC 749), it implies this increase in relative personal income will be spent relatively more on SIC79 and SIC749 in the city, compared to the state average. In other words, if a professional sport is a strong export sector or import substitute sector in

[30] As in Baade (1994), Baade and Dye (1988, 1990), Quirk (1987), Quirk and Fort (1992), Biam (1990, 1992), Echner (1993), and Greco (1993), this effect is shown to be negligible or negative.

[31] A city's share of statewide employment in SIC 79; a ratio of a city's real per capita personal income to the state; a city's share of state population, and ratio of average hours worked per week in SIC 20-39 in the city, relative to the state.

the region, then adding a stadium or a new franchise would have a positive impact on employment in the direct sectors, such as Amusement and Recreation Services (SIC79) and Commercial Sports (SIC 794). By controlling for demographic structure, the number of new stadiums or professional franchises, working hours, and business cycles, the results show that building/renovating a stadium or introducing a new franchise did not really increase aggregate spending on city goods and services, except in Indianapolis, Kansas City and San Diego. Their results show that there was actually a substitution from other expenditures, and there was not any real personal income increase within the region.

Baade and Sanderson (1997) use the same concepts and econometrics technique as Baade's 1996 research but adopt data from a smaller geographic area,[32] and focus only on the Amusement and Recreation (SIC79) and Commercial Sports Industries (SIC794) in 10 cities from 1958-1993.[33] By also controlling for the optimal novelty of a new stadium, they found sports stadium- related variables had a positive effect in only three cities, Denver, Kansas City, and San Diego; however, the economic significance of new job creations was limited, compared to subsidy amounts.

Hudson (1999) applied a general regional growth concept to examine if changing the number of professional sports teams in a region has an impact on urban employment growth rates. Hudson argued that regional growth comes not only from the demand side, such as strong local export sectors, but also from the supply side, such as the intermediate inputs, capital, land or the quality of entrepreneurs available. By controlling for both sides' variables, i.e., wages, education levels, tax rates, electricity prices, personal income,

---

[32] The main difference is they replace total state employment with aggregated county employment around the city.

[33] Cincinnati, Denver, Detroit, Kansas City, New Orleans, Pittsburgh, San Diego, Seattle, and Tampa Bay

market size, and number of sports teams, he found that professional sports did not have a positive statistically significant impact on regional employment rates. Furthermore, when estimating each professional sport separately, MLB, NFL, NHL, and NBA, there was still no significant impact on employment.

Miller (2002) undertook the same concept as Baade, but he used a time series econometrics technique to investigate employment growth of the direct sector, Construction (SIC 15-17), in the St. Louis' SMSA during the Kiel Center and the Trans World construction period, from 1971, 1st quarter to 1998, 4th quarter. If the overall regional construction employment is significantly higher during the construction period than in the previous period, then it is reasonable to say that building a facility has positive net benefits for the regional economy. However, Miller found that during the 1970s, 1980s, and 1990s, there was no significant improvement in overall construction employment, which again shows that there was only substituted employment between the different construction projects in the same region.

Coates and Humphreys (1999) adopted the Event Study Methodology[34] to analyze the level and growth rate of real per capita income change in an SMSA during a stadium construction period compared with the mean of all other SMSAs without stadiums. Their contributions to the literature: (1) include more cities: 37 metropolitan areas instead of 9 cities; (2) cover a longer period of time, 1969-1994; (3) separate the effects of building a new stadium into the following categories: introducing a new franchise, losing a franchise, exiting a franchise, and single- or multiple-use of a stadium; (4) account for

[34] The main idea of an Event Study Methodology is to measure behavioral changes because of external environment changes. This type of study has also been adopted in various areas, such as examining how a corporation's events affect its own stock price change. The article "The Econometrics of Event Studies," by Kothari and Warner (2004), provides more details.

stadium capacity; (5) contain SMSA specific effects in the disturbance term in their dynamic panel data model; (6) control for multi-colinearity issues.[35] The results show introducing a baseball franchise would increase per capita income by about $67 per year, but building a new baseball stadium would decrease per capita income by $73 per year. The combined the result was a $6 net loss per person per year for having a baseball team in the region. Furthermore, other interesting findings of this research include the total cost of keeping a franchise in an SMSA was about $400 per capita per year, and most coefficients of building a new stadium - three out of four- are negatively significant. Coates and Humphreys acknowledge that the negative impact might have resulted from excluding the nonpecuniary benefits in their model. The residents of SMASs with a sports franchise may accept lower wages as a trade-off for enjoying the positive amenity of a professional franchise or a new stadium.

Further, Coates and Humphreys (2001) examined the local economy hit by temporary and permanent strikes from 1969 to 1996. If having a professional sports team is an engine for economic development, then one should expect the absence of play would have a significant harmful impact on local economic development. The NBA had lockouts in the 1998-1999 season; the MLB cancelled a significant number of games in 1972, 1981 and 1994; and the NFL went on strike in 1982 and 1987. By including the impacts of both temporary professional sports changes (lockouts) and permanent changes (franchise introductions and departures), their results show the stoppages in NHL or MLB had no impact on real per capita personal income, and losing a franchise in either NHL, MLB or NBA also had no significant impact on lowering real per capita personal income

[35] Previous analyses usually include population and time trends in the regression; however, these two are highly correlated over time.

in an SMSA. These results are consistent with the findings of Baade and Dye (1990), Baade (1996), and Coates and Humphreys (1999).

Coates and Humphreys (2003) also reexamined the same concepts as before but this time focused on the impact of professional sports environment change on earnings and employment, instead of personal income and employment of the direct sectors.[36] For 37 main SMSAs from 1969-1997, the results show that sports environment variables had a significant impact on retail employment, and on wage per employee in Hotels and Other Lodgings, and Amusements and Recreation. However, even though the positive impacts are statistically significant, they are relatively small across all cities, for example, producing about a 0.4 dollar per worker per year increase for the Hotels and Other Lodgings sector, and increasing about 15 dollars per worker per year for the Amusements and Recreation sector. In addition, these positive effects are offset by other sectors of the economy in a region. Coates and Humphreys found that across the three different professional sports, the presence of a football franchise had the greatest economic impact on the Amusements and Recreation sector (about $1200 more per year).[37] Furthermore, their results show the mean impact of sports environment variables produced a substantial negative effect on employment and earnings for the major SMSAs.[38]

Nunn and Rosentraub (1997) compared the regional economic performance between stadium investor cities and non-investor cities. From the various tax data from 1970 to 1990, results show that the population grew faster in non-investor cities, and most non-

---

[36] 2-digit SIC: Retail Trade (SIC5) and Services (SIC7). 3-digit SIC: Hotels (SIC 70), Amusements and Recreation Services (SIC 79), and Eating and Drinking Establishments (SIC 58)

[37] The authors admit that the results may be misleading because data include the professional athletes whose wages are much higher than the average, although they usually do not spend their money in the city where the team belongs.

[38] There is 67% of the SMSAs in service employment, 76% of SMSAs in retail employment, 95% of MSAs on Eating and Drinking Establishments wage, 28% of MSAs on Amusements and Recreation wage, and 37% of MSAs on Hotels and Other Lodgings have negative impact.

investor cities had a higher proportion of highly skilled labor employment (35%) than the investor cities (33%).[39] The investor cities generated more tax revenue, but also higher public debt for the municipality. When comparing fiscal benefits and growth, the investor cities could not really demonstrate real benefits over the non-investor cities. This substantiates what even the most recent literature has shown, that it is impossible to generate enough benefits by a single city to compensate for stadium subsidies; however, the surrounding cities would likely encourage the city with a franchise to invest in a stadium because they would enjoy the benefits of having a franchise without the costs, as free riders.

4.2.1.2 Positive Results

In contrast, other research supports the economic benefits of stadium.

"Sports and the hospitality concentration did help to focus economic attention and political support for the maintenance of a downtown presence for employers in both Cleveland and Indianapolis. In both regions there are very attractive locations for commerce in suburban areas, and indeed that is where more growth is taking place (p.560)." –Austrian and Rosentraub (2002)

Austrian and Rosentraub (2002) argue if public funding is indeed being spent on a new stadium, then a consolidation policy plays an important role for the sustained and economic stabilization of the downtown area. They use micro-data, ES202, to investigate the downtown economic activity changes after new stadiums were built in Cincinnati, Cleveland, Columbus and Indianapolis. They find that if a city with a *sports consolidation strategy* defines itself as a center of recreation and culture, such as Cleveland and Indianapolis, then building a stadium can generate more benefits than

[39] The authors also argue that higher high-skill employment growth will generate more property tax and sales tax revenue per capita to support higher public municipal spending and decrease public debt per capita.

experienced in other cities without this designation, such as Cincinnati and Columbus. Cleveland and Indianapolis downtown areas have lower decentralization rates than the other two cities. Furthermore, comparing decentralization rates of these downtown areas with other areas, such as at the county and city levels, indicates Cleveland and Indianapolis have a reduced tendency for job relocation away from their downtown areas. This could suggest that the two cities are focusing on sports and hospitality to revive their downtown areas and attract more jobs, whereas Cincinnati and Columbus are not.

Nelson (2001) shows that *location* of a stadium, in a Central Business Distinct (CBD) vs. a non-CBD, and the number of major league teams did matter to the personal income growth for 43 SMSAs from 1969-1995. By controlling for the distance between a stadium and the downtown area, population, labor characteristics, local economic structure, and number of stadiums, Nelson's results show that the farther a stadium was located from the CBD, the lower the increase of the SMSA's share of regional personal income. In other words, building a stadium closer to the CBD would increase the share of regional income more than if located in other regions. It provides more opportunities for people to patronize local businesses because people were more likely to spend money before and after games at nearby establishments. Thus, a CBD location for a stadium integrated more businesses and contributes to more economic activity. Furthermore, Nelson examined whether multiple major league teams playing in the CBD would create greater impact than a single league in a CBD. In fact, he found that three stadiums in a CBD have a greater positive effect than two, whereas, outside the CBD, the stadium effect is ambiguous. However, Wassmer (2001) argues that Neolson's results may be biased because Nelson excluded personal income, poverty and unemployment rates, which are important to personal income growth.

Santo (2005) argues previous research ignores the importance of *context* and location because the stadiums built more recently have a very different purpose than the ones built in the 1960s and 1970s. The modern facility not only hosts ballgames but also serves as an architectural symbol, cooperates with tourism, encourages additional spending before and after games, and attracts new businesses. Also, newer stadiums are more baseball-only or football-only stadiums, and new generation stadiums are more likely to be built in an urban core or downtown area instead of a suburban area. Furthermore, more cities utilize sports as part of their local development strategy. Santo reexamines Baade and Dye's (1996) research by including context factors in his model and using a more current data set, from 1984-2001. The results for the aggregated income show mixed impact, positively significant for Anaheim, Phoenix, Seattle, and Tampa, but negatively significant for Baltimore and Chicago. In income share, Santo's finding contradicts most previous research. For example, eight metropolitan areas (Atlanta, Cleveland, Denver, Jacksonville, Nashville, Anaheim, Seattle and Tampa) enjoyed a positive significant impact. In addition, other cities with a negative stadium coefficient are not very large or of significant size. His results show that at least building a new stadium did not have a negative impact on local economic growth. This result implies by considering the context factor, building/renovating a stadium or attracting a new franchise is a potentially beneficial way to invest public revenue. Santo believes that the aforementioned cities have experienced a positive impact because those city governments use a sports plan in combination with other related efforts as a local economic development strategy, rather than solely introducing a sports stadium. These results are consistent with ideas noted by Austrian and Rosentraub (1997 and 2002), Nelson (2001), and Newson and Comer (2000).

In sum, the literature indicates that building a stadium or gaining/losing a franchise offers an ambiguous impact on regional employment, wages, and real personal income for direct and indirect sectors. The majority of research shows a negative impact on the regional economy, but if context (a sports consolidation strategy) and location are included, then the results may be different (Rosentraub, 2006). However, none of the studies considered any form of intangible value. The following section provides research measuring the nonpecuniary value of a stadium.

4.2.2 Intangible Effects

Another way to measure the benefits of introducing a new stadium is to measure the *nonpecuniary* benefits, by using an Hedonic Model or Contingent Variation Method (CVM), both of which are popularly used in environmental economics. According to Rosen (1979), individual and firm location decisions are determined by wages, rents, and amenities of the region. To enjoy positive amenities, such as clean air, lower crime rate or better quality neighborhoods, people are willing to accept lower wages or pay higher housing prices (Blomqist et al, 1988; Gyourko and Tracy 1991; Rosen, 1976). This extends to obtaining benefits from a local stadium either directly, by attending games, or indirectly from the civic pride it engenders. According to Rosen, if residents think having a new team is a positive amenity, they would be willing to pay higher housing rates and accept lower wages to live in that area.

In another study, Johnson, Groothusi and Whitehead (2001) adopted the Contingent

Variation Method (CVM) to measure the non-market value of the Pittsburgh Penguins (NHL) for Pittsburgh city residents. Their results show a Pittsburgh resident would be willing to pay $5.57 per year to retain the Penguins.[40] For the aggregated annual Willingness To Pay (WTP) for Pittsburgh, the upper-limit is about $5.3 million, and lower-limit is about $1.9 million per year.

The other approach is to apply the hedonic method. Carlino and Coulson (2004) measured the nonpecuniary value of having a stadium or a new franchise. They examined whether gaining a new NFL team or building a new stadium for a region lowered wages and raised housing prices in sixty of the largest metropolitan areas of the United States from 1993 and 1999.[41] While controlling for housing and city characteristics, they found that rents were about 8% higher in central cities with an NFL team. In addition, controlling for demographic and employment characteristics, the results show wages were about 2% lower in the metropolitan areas with an NFL team;[42] however, the NFL coefficient is not statistically significant.[43] In addition, according to the results of the rent equation, there is about a $480 yearly amenity premium per household for a representative city. The aggregate amenity value is about $139 million for a city per year, which may be substantially larger than annual public subsidies. Comparing these results with the previous research, the authors point out, "Once the quality-of-life benefits are included in the calculation, the seemingly large public expenditure on new stadiums

[40] A typical Pittsburgh resident would be willing to pay on average $1.49 per year for the opportunity to attend a local game, and $4.08 per year to retain the team in the city.
[41] The authors also attempted to estimate rent equations for different geographic areas; however, the results are not robust because of colinearity issues. Some NFL franchises moved between 1993 and 1999. In 1994, Huston lost the Oliers to Tennessee; in 1998, Jacksonville gained the Jaguars; and in 1995, the Rams moved to St. Louis.
[42] Since CPS does not report if an individual works in the central city or outside the city, the author used Consolidated Metropolitan Statistical Area (CMSA) as a geographic area for estimating wages equation.
[43] The author also mentions there may be some unobserved characteristics correlated with economic growth.

appears to be a good investment for cities and their residents (p.29)."

Furthermore, Tu (2005) argues most opponents have "not in my back yard" thoughts because people who live near proposed stadium sites argue that it would bring about negative impacts. However, there is no previous empirical research to support this notion. Tu applied an hedonic spatial model to look into the impact of real estate value (single-family homes) around the FedEx Field before and after its construction. Cooke Jack Kent announced FedEx Field would locate in Landover, Maryland in December 1992, and it opened in September 1997. He separates the housing data into three time periods: 30 months before the Redskins might locate there (pre-development), the FedEx Field construction period (April 1995 to September 1997), and the following 30 months after FedEx Field opened. Furthermore, he not only considers the geographical spatial autocorrelation (spatial dependence), but also time dependence (because housing prices are also affected by previous transaction prices.) The results show that the closer the stadium, the higher discount rate for the property value if sold during the pre-development period. However, price differentials between homes closer to and farther from the stadium were reduced during development and after the opening of the stadium. Even though housing prices around the proposed location decreased after the announcement was made, housing prices around that area actually increased later, and the closer the stadium, the higher the housing prices. The aggregate increase in property value in this case study was approximately $42 million.

Review of the stadium impact study shows the results depend heavily on whether the analysis considers the location of the stadium, the context of the development strategy, and intangible effects. The majority of research on tangible effects shows no positive impact on regional employment and growth if it does not consider the location and context of stadiums, but when including intangible value, the results show positive impacts for the region. However, the previous analysis for the employment effect is estimated by reduced from, and none of it considers regional labor demand and labor supply simultaneously by using a structural form which factors out the impacts from either demand, supply or both. The goal of this analysis is to build a simultaneous model, considering labor demand and supply factors to examine the impacts of building three stadiums in Denver.

4.3. Denver Metro Area

With fan support and plenty of recreational opportunities, Denver became the number one sports city in America in the 1990s (Sports News, 1997). In the early ‘90s, the local government’s goal was to redevelop the Denver area into an entertainment center. Local government officials believed a new stadium would add to Denver’s attractiveness. In 1990, the Coors Brewing Company family announced the idea for a new baseball stadium, Coors Field, in the LoDo area. Construction of Coors Field started on October 16, 1992, and the stadium opened to the public on April 26, 1995. The total building costs were about $215 million, and $168 million of that (about 78%) came from public funding. In addition, in March 1998, construction began on the Pepsi Center, replacing the original McNichols Arena, and the new stadium opened on October 1, 1999. The Pepsi Center’s total cost was around $180 million, and it was almost 100% privately funded. Invesco Field at Mile High replaced the original Denver Mile High Stadium. The groundbreaking date was August 17, 1999, and the facility was finished on

September 10, 2001. The total cost was about $400 million, with 75% of the total coming from various public funding sources. These three new stadiums located in the downtown Denver area have hosted seven professional teams[44] over the years.

Public funding for building these stadiums was generated by an increase of 0.1% in sales tax in seven counties surrounding Denver County.[45] Also, a $4.7 billion plan to build a 155 mile light rail and commuter rail for improving the transportation around the Denver area was included in government planning (Reich, 2001). Since most of the funds for building the stadiums in the Denver area came from state and nearby county taxes, it is reasonable to expect that the Denver area would subsequently attract new jobs, increase tourism and business investments, and experience an increased quality of life leading to further economic growth in the long run.

Baade and Dye (1990) assert the best way to measure the impact of a stadium is to compare economic growth in a locality with a sports environment to an economy without one. The data consists of 60 quarterly observations across time from the first quarter of 1991 to the fourth quarter of 2005 for seven different NAICS sectors to estimate the aggregate labor demand and supply for the Denver area. This time frame was chosen because the construction of Coors Field was announced in late 1990, with the stadium opening in 1995. The Pepsi Center construction was announced in 1997, opening in 1999. And the construction of Invesco Field at Mile High was announced in 1996, opening in 2001.

According to the Bright Lights Hypothesis, building a stadium will attract new

---

[44] Including the Colorado Rockies (MLB), the Denver Nuggets (NBA), the Denver Broncos (NFL), the Colorado Avalanche (NHL), the Colorado Rapids (MLS), the Colorado Crush, the Denver Barbarians, and the Colorado Mammoths.

[45] Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties.

businesses which are not necessarily sports-related or stadium-related industries. Seven different 2-digit NAICS sectors, Construction (NAICS23), Wholesale Trade (NAICS42), Retail Trade (NAICS44-45), Information (NAICS51), Finance and Insurance (NAICS52), Professional, Scientific, and Technical Services (NAICS54) and Accommodation and Food Service (NAICS72) were chosen based on previous research listed in the literature review section, and on the absorption matrix, showing the sectors with the most direct impact on the labor market when a new stadium is introduced. Table 4-1 presents the mean for the variables used in the regressions, and Figures 4-1 to Figure 4-4 present the pattern of total quarterly employment, number of establishments, average employment and average wage from 1991.1 to 2005.4.

Table 4-1 Variable Averages

Industry (NAICS)	Monthly Average Wages (Dollars)[a]	Monthly Average Number of Firms (Count)[a]	Approximated Output (Dollars)[b]	Materials Cost (Dollars)[b]	Total Employment (Count)[a]
Construction (23)	3144	1508	5566	1307	53075
Wholesale Trade (42)	3715	2348	4400	470	84824
Retail Trade (44-45)	1993	2278	5676	1971	83262
Information (51)	4910	593	9119	1665	63768
Finance and Insurance (52)	4745	1611	10137	1976	83518
Professional, Scientific, and Technical Services (54)	4623	3695	7219	1188	99755
Accommodation and Food Services (72)	1287	1498	2441	1473	101941

Resource: [a] From QCEW [b] Calculate by the researcher

4.4 Theoretical Model and Estimation

The propose of this analysis is to focus on the regional labor market, which was boosted in the Denver area due to the addition of Invesco Field at Mile High, Coors Field, and Pepsi Center. Based on the theoretical model described in Chapter 2, the following section will present the econometric model and estimation procedures used for empirical analysis.

4.4.1 Theoretical Model

The theoretical model for this essay has been described in chapter 2. A new stadium, s_c, located in the Denver area, treated as an amenity change, impacts the local labor market through wages, rents and individual preferences. Equation (2-30) in Chapter 4 shows that if having a new stadium is a positive amenity for all individuals, i.e., $\frac{\partial A_u(s_c)}{\partial s_s} > 0$, it increases the utility level for each individual and the regional labor supply curve shifts outward. Therefore, at any employment level, an individual in Denver would be willing to accept a lower wage due to the amenity change without having an incentive to leave.

$$\frac{\partial L_c}{\partial s_c} = \frac{1}{\alpha_1} A_u(s_c)^{\alpha_1^{-1}-1} \Theta^{\alpha_1^{-1}} \overline{V}^{\alpha_1^{-1}} w_c^{\frac{\alpha_2}{\alpha_1}-1} H_c \overline{P}_c^{-\frac{\alpha_2}{\alpha_1}} > 0 \tag{2-30}$$

Also, equation (34) in chapter 4 shows that if having a new stadium is a positive amenity for firms in the region, i.e., $\frac{\partial A_Y(s_c)}{\partial s_c} > 0$, which increases the productivity for each firm and shifts the regional demand curve outward.

$$\frac{\partial L_c}{\partial s_c} = \frac{1}{\beta_1} A_Y(s_c)^{\beta_1^{-1}-1} \Delta^{-\beta_1^{-1}} \overline{P}^{\beta_1^{-1}} w_c^{-\beta_1^{-1}-1} H_c > 0 \tag{2-34}$$

There are many ways to define regional condition change. Since this study is focused on the impact of building three stadiums in the Denver Area, for simplification

s_c will be defined as a dummy variable for Coors Field (*Coors*), Pepsi Center (*Pepsi*) and Invesco Field (*Invesco*). However, dynamic externality factors may also influence the regional labor market which may be included in future models.[46]

4.4.2 Econometric Model and Estimation

In addition, the previous section and previous literature suggest that amenity changes, such as building a stadium or introducing a new franchise, not only influences the regional labor demand but also regional labor supply. Wage and employment are determined simultaneously in this model. A Simultaneous Equations Model (SEM) of regional labor demand and supply in this analysis can be presented generally as:

$$L^d = f(w, i, M, N, Q, Edu, T, I; s) \quad (4\text{-}1)$$

$$L^s = f(w, D, P, T; s) \quad (4\text{-}2)$$

Where

L: Average employment per establishment

w: Average wage per worker

i: Interest rate

M: Approximate material cost

N: Number of establishments in the area

Q: Estimated output

[46] It is worth noting that a light rail system in the Denver area may also impact regional growth. However, the timing of building Coors Field and light rail (building started in 1995) are overlapping, which does not allow for factoring these two effects at this point. In the future, if micro-level data is available, adopting a geographic distance concept would allow us to differentiate these two effects.

Edu: Education level

T: Time trend variables

I: Producer price index and housing price index

s: Stadium dummy variable

D: Demographic data, including gender, age, education, race, etc.

P: Population

4.4.2.1 Estimation Method

For simplification, the following will present a SEM as:

Labor demand: $L^d = \beta W + \boldsymbol{\gamma} \mathbf{X} + u$ (4-3)

Labor supply: $L^s = \delta W + \boldsymbol{\eta} \boldsymbol{Z} + \varepsilon$ (4-4)

Equilibrium condition: $L^d = L^s = L$ (4-5)

Where L and W are endogenous variables, $\boldsymbol{X}$ variables are exogenous shifts for regional labor demand; $\boldsymbol{Z}$ variables are exogenous shifts for labor supply; $\boldsymbol{u}$ is an error term for labor demand; $\boldsymbol{\varepsilon}$ is an error term for labor supply; β is the coefficient of W for labor demand; δ is the coefficient of W for labor supply; γ is a vector of parameters of $\boldsymbol{X}$; $\boldsymbol{\eta}$ is a vector of parameters of $\boldsymbol{Z}$. Since L and W are simultaneously determined by the interaction of workers and employers, A Ordinary Least Square (OLS) estimation will generate biased, inconsistent and inefficient results,[47] i.e., $Cov(\varepsilon, W) \neq Cov(u, W) \neq 0$.

For estimating the Denver area labor market, Two-Stage Least Square (2SLS) and Three-Stage Least Square (3SLS) are used. The 2SLS is the most popular method used

[47] The error terms are correlated with W, $Cov(\varepsilon, W) \neq Cov(u, W) \neq 0$.

for estimating a simultaneous equation model, and it provides a consistent estimator when the sample size gets larger. Furthermore, 3SLS is used because it provides more efficient results than 2SLS and OLS since it takes into account cross-equation correlation.

4.4.3 Expected Signs

The relationships between the independent variables and the dependent variable, regional employment, need further explanation. The data source and detailed definition of each variable are described in Chapter 3. The demand and supply variables are discussed below.

4.4.3.1 Labor Demand Factors

Table 4-2 provides the summary and explanations of expected signs for each variable included in the regional labor demand equation. In a perfect competitive market in the long run, a firm maximizes profit by choosing the number of workers to hire, how much capital to use, and where to locate. For wage rate, w, the expected sign is negative because of a downward sloping regional labor demand curve. For the material costs, the expected sign is uncertain because the material costs estimated in this analysis includes all inputs, some of which may substitute or complement each other. For the interest rate, r, it is reasonable to assume labor and capital are substituted in the long run. If the interest rate increases, the labor demand will increase, so the expected sign is positive. The expected sign is also positive for estimated output. The higher the output level, the higher the labor demand. For number of establishments, N, the expected sign is also positive, since the more firms located in the Denver area, the higher the labor demand. Education is used as an approximation of labor skills (Hudson, 1999). The higher the education level, the higher the expected productivity, which implies the lower the labor demand given the same level of output. The expected sign is positive for the population. A higher population, *P*, in the region will increase the demand for final goods, which increases the labor demand. In this research, a stadium dummy variable, s, is used to measure the impact of building a stadium on the regional labor demand. The previous theoretical model shows if building a new stadium is a positive amenity change, and it makes the region more attractive, the labor demand curve shifts to the right, $\frac{\partial L_c}{\partial A_Y(s_c)} > 0$.

Table 4-2 Labor Demand

Variable	Definitions	Expected Sign	Reasoning
Wage, *w*	Quarterly average wage per worker	-	The demand curve is downward sloping, which implies the higher the wage rate, the lower the amount of labor needed for a typical firm.
Material costs, *M*	Quarterly total input cost	+ / -	Includes all input costs; sign could be positive or negative because the inputs include substitutes and complements.
Interest rate, *r*	Cost of capital	+	Labor and capital are substituted in the long run, thus the coefficient is expected to be positive.
Estimated output, *Q*	Quarterly estimated output	+	If output increases, the firm will need to hire more labor.
Establishments, *N*	Number of firms in Denver	+	The more firms located in the Denver area, the higher the labor demand.
Education, *Edu*	Average years of Education	-	The higher the education level, the greater the productivity of the labor force, which implies given the same level of output, the labor demand decreases.
Population, *P*	The total employment for 5 counties as a labor pool	+	The higher the population, the greater the demand for final goods.
Stadium, *s*	Coors, Pepsi, and Invesco dummy variables	+/-	If the sign is positive (negative), it means the stadium provides positive (negative) amenity changes for labor demand.
Seasonal Dummy, *S1*, *S2*, *S3*	1^{st} Quarter 2^{nd} Quarter 3^{rd} Quarter dummy variables	+/-	Captures the seasonal adjustment for labor demand; if the sign is positive (negative), it means that the labor demand for a specific season is more (less) than for the 4^{th} quarter.
Quarter Trend, T	Quarter Trend variable	+/-	Used as time trend variable for capturing the general growth pattern from 1991.1 to 2005.4, and T=1~60.
Total	Quarterly total	+/-	There are two functions of *P*

Employment for Lager Geographic Area	employment in Denver MSA[48] and Colorado		a. Used as time trend variable for capturing the general growth pattern. b. For controlling the general influences of the omitted variables not included over time. The sign can be positive or negative.
Housing Price, *H*	Quarterly Housing Index at Denver-Aurora-Broomfield Metropolitan	-	The expected sign is negative because the higher the housing price index, the higher the housing prices, which makes the area less attractive for the firm to locate in the area.

4.4.3.2 Labor Supply Side Factors

Table 4-3 provides the summary and explanations for expected signs for each variable, including in the regional labor supply equation. For wage rate, *w*, the expected sign is positive because of the upward sloping regional labor demand curve. Socio-economic variables affect individuals' migration decisions, which in turn shift the regional supply curve (Dunlevy and Ballante, 1983; Mathur and Stein, 1993). For the education variable, *Edu*, the sign is negative because the higher the education level, the higher the expected wage rate, causing labor supply curve to shift inward, provided that other factors are equal. For race, the sign is uncertain because cultural variety in a region may make some people happier, but it may also make other people less happy. For gender, the expected sign is positive. Previous literature shows females typically earn lower wages than males. For a region with a higher proportion of female laborers, the lower the regional labor supply curve. For age, the expected sign is negative. Since age and work experience are highly correlated, the employee who has more work experience would expect a higher wage, shifting the regional labor supply curve inward, provided that other factors are equal. For family income, the sign is negative. The higher the income, the higher the demand for leisure, which implies a lower the labor supply. For

[48] Adams, Arapahoe, Denver, Douglas, and Jefferson counties.

population, the expected sign is positive, because a higher population implies a lager labor pool. For the housing price index, the expected sign is negative because a higher housing price makes the area less attractive for an individual to locate there.

The previous theoretical model shows if building a new stadium is a positive amenity change, it will make the region more attractive. This will shift the labor supply curve to right $\frac{\partial L_c}{\partial A_U(s_c)} > 0$. However, there may be muliticolinearity issues for several variables; for example, time trend variables and population are highly correlated. However, this happened only in the first stage regression when I tried to get predicted dependent variables, $\hat{w}$ and $\widehat{Emp}$, for the second stage estimation, and including those variables actually increased the explanation of predicted value in the first stage.

Table 4-3 Variables List for Labor Supply Equation

Variable		Sign	Reasoning
Wage, *w*	Quarterly average wage per worker	+	The supply curve is upward sloping, which implies the higher the wage rate, the higher the amount of labor supplied for a typical individual.
Education, *Edu*	Education Level	-	The higher the education level, the higher the expected wage, holding other things are equal. A higher education level shifts the supply curve inward.
Race	The Variance of Race	+/-	The higher the variation of race, the more diversity in the labor market. Cultural diversity in a region may make some people happier, but it may also make other people less happy.
Gender	The percentage of females in population	+	The higher the proportion of female laborers, the lower the regional labor supply curve.
Age	Age of the head of household	-	Since age and work experience are highly correlated, holding other things equal, the greater the work experience, the higher the expected wage.
Family Income		+/-	The higher the income, the higher the demand for leisure, which shifts labor supply inward.
Population, *P*	Total employment for five counties as a labor pool	+	The higher the population, the greater the labor pool.
Stadium,	The summation of number of stadiums	+/-	If the sign is positive (negative), it means the more stadiums in the Denver area, the more people are attracted to the city, implying positive (negative) amenity changes for labor supply.
Seasonal Dummy,	1st Quarter 2nd Quarter	+/-	Captures the seasonal adjustment for the labor demand. If the sign of the coefficient is positive (negative), it means that the

S1, S2, S3	3rd Quarter dummy variables		labor demand for a specific season is more (less) than in the 4th quarter.
Quarter Trend, *T*	Quarter Trend variable	+/-	Used as a time trend variable for capturing the general growth pattern from 1991, 1st quarter to 2005, 4th quarter, and T=1-60.
Housing Price, *H*	Quarterly Housing Index in Denver-Aurora-Broomfield Metropolitan Area	-	The expected sign is negative because the higher the housing price index, the less attractive the area is for individuals to relocate there.

4.5 Estimated Results

This section presents the estimated results for seven different industrial sectors. The SAS9.2 was used to estimate the simultaneous regional labor demand and supply functions for the Denver area. 2SLS and 3SLS are used for estimating. Variables included in the model for each industry are presented first; the interpretation of the results follows.

With regard to the impact of the three stadiums on the regional labor market, the results are mixed. Tables 4-4 to 4-11 provide the estimated results for the Denver labor market in each industry. The left panel of each table shows the results for 2SLS estimation, and the right panel, for 3SLS estimation. The main variables used in the labor demand and supply functions have been described in the Theoretical Model and Data Source and Estimation Procedure sections. Several other variables may be used in different industry estimations to control for different growth patterns and omitted variables. Overall, the regression results have correct signs for the average wages in regional labor demand and supply equations, which satisfies the regional labor demand and supply equation discussed in the Theoretical Model section. Also, the coefficients of other major regressors have correct signs for supporting the previous studies, too, except for the number of establishments, *N*. Since the goal of this research is to determine the impacts of building stadiums in the Denver area, the following discussion of the results will focus only on the *Coors*, *Invesco* and *Pepsi* variables.

4.5.1 Stadium

If there is a significant positive (negative) coefficient for a stadium in the labor supply equation, it represents an outward shift in the regional labor supply curve. It suggests, holding the same utility level as before building a new stadium, a worker would be willing to accept a lower (higher) wage to enjoy this positive (negative) amenity. A significantly positive coefficient for a stadium in the labor demand equation represents an outward shift in the regional demand curve. It indicates, after introducing a new stadium, firms in the Denver area would have to pay higher wages for staying the same place (according to the profit maximization assumption). The sum of significant estimated *Coors*, *Pepsi* and *Invesco* coefficients for labor demand and supply represents the total stadium impact on the labor market. In addition, the total impact on employment and wages depends on the elasticity of the labor demand and supply. If the |Slope of Demand| > |Slope of Supply| and labor demand shift more than labor supply, increasing employment and increasing wages result.

The estimated results, Table 4-4, suggest that the Construction sector (NAICS23) in the Denver area was positively affected by *Coors* and *Pepsi* in labor demand from 1993 to 2005, but negatively affected by *Invesco*. On the labor supply side, *Coors* has had a significant negative impact on labor supply, but *Pepsi* and *Invesco* have had no impact on labor supply.

As shown in Table 4-5, NAICS42 Wholesale Trade sector, *Pepsi* was significantly and negatively associated with labor demand in the Denver area, from 1998 to 2005; however, labor demand was not affected by *Coors* and *Invesco*. In the regional labor supply equation, none of the stadiums has a significant coefficient. Combining labor demand and supply sides, an inward shift of the labor demand curve results in decreasing employment and wages.

As shown in Table 4-6, NAICS44-45 Retail Trade, *Coors* and *Invesco* are significantly and negatively associated with labor supply in the Denver area; however, none of the stadiums has a significant coefficient on the labor demand side. The sum of significant estimated *Coors* and *Invesco* coefficients for labor supply represents an inward shift of labor supply, resulting in decreasing employment and an increasing wages. In other words, holding the same utility level and profit level as before building new stadiums, the average wage rate increased but employment decreased.

In the NAICS51 Information sector, Table 4-7, there is a significant negative impact of *Coors* on the labor demand side; however, none of the stadiums has a significant coefficient on labor supply side. An inward shift of the labor demand curve shows decreasing wages and employment at the new equilibrium.

As shown in Table 4-8, the NAICS52 Finance and Insurance sector, *Coors* is significantly and negatively associated with labor supply in the Denver area, from 1995 to 2005; however, none of the stadiums has a significant coefficient on labor demand side. An inward shift of the labor supply curve shows decreasing employment and increasing wages.

The estimated results, Table 4-9, suggest that the Professional Scientific and Technical Service sector (NAICS54) in the Denver area was positively affected by *Pepsi* in labor demand during the 1998 to 2005 period, but negatively affected by *Invesco* after 2001. In labor supply, *Coors* and *Invesco* had significantly negative impacts, but *Pepsi* had a significant positive impact. In the sum of significant estimated *Coors*, *Pepsi* and *Invesco* coefficients for labor demand and supply, the net impact shows an increased wage (since |Slope of Demand| > |Slope of Supply|, but labor supply shifted more than labor demand).

As shown in Table 4-10, the NAICS72 Accommodations and Food Service sector, *Pepsi* is significantly and positively associated with labor supply; however, *Coors* is significantly and negatively associated with labor supply in the Denver area. In the regional labor demand equation, none of the stadiums has a significant coefficient on labor demand. Summing *Coors* and *Pepsi* coefficients for labor supply show a net negative impact on labor supply, which resulted in decreasing employment and increasing wages.

Table 4-11 shows the summary of results. Comparing the results to the previous related research, building three stadiums in the Denver area increased employment and wages in the Construction sector, compared to either no significant or a negative impact in other research. Similar results can be obtained for the Professional, Scientific and Technical Services sector.

Comparing the three stadium dummy variables (*Coors, Pepsi, and Invesco*) only, most coefficients are positively significant for *Coors* and *Pepsi*, but negative for *Invesco* (Table 4-8). There may be several reasons for this. First, Coors Field was built for the

Rockies which was a brand new professional sports franchise. Also, baseball season (April to September) is different from basketball and football season, and baseball season. Baseball season is longer than either basketball or football season. For these reasons more businesses might be attracted to a stadium built for a new franchise than a new stadium for an existing franchise. Furthermore, the sign for the dummy variable, *Invesco Field*, is negative. This may be due to the different culture style associated with football. For example, people who attend football games would rather tailgate than eat at restaurants, or bars before the games.

In terms of the total number of jobs created because of Coors Field after 1992.4, the model predicts that the total job value expanded about $ 661,493.24 per year for the Construction sector in the Denver area, and thus about 216 new jobs were created. Comparing the results to the previous related research, building three stadiums in the Denver area increased employment and wages in the Construction sector, while other studies found either no effect or a negative impact (Baade and Dye, 1990, and Baade, 1994 and 1996).

Focusing on the total value of employment creation, *Pepsi* has a negative value which indicates that holding the optimal utility level and optimal profit level constant, the *net* effect of higher wages is that the firms are willing to pay more than the residents in the Denver area are willing to give up (since |Slope of Demand| > |Slope of Supply | and the coefficients of demand of *Pepsi* is greater than the supply coefficient). In other words, this negative value can be interpreted as a net positive amenity value (or *nonpecuniary* value) of having the Pepsi Center in the Denver Area. Furthermore, even though the number of jobs created yearly looks limited compared to the subsidy value, the value of job creation is still noticeable. As Carlion and Coulson (2004) pointed out, the aggregate amenity value is about $413,914 for the Construction sector a per year, which may be substantially larger than annual public subsidies. Also, similar results can be obtained for the Professional, Scientific and Technical Services sectors. The net total job value creation for those seven industry sectors in the Denver is about $4.26 million, which is a substantial amount per year.

4.6 Conclusion

The purpose of this study was twofold. The first goal was to build a more complete data set, and to provide a way to estimate material costs, to provide a more accurate estimate of a regional labor market. The second goal was to estimate the impact of building new stadiums in the Denver area with a structural model. As Carlion and Coulson (2004) pointed out, previous researchers missed one important basic point—professional sports teams will increase residents' quality of life in their home cities. If these aspects are included, the results may differ. In this research, the results are mixed for different stadiums and industry sectors. *Coors* and *Pepsi* showed higher positive effects on the employment in several sectors, but *Invesco Field* had negative impacts in most sectors. This may suggest that the impact for football stadiums is limited compared to baseball and basketball because of the sports culture. By applying simultaneous equations and a theoretical model setup, the results indicate that employment value creation increased significantly for the Denver area.

Public funding for building these stadiums was generated by an increase of 0.1% in sales tax in seven counties surrounding Denver County which includes Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson counties. As Nunn and Rosentraub (1997) pointed out surrounding cities (who do not increase taxes for subsidizing building stadiums) would likely encourage another city with a franchise to invest in a stadium because they would enjoy the benefits of having a franchise without the costs. This study shows there is a noticeable value of job creation per year, even when examining only the Denver county labor market. However, some researchers may argue that there may be significant migration from outside counties which suggests that the net impact of the whole seven counties is not positively significant. Some researchers may argue that Denver is a special case because there is no other city in the United States which has built three new stadiums in such a short time period. Therefore, this study does not try to make the general conclusion that this structural model will always be preferred over IMPLAN's model.

Nevertheless, separate industry sectors are estimated in this study which assumes there are no switch jobs for individuals between industries. In other words, the results we presented here ignoring the interaction of the net impacts of each industry sector. In the future, if micro level data is available, it is possible to correctly specify the econometric models in order to distinguish the individuals' and firms' perspective and the interactions among these seven counties. However, there is no such public use data available over time for researchers to conduct this type of quantitative economic analysis at present.

Table 4-4 Quarterly Regional Labor Demand and Supply Estimation for NAICS23 Construction
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	51.6647	8.9960	5.74	48.3556	8.7715	5.51
real_wage	-0.6254	0.4462	-1.40	-1.0454	0.4363	-2.40
real_material1	-1.5879	1.1144	-1.42	-2.8749	1.0779	-2.67
interest_rate	-0.4083	0.1959	-2.08	-0.2598	0.1853	-1.40
real_output	0.6667	0.3812	1.75	1.1032	0.3704	2.98
Estab	-0.0286	0.0055	-5.22	-0.0198	0.0052	-3.81
re_edu	0.2551	0.5642	0.45	0.1526	0.5377	0.28
Coors	1.2561	0.6350	1.98	0.9048	0.6261	1.45
Pepsi	3.3565	0.9356	3.59	3.3706	0.9294	3.63
Invesco	-0.5001	1.0086	-0.50	-1.1777	0.9964	-1.18
Structure	-3.8254	1.0604	-3.61	-3.7847	1.0192	-3.71
co_emp	0.0001	0.0000	6.37	0.0001	0.0000	5.42
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	27.9610	4.5358	6.16	30.7393	4.4322	6.94
real_wage	0.1330	0.0930	1.43	0.1415	0.0929	1.52
lag_real_wage	-0.0193	0.0905	-0.21	-0.0880	0.0876	-1.00
Emp	0.0005	0.0001	9.03	0.0004	0.0001	8.21
var_race	0.6123	0.5805	1.05	0.6477	0.5486	1.18
Age	-0.1732	0.0801	-2.16	-0.1643	0.0769	-2.14
family_inc	-0.1652	0.2626	-0.63	-0.2314	0.2522	-0.92
Coors	-1.0342	0.5927	-1.74	-0.4223	0.5776	-0.73
Pepsi	-0.6989	0.7926	-0.88	-0.0105	0.7795	-0.01
Invesco	-0.7238	0.7831	-0.92	-0.4867	0.7740	-0.63
Housing_idex	-0.0796	0.0127	-6.26	-0.0719	0.0124	-5.79

Table 4-5 Quarterly Regional Labor Demand and Supply Estimation for NAICS42 Wholesale Trade
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	36.4940	6.3997	5.70	32.6117	6.3574	5.13
real_wage	-1.3188	0.6471	-2.04	-1.3585	0.6464	-2.10
real_material1	-1.8606	0.9531	-1.95	-1.9146	0.9519	-2.01
interest_rate	-0.1213	0.0897	-1.35	-0.1194	0.0891	-1.34
real_output	1.2063	0.6357	1.90	1.2446	0.6348	1.96
Estab	-0.0120	0.0037	-3.25	-0.0095	0.0037	-2.59
re_edu	0.4353	0.2020	2.16	0.4264	0.2007	2.12
Coors	-0.4415	0.3530	-1.25	-0.4686	0.3523	-1.33
Pepsi	-1.8362	0.3859	-4.76	-1.7879	0.3855	-4.64
Invesco	0.8228	0.7946	1.04	0.7083	0.7908	0.90
season1	-0.3559	0.1963	-1.81	-0.3479	0.1947	-1.79
season2	-0.8239	0.2806	-2.94	-0.8269	0.2789	-2.96
season3	-0.7529	0.2768	-2.72	-0.7784	0.2756	-2.82
Housing_idex	-0.0310	0.0162	-1.92	-0.0265	0.0160	-1.65
larger_emp	0.0002	0.0000	6.27	0.0002	0.0000	5.81
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	10.6826	2.3245	4.60	11.4180	2.3181	4.93
real_wage	0.0139	0.0348	0.40	0.0125	0.0347	0.36
Emp	0.0003	0.0000	7.69	0.0003	0.0000	7.30
var_race	0.4970	0.1582	3.14	0.4874	0.1579	3.09
re_sex	0.7195	0.8215	0.88	0.5687	0.8162	0.70
Age	0.0647	0.0246	2.63	0.0621	0.0245	2.53
family_inc	0.1091	0.0864	1.26	0.1208	0.0860	1.41
Coors	-0.2186	0.2556	-0.86	-0.2505	0.2553	-0.98
Pepsi	0.2628	0.3796	0.69	0.1585	0.3789	0.42
Invesco	-0.2711	0.2681	-1.01	-0.3412	0.2677	-1.27
larger_emp	0.0000	0.0000	-2.13	0.0000	0.0000	-1.82

Table 4-6 Quarterly Regional Labor Demand and Supply Estimation for NAICS44-45 Retail Trade
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	32.5140	6.1410	5.29	35.3070	5.8957	5.99
real_wage	-0.3364	0.2694	-1.25	-0.4228	0.2606	-1.62
lag_real_wage	0.1303	0.1718	0.76	0.2093	0.1620	1.29
real_material1	0.2319	0.1685	1.38	0.3598	0.1605	2.24
lag_real_material1	0.1862	0.1000	1.86	0.2138	0.0948	2.26
interest_rate	-0.0974	0.1032	-0.94	-0.1101	0.0977	-1.13
real_output	-0.0250	0.0263	-0.95	-0.0483	0.0250	-1.93
Estab	-0.0052	0.0031	-1.68	-0.0059	0.0030	-1.96
lag_estab	0.0064	0.0028	2.31	0.0056	0.0026	2.17
re_edu	-0.3538	0.1292	-2.74	-0.3681	0.1229	-3.00
Coors	0.0373	0.2691	0.14	-0.0727	0.2650	-0.27
Pepsi	0.2933	0.4517	0.65	0.2501	0.4313	0.58
Invesco	-0.3268	0.4728	-0.69	-0.4941	0.4528	-1.09
season1	-1.7319	0.3352	-5.17	-1.7176	0.3184	-5.40
season2	-1.2385	0.2123	-5.83	-1.0446	0.2012	-5.19
season3	-1.0295	0.1915	-5.37	-0.8303	0.1816	-4.57
Housing_idex	0.1085	0.0258	4.20	0.0970	0.0243	3.99
quarter_trend	-0.2949	0.0558	-5.29	-0.2614	0.0530	-4.93
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	65.7550	3.5844	18.34	64.9687	3.5628	18.24
real_wage	0.4640	0.1142	4.06	0.4829	0.1121	4.31
Estab	-0.0229	0.0024	-9.67	-0.0222	0.0024	-9.43
var_race	-0.1098	0.1729	-0.63	-0.0950	0.1643	-0.58
re_sex	0.7789	0.9892	0.79	0.7811	0.9389	0.83
Age	-0.1082	0.0202	-5.36	-0.1080	0.0201	-5.38
Coors	-0.7618	0.3218	-2.37	-0.7085	0.3205	-2.21
Pepsi	-0.3193	0.3028	-1.05	-0.2499	0.3017	-0.83
Invesco	-2.0242	0.2347	-8.62	-2.0147	0.2345	-8.59
larger_emp	0.0001	0.0000	6.92	0.0001	0.0000	6.61

Table 4-7 Quarterly Regional Labor Demand and Supply Estimation for NAICS51 Information
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	106.6060	41.5016	2.57	106.1097	41.4733	2.56
real_wage	-3.4000	1.3891	-2.45	-3.2183	1.3883	-2.32
real_material1	-4.0271	2.7906	-1.44	-3.7974	2.7890	-1.36
interest_rate	-3.6722	1.6172	-2.27	-3.5127	1.6161	-2.17
real_output	1.5635	0.6868	2.28	1.4844	0.6865	2.16
lag_estab	-0.0564	0.0639	-0.88	-0.0554	0.0639	-0.87
re_edu	3.9363	2.8974	1.36	3.8078	2.8958	1.31
Coors	-9.3004	4.9810	-1.87	-9.2480	4.9795	-1.86
Pepsi	-4.3914	6.8919	-0.64	-4.4490	6.8896	-0.65
Invesco	-7.5890	12.8829	-0.59	-7.5382	12.8782	-0.59
Structure	4.9248	9.2031	0.54	4.6298	9.2009	0.50
Housing_idex	-0.0272	0.1910	-0.14	-0.0346	0.1910	-0.18
larger_emp	0.0006	0.0002	4.16	0.0006	0.0002	4.04
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	83.7084	28.4407	2.94	84.8031	28.4220	2.98
real_wage	0.4533	0.2621	1.73	0.4579	0.2621	1.75
re_race	-6.7829	8.0350	-0.84	-6.4926	8.0301	-0.81
re_sex	15.8926	16.0759	0.99	15.7522	16.0645	0.98
Age	-0.6433	0.6548	-0.98	-0.6604	0.6544	-1.01
family_inc	4.6993	1.9480	2.41	4.6229	1.9467	2.37
Coors	-6.5277	4.8179	-1.35	-6.5075	4.8177	-1.35
Pepsi	-6.8091	5.3286	-1.28	-6.7994	5.3285	-1.28
Invesco	-11.4731	9.7008	-1.18	-11.3313	9.7001	-1.17
Structure	-1.6996	8.5426	-0.20	-1.7916	8.5424	-0.21
quarter_trend	-0.3537	0.2829	-1.25	-0.3547	0.2828	-1.25

Table 4-8 Quarterly Regional Labor Demand and Supply Estimation for NAICS52 Finance and Insurance
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	40.8545	85.6317	0.48	29.0101	84.6358	0.34
real_wage	-1.1431	2.0561	-0.56	-1.4783	2.0395	-0.72
lag_real_wage	-0.0285	0.1056	-0.27	-0.0490	0.1041	-0.47
real_material1	0.5388	0.8118	0.66	0.5510	0.8038	0.69
interest_rate	-0.5776	1.0557	-0.55	-0.5791	1.0448	-0.55
real_output	0.4156	0.8372	0.50	0.5549	0.8302	0.67
Estab	-0.0417	0.0172	-2.43	-0.0514	0.0170	-3.03
re_edu	-0.1700	0.9134	-0.19	0.1600	0.8991	0.18
Coors	0.5867	2.1167	0.28	1.1537	2.1067	0.55
Pepsi	-4.3014	8.2443	-0.52	-6.0815	8.1617	-0.75
Invesco	-2.0018	3.9687	-0.50	-2.1544	3.9359	-0.55
Structure	-6.2604	10.6656	-0.59	-6.7439	10.5881	-0.64
Housing_idex	0.6374	1.2283	0.52	0.8218	1.2170	0.68
quarter_trend	-1.1148	1.9086	-0.58	-1.3530	1.8892	-0.72
larger_emp	0.0002	0.0002	1.53	0.0003	0.0002	1.85
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	63.0430	6.6951	9.42	62.1396	6.6076	9.40
real_wage	0.0599	0.0270	2.22	0.0597	0.0270	2.21
Emp	0.0004	0.0001	4.48	0.0004	0.0001	4.71
lag_estab	-0.0293	0.0037	-8.00	-0.0289	0.0036	-7.94
var_race	-0.5135	0.5713	-0.90	-0.5365	0.5651	-0.95
re_sex	-1.3863	1.5017	-0.92	-1.4058	1.4821	-0.95
Age	0.0356	0.0723	0.49	0.0345	0.0711	0.49
family_inc	-0.2289	0.2082	-1.10	-0.2106	0.2071	-1.02
Coors	-1.1443	0.5722	-2.00	-1.1827	0.5706	-2.07
Pepsi	-0.0963	0.5869	-0.16	-0.0407	0.5852	-0.07
Invesco	-0.2536	0.8916	-0.28	-0.2234	0.8905	-0.25
Structure	-1.1925	0.9376	-1.27	-1.1355	0.9352	-1.21
larger_emp	0.0000	0.0001	0.43	0.0000	0.0001	0.29

Table 4-9 Quarterly Regional Labor Demand and Supply Estimation for NAICS54 Professional, Scientific and Technical Services
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	48.8857	5.1148	9.56	46.3670	4.5759	10.13
real_wage	-0.1461	0.2234	-0.65	-0.3374	0.1958	-1.72
real_material1	-0.5141	0.5577	-0.92	-1.0557	0.4875	-2.17
interest_rate	-0.1330	0.1604	-0.83	-0.1858	0.1364	-1.36
real_output	0.1561	0.1873	0.83	0.3216	0.1637	1.96
Estab	-0.0091	0.0024	-3.79	-0.0072	0.0021	-3.38
lag_estab	-0.0037	0.0020	-1.84	-0.0032	0.0016	-1.92
re_edu	-0.1248	0.0453	-2.76	-0.1120	0.0379	-2.95
Coors	-0.3634	0.3454	-1.05	-0.3770	0.3325	-1.13
Pepsi	1.1272	0.4391	2.57	1.6838	0.4004	4.21
Invesco	-0.5375	0.6337	-0.85	-1.2056	0.5648	-2.13
Structure	-1.9985	0.5509	-3.63	-1.2413	0.4534	-2.74
Housing_idex	0.0575	0.0239	2.40	0.0324	0.0211	1.53
co_emp	0.0001	0.0000	4.14	0.0001	0.0000	4.61
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	19.5748	1.8918	10.35	20.2336	1.8042	11.21
real_wage	0.0266	0.0197	1.35	0.0297	0.0194	1.53
var_race	-0.0153	0.1982	-0.08	0.0366	0.1675	0.22
re_sex	-0.3388	0.4513	-0.75	-0.5025	0.4001	-1.26
Age	-0.0253	0.0128	-1.98	-0.0131	0.0108	-1.21
family_inc	-0.0217	0.0529	-0.41	-0.0159	0.0444	-0.36
Coors	-1.0573	0.3554	-2.98	-0.9951	0.3505	-2.84
Pepsi	1.5483	0.3839	4.03	1.6967	0.3810	4.45
Invesco	-0.9671	0.4343	-2.23	-1.2274	0.4276	-2.87
larger_emp	0.0001	0.0000	6.21	0.0001	0.0000	5.68
quarter_trend	-0.1761	0.0204	-8.64	-0.1670	0.0197	-8.49

Table 4-10 Quarterly Regional Labor Demand and Supply Estimation for NAICS72 Accommodation and Food Services
Dependent Variable is Average Quarterly Employment per Establishment

Demand	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	98.9642	20.4860	4.83	102.4834	20.4562	5.01
real_wage	-7.9675	2.7663	-2.88	-8.1718	2.7634	-2.96
real_material1	-1.5534	0.7425	-2.09	-1.5913	0.7414	-2.15
interest_rate	-3.1537	1.0166	-3.10	-3.2513	1.0154	-3.20
real_output	2.3815	0.7355	3.24	2.4262	0.7347	3.30
lag_estab	-0.0229	0.0208	-1.10	-0.0214	0.0208	-1.03
Estab	-0.0759	0.0260	-2.92	-0.0809	0.0260	-3.11
re_edu	0.9101	0.6573	1.38	0.9039	0.6561	1.38
Coors	0.9901	1.7878	0.55	1.1745	1.7866	0.66
Pepsi	0.1234	2.1594	0.06	-0.0822	2.1572	-0.04
Invesco	-0.8075	2.6703	-0.30	-0.9087	2.6673	-0.34
season1	1.8117	1.0065	1.80	1.8843	1.0047	1.88
season2	-5.4516	2.0066	-2.72	-5.5613	2.0038	-2.78
season3	-5.7312	1.8150	-3.16	-5.8593	1.8125	-3.23
Housing_idex	-0.2522	0.0789	-3.20	-0.2467	0.0788	-3.13
larger_emp	0.0011	0.0002	5.43	0.0011	0.0002	5.52
Supply	**2SLS**			**3SLS**		
Variables	*Coefficients*	*S.D*	*t-value*	*Coefficients*	*S.D*	*t-value*
Intercept	0.2434	4.3672	0.06	0.1651	4.3657	0.04
real_wage	0.4454	0.2120	2.10	0.4459	0.2120	2.10
Emp	0.0007	0.0000	15.52	0.0007	0.0000	15.55
var_race	-0.3254	0.4587	-0.71	-0.3453	0.4579	-0.75
re_sex	0.4039	1.1162	0.36	0.4482	1.1150	0.40
Age	0.0271	0.0437	0.62	0.0277	0.0437	0.64
family_inc	-0.0358	0.1737	-0.21	-0.0531	0.1734	-0.31
Coors	-2.1868	0.7177	-3.05	-2.1986	0.7177	-3.06
Pepsi	1.9252	0.8133	2.37	1.9340	0.8131	2.38
Invesco	-0.4623	0.8562	-0.54	-0.5005	0.8558	-0.58
quarter_trend	-0.3738	0.0463	-8.08	-0.3719	0.0463	-8.04

Table 4-11 Summary of Results by Industry Sector

	NAICS23	NAICS42	NAICS44-45	NAICS51	NAICS52	NAICS54	NAICS72
Demand							
Coors	+	/	/	-	/	/	/
Pepsi	+	-	/	/	/	+	/
Invesco	/	/	/	/	/	/	/
Supply							
Coors	-	/	-	/	-	-	-
Pepsi	/	/	/	/	/	+	+
Invesco	/	/	-	/	/	-	/

Note: +: significantly positive coefficient;
-: significantly negative coefficient;
/: not significant coefficient

CHAPTER 5: SECOND APPLIED STUDY: THE EFFECTS OF DYNAMIC EXTERNALITY ON REGIONAL GROWTH- A CASE STUDY FOR THE DENVER AREA

Beaudry and Schiffauerova (2009) point out that dynamic externalities on regional growth results may depend heavily on the choice of industry sector, industrial aggregate level, geographic area, geographic level and the time period. Various econometric techniques and index definitions have been examined in previous studies. However, none has examined whether the empirical results depend on the choice of econometric techniques and indices. The goal of this chapter is to compare the various dynamic externality indices directly across different econometric specifications to highlight the sensitivity of index and econometrics technique choices by using the Denver area data. In sum, this chapter adds value to the recent literature in at least four aspects.

One: this chapter estimates dynamic externalities on regional growth with a structural model from a regional labor market perspective, based on the theoretical framework that has been discussed in Chapter 2. There are several ways to estimate this. The direct way to estimate the production function is through equation (2-9). However, due to data limitations, most previous studies use employment to measure regional growth (as a dependent variable), instead of total output (Rosenthal and Strange, 2003). As Dekle (2002) and Glaeser et al. (1992) pointed out, using total output instead of employment to measure regional growth will produces a more accurate empirical measurement. In other words, there is a strong assumption, monotonic transformation, relating employment and output, but this relationship may be broken if the factor price change does not totally respond to output price change (Cingano and Schivardi, 2004). Another way to understand agglomeration economies on regional growth is to estimate regional labor market directly (Rosenthal and Strange, 2003). To carry out this estimation, various input data will be needed, such as employment, output, land, capital and other materials. Typically, data on material costs and output are not available, but Chapter 3 provides a possible way to calculate estimated material costs and estimated output. The first contribution of this chapter is to include regional industrial output and material costs data, which allows us to better estimate dynamic externalities on regional growth.

Two: as Cingano and Schivardi (2004) pointed out, previous dynamic externality researchers usually include labor demand side factors only, which implies a horizontal regional labor supply curve. However, a regional labor supply curve should be positive, like the theoretical model presented in Chapter 2. When a regional condition changes, it will cause a regional labor supply curve shift. For example, if the size of a regional economy is increasing, this implies an outward shift of the regional labor demand curve. However, this force may also cause a congestion externality (i.e., heavy traffic, higher housing prices, etc.) in a region, which may shift the regional labor supply curve inward (Fujita, 1989). Therefore, the net effect of employment is ambiguous. Simon (1988) showed that laborers in a city with a higher specialized industrial sector would have a greater incentive to move somewhere else for more opportunities. This suggests that a city with a higher specialization industry may shift its regional labor demand curve outward; however, this specialized force may also shift the regional labor supply curve inward due to a higher chance of unemployment. Therefore, in order to get a more accurate estimation, labor supply side factors will also be included in the empirical model. The second contribution of this chapter is to include the supply factor in estimating dynamic externalities on a region with a structural model (as described in Chapter 2).

Three: for comparison with previous studies, this study will also reproduce the various econometric techniques which were used in the previous literature with more complete Denver Area data during the period of 1991 to 2008. Doing so allows me to compare dynamic externality results with different specifications. However, if the results are not consistent, then it may shed light on an omitted variable bias, endogeneity, or simultaneous bias.

The econometric models include:

a. Ordinary Least Square (OLS), (Glaeser, 1992 and Lee et al., 2005, etc.)
b. Recursive Vector Auto Regression (RVAR), (Combes et al, 2004)
c. Dynamic Panel Estimation (DE), (Bline, 2006)
d. Simultaneous Equations Model (SEM) used in Chapter 4

Generally speaking, Comb's RVAR and SEM are structural models, and Glaeser's OLS, Beline's DE are reduced from models. RVAR and DE are estimated by GMM, Glaeser's approach is estimated by OLS, and SEM is estimated using 2SLS and 3SLS. The third contribution of this chapter is to compare various econometric techniques, which allows me to compare dynamic externality results with different specifications. If the results are not consistent across these four econometric techniques, then it may shed light on an omitted variable bias, endogeneity, or simultaneous bias.

Four: Chapter 3 explains the most popular indices for measuring specialization, diversity, and local competition.[49] However, the choice of indices is important for empirical research; this choice affects estimation results and policy implication significantly. For simplification and addressing the sensitivity of index choice, Glaeser's diversity, simple HHI, improved HHI, and Krugman diversity indices are examined with the four econometrics models. Comparing the results allows us to see if different diversity formulas affect empirical results. If the results are not consistent across indices, then it shows the sensitivity of diversity indices selection.

In sum, the goals of this chapter are: First, include the approximated total output, approximated material costs, and labor supply side factors to estimate the effects of dynamic externality on regional growth with a structural model. Second, Glaeser's OLS, Combes et al.'s RVAR, and Bline et al.'s DE, and simultaneous equation models will be utilized with Denver Area data from 1990 to 2008. Third, comparing the dynamic externality results directly across different specifications would shed light on the omitted variables bias, endogeneity, and simultaneous bias issues. Fourth, the choice of diversity formula may affect empirical results, which would in turn affect policy implications significantly. The final goal of this chapter is to show whether the choice of diversity index affects empirical results.

5.1 Static vs. Dynamic Externalities

Most previous empirical studies of externalities on regional growth have been categorized into two main groups: static externalities and dynamic externalities. These two terms have been defined in various ways and are used interchangeably. The main

[49] Of course, additional diversity index formulas have been used in this literature. For simplification and due to data limitations, only several indices have been used in this study. Additional formulas and a detailed discussion can be found in Mack et. al (2007).

difference between static and dynamic externalities is the time period considered (Glaeser et al, 1992; Blien, 2006; Henderson, 2003 and Partridge and Rickman, 1999). Static externalities, usually defined as urbanization and localization, focus on the immediate information spillover on regional development at a specific point of time, which can be treated as a snapshot of the region at that time. Dynamic externalities, however, focus on the accumulated information spillover on regional growth over a period of time. Dynamic externalities are related to MAR, diversity and competition.

The static externalities concept focuses on immediate information spillover effects on regional growth; while the dynamic concept addresses the accumulation of previous information that affects current regional growth. Though the terms static and dynamic externalities are used interchangeably in some studies, this study will define static externalities as urbanization and localization, and dynamic externalities as specialization (MAR), diversity and competition following the approach of Glaeser et al. (1992), Henderson (1995), Henderson et al. (1997), and Partridge and Richman (1999). Table 5-1 summarizes the characteristics of static and dynamic externalities. In addition, since this study focuses on a time-series perspective regional growth of the Denver County area, each index is calculated over time showing the composition of industry changes in the region over time.

Table 5-1 Static Externalities vs. Dynamic Externalities

	Static	Dynamic
Timing Focus	One time point	A period of time
Characteristics	• Immediate information spillover of the current market	• Accumulation of prior information's impact on current regional growth

	• Current local scale	• Historical regional environment
Terminology	• Localization • Urbanization	• Specialization (MAR) • Diversity • Competition

5.2 Discussions of Various Diversity Indices

There are various indices to describe the economic composition of regions, and the most frequently used indices are described in Chapter 3. Dissart (2003), Duranton and Puga (1999), Elizabeth et al. (2007), and Wanger (2000)[50] provide detailed explanations and comparisons of various diversity indices and their applicability. Since one goal of this study is to determine if different diversity indices affect empirical results, it is important to first understand the similarities and differences among those diversity indices in Chapter 3. Those diversity indices include:

$$Glaser_{Div_{s,z,t}} = \frac{\sum_{s' \neq s} Top\ 5\ ind\ Emp_{s'z,t}}{Emp_{z,t} - Emp_{s,z,t}} \quad (3\text{-}8)$$

$$HHIz,t = \sum_{s=1}^{S} \left(\frac{Emp_{s,z,t}}{Emp_{z,t}}\right)^2 \quad (3\text{-}9)$$

$$HHIs,z,t = -\sum_{s'=1}^{S} \left(\frac{Emp_{s',z,t}}{Emp_{z,t} - Emp_{s,z,t}}\right)^2 \quad (3\text{-}10)$$

$$Krugman\_divs,z,t = -\sum_{s'=1,s' \neq s}^{S} \left|\frac{Emp_{z,s',t}}{Emp_{z,t}} - \frac{Emp_{s',t}}{Emp_{t}}\right| \quad (3\text{-}12)$$

A detailed discussion of each diversity index above appears in Chapter 3. Further, Wanger (2000) suggested five factors which need to be examined when choosing various

[50] In Wanger's paper, diversity indices are grouped into four different measurement concepts: equiproportional, type of industy, portfolio and input-output measures. These indices are also divided into five categories: standard, static vs. dynamic, growth vs. stability, scalar vs. matrix, computational ease vs. quality of information.

diversity indices, and they are: (1) measuring diversity relative to a standard; (2) using a static vs. dynamic index; (3) using a diversity index to examine regional growth or stability; (4) using a single number, a scalar or a matrix; (5) computational ease of calculating vs. quality of information received. This study first examines diversity indices based on these five factors.

5.2.1 Standard

A standard is an important benchmark which allows comparison either among the regions or among the industries. In Glaeser's diversity, Dekle's HHI and typical HHI, the underlying assumptions imply the ideal diversity environment is equiproportional industrial activity in a region. Then, the standard of these three indices is equiproportional. These indices focus more on the variety of industries in a region rather than the type of industries (Siegel et al., 1995a and 1995b, and Wanger, 2000). However, an equiproportional standard will not reflect diversity composition in real life. For example, Mining and Logging and Utility sectors are usually relatively small, and Professional, Scientific and Technical Service sectors are usually relatively large. In the Krugman diversity index, the underlying assumption implies the most diversified environment is at the national economic employment share, sometimes called the base economy. The standard used by Krugman is the employment share composition at the national level. The advantage of this index is it allows the standard and ideal economic structure to adjust over time. In sum, the standard choice could be either equiproportional or national employment share. Equiproportional is a more mathematical and conceptually perfect diversified employment composition idea; however, the national level of employment composition would be a more realistic employment composition and a better one that includes real life situations over time, i.e., the Krugman diversity index. This study will examine both standards for highlighting the difference of index standard choice.

5.2.2 Static vs. Dynamic

The main difference between static and dynamic concepts of diversity indices is the same as static and dynamic externalities. *Static* focuses on the immediate information spillover on regional development at a specific point of time; while *dynamic* focuses on the process of accumulating various information spillovers over a period of time. Even though this study uses time series data for calculating various indices, if diversity indices used in this study reflect the current economic structure, say at time *t*, then diversity is a static concept, i.e., urbanization (Wanger, 2000); however, if they reflect a lag or a longer time process in the economic composition structure, say a time period before (t-1), then this diversity will more likely be a dynamic concept, i.e., the Jacob diversity concept. Therefore, each dynamic externalities index can be used as a static or dynamic concept, which will depend on the timing of dynamic externalities on current regional growth.

5.2.3 Examining Growth or Stability

Diversity has been used by regional policy makers to promote economic growth and stability for reducing the volatility due to chronic unemployment or inflationary booms. Typically, job creation is a short-run goal for regional policy makers, and they often measure this goal is by using employment growth. While reducing industrial dependence during a severe overall economic shock is a long-run goal, this goal is often measured by the using the unemployment rate. Since this study focuses on dynamic externalities effect on regional growth, specifically employment growth only, all diversity indices used in this study are used for measuring growth.

5.2.4 Scalar vs. Matrix

Diversity indices could use a scalar or matrix format. The scalar format represents the diversity environment for own industry in general, which only considers direct effects. The matrix style format considers not only own industry but also the interaction among industries, e.g., the absorption table reflects how local firms use local inputs. These interaction terms capture the structure of the regional economy and how all other industries in that region react when a new activity changes. The strength of the interaction term, or the size of the interaction term, actually corresponds to growth more from a diversity perspective because it better represents the economic composition.

Wanger (2000) summarized the diversity index definitions in previous studies, and he concluded, "Regional economic diversity relates not only to the size of the regional economy and the presence of multiple specializations but also to the interactions or linkages present among industries (p.4)." In other words, the ideal diversity index should address the interaction between industrial complexes and inter-industry linkages. However, the goal of this study is to address whether the choice of different diversity index definitions would cause different empirical results. For simplification and comparison proposes, all diversity indices used in this study use scalar format only.

5.2.5 Computational Ease vs. Quality of Information

Different diversity indices have different data requirements, in this study Glaeser's, Dekle's and typical HHI require only the industrial employment share in its own region. In contrast, Krugman's diversity index requires both regional employment share and national employment share data. All dynamic externalities indices used in this study are relatively easy to compute compared to using the I-O table, which considers interactions between industries when calculating a diversity index in a matrix format.

In sum, according to Wanger's (2000) classification, diversity indices adopted in this study are used to examine regional employment growth, scalar concept, and computational ease. The Krugman diversity index uses national share as a standard, but the others use equiproportion as a standard. Static or dynamic concept will depend on the lag structure of diversity index in the empirical studies. If current dynamic externalities indices have an impact on current regional growth, then it is a static concept, but if the lag index has an impact on current growth, then it is a dynamic concept. Table 5-2 provides a summary of the four diversity indices based on those five characteristics. However, as Wanger (2000) pointed out,

> "No one diversity measure is critique free; care should be taken when using a diversity measure as the only factor in a policy designed to change the structure of a region's economy, given the goals of growth and stability." (p.1) – John Wanger (2000)

Table 5-2 Summary of Diversity Indices Characteristics

	Glaeser's HHI	Dekle's HHI	Typical HHI	Krugman
1. Standard (Equiproportional vs. National Share)	E	E	E	NS
2. Static vs. Dynamic	S/D	S/D	S/D	S/D
3. Growth vs. Stability	G	G	G	G

4. Scalar vs. Matrix	S	S	S	S
5. Computational Ease vs. Information	CE	CE	CE	CE

5.3 Literature Review for Dynamic Externalities Empirical Work

This section will review three mainstream econometric studies that have been used in dynamic externalities literature. Rosenthal and Strange (2003) categorize agglomeration on regional growth in three scopes: industrial, geographic, and temporal. Since this study focuses on the time perspective of regional growth in the Denver County area from 1990 to 2008, I would like to further divide the temporal perspective into three parts: Glaeser's two time period approach, Henderson's panel data approach, and Rosenthal and Strange's (2003) entrepreneur approach. Each part can be further categorized based on the data structure, i.e., two-point time period, panel data and time series, econometric techniques and model assumptions set up. The three groups of agglomeration on regional growth appear in Table 5-3, and it provides background and a summary of the main variables and estimation methodology.

Table 5-3 Three Different Approaches for Estimating Dynamic Externalties

	Glaeser	Henderson	Rosenthal and Strange
Time Frame	Two point time period	A period of time	A period of time
Model Assumptions	Perfect Competition	Perfect Competition	Cournot Competition
Date Aggregation	Aggregate data	Microfoundation/Aggregate data	Microfoundation
Selected Literature	• Glaeser et al. (1992) • Henderson et al. (1995) • Combes (2000b) • Glaeser and Mare (2001) • Cota (2002) • Dekle (2002) • Batisse (2002) • Cingano and Schivardi (2004) • Gao (2004)	• Henderson (1997) • Henderson (2003) • De Lucio et al. (2002) • Zheng (2010)	• Henderson (1994) • Rosenthal and Strange (2003) • Combes et al. (2004) • Belin et al. (2006)

5.3.1 Glaeser's Approach (Two Point Time Period)

The first approach is to tie the beginning-of-period agglomeration effect with end-of-period employment growth. Glaeser et al. (1992) built a simplified general equilibrium model as described in Chapter 2. The main idea is, under perfect competition, a typical firm will choose the technology level of a region s_c, $A_Y(s_c)$, and labor, L_s, and output cost of production.[51] At equilibrium, marginal value product equals the wage rate, similar to equation (2-12) in Chapter 2, but abstracts from capital input and set output price equals one; this equation can be rewritten as follows:

$$A_Y\left(s_{c,t}\right)\beta L_{j,c,t}^{\beta-1} = w_{c,t} \qquad (5\text{-}1)$$

Using logs on both sides, equation (5-1) can be arranged according to growth rate as follows:

$$(\beta - 1)log\left(\frac{L_{j,c,t+1}}{L_{j,c,t}}\right) = log\left(\frac{A_{j,c,t+1}}{A_{j,c,t}}\right) - log\left(\frac{w_{j,c,t+1}}{w_{j,c,t}}\right) \qquad (5\text{-}2)$$

The above equation states that employment growth rate depends on regional technological growth positively and wage growth rate negatively. Furthermore, regional technology growth, $log\left(\frac{A_{j,c,t+1}}{A_{j,c,t}}\right)$, depends on the national technology growth rate[52] and the regional component, which is explained by dynamic externalities, such as specialization, competition and diversity. By assuming a constant real wage growth rate, regional technology growth in Equation (5-2) can be rewritten as:

$$\text{Log}\left(\frac{A_{j,c,t+1}}{A_{j,c,t}}\right) = log\left(\frac{A_{j,c,t+1,national}}{A_{j,c,t,national}}\right)$$
$$+g(Special, Comp, Div, Initial\ Conditions) \qquad (5\text{-}3)$$

[51] It is assumed that productivity shocks depend on local characteristics, such as specialization, diversity, competition, industry size or total regional market size.

[52] National technology growth is used to capture nationwide industrial employment and product price changes.

Initial conditions are included to control for the scale and regional effect, to control for some sort of regional heterogeneity. Finally, combining Equation (5-2) with (5-3) will results in

$$(\beta - 1)log\left(\frac{L_{j,c,t+1}}{L_{j,c,t}}\right) = -log\left(\frac{w_{j,c,t+1}}{w_{j,c,t}}\right) + log\left(\frac{A_{j,c,t+1,national}}{A_{j,c,t,national}}\right)$$
$$+g(Special, ComP, Div, Initial\ Condition) \qquad (5\text{-}4)$$

Glaeser et al. (1992) used the County Business Patterns data to examine if specialization, diversity and competition enhanced regional growth between 1956 and 1987 for 170 U.S. MSAs. They considered only the top 5 industries in a city in their study because they believe if externalities are permanent and important, those top five industries are the main engine that will drive permanent regional growth. Additionally, they used deep lagged levels of past regional conditions (1956), such as city-industry employment, number of establishments, wages, and city employment, etc. to control for the regional effect, scale effect and national demand. They argued that it is reasonable to treat historical regional conditions as exogenous variables in estimating current regional growth. They estimated the pooled regression by OLS, and they found diversity and competition in 1956 had significantly positive impacts on regional growth, which supports Jacobs' and Porter's theory, but not specialization. This original approach has been used in a wide range of studies in different regions, various industries, and time periods, different proxy dynamic externality indices and diverse econometric estimation techniques, such as Combes (2000), Cota (2002), Dekle (2002), Batisse (2002), Cingano and Schivardi (2004), et al.

Henderson et al. (1995) employed an idea similar to Glaeser's et al. (1992). They used 1970 and 1987 Census of Manufactures data to estimate the impact of dynamic externalities on regional growth for mature and new high-tech industries separately.[53] Henderson et al. improved Glaesers' (1992) approach in three different main areas. First, they believe different industries have different product cycles and stages, such as with mature vs. new industries. It is more reasonable to estimate different industries separately. Secondly, one characteristic of the Census of Manufactures data set is if industrial employment in a city is less than 250, zero employment would be reported. The employment levels data are actually censored. When including entire available samples in analysis, Henderson et al. believe that the Tobit model provides a more realistic estimation. Third, other factors, such as historical local labor demand and regional product demand conditions, are also important for regional growth and should be included in the model. By including typical dynamic externalities, regional characteristics, access to major urban market centers, local metro demand for capital good products and labor force in higher education, Henderson et al. found MAR externalities to be more important, but not Jacobs for mature industries. However, MAR and Jacobs are both important for new technology industries. They concluded that mature industries are more favored in specialized cities, but new-tech industries are more favored in large and diverse metropolitan cities.

Combes (2000b) took Henderson's (1995) approach but used French data to estimate 52 manufacturing and 42 service sectors, separately. He divided agglomeration effects into two groups: information spillovers, such as face-to-face contact or employment turnover among firms and market-based forces, due to transportation costs

[53] Traditional capital goods industries include primary metals, machinery, electrical machinery, transport equipment, and instruments. New high-tech industries include computers, electronic components and medical equipment.

and non-zero transportation costs, firms would like to locate closer to large input or output market. Additionally, the distribution of activities is uneven across space. Instead of using total regional industrial employment, Combes used total regional employment because the level and quality of information exchange is strongly affected by the number of industry firms and complementary industries. Similar to Henderson's (1995) work, owing to truncated employment, OLS estimates are biased, so Henderson adopted the Tobit model for estimation. By controlling for dynamic externalities, size of local economy, average plant size, employment density, and local employment density, he found different results between industry and service sectors. For most industry sectors, competition and plant size has a negative impact on employment growth. For all service sectors, there were positive diversity effects, and negative specialization effects on regional employment growth, but for competition and plant size, the results were mixed.

Dekle (2002) adopted Glaeser's approach, but used Total Factor Productive (TFP) as a dependent variable instead of estimating the specific industrial dynamic externalities on regional growth for Japan. Dekle argued most previous studies that used employment growth rate had several disadvantages. First, since capital goods are non-tradable goods, it is not reasonable to assume the capital growth rate is zero. Second, Glaeser et al. (1992) assumed output price is determined at the nationalwide level, which implies all goods are tradable; however, some input components are non-tradable during the production process. In other words, a constant output price across regions is not a realistic assumption. Third, living costs, such as housing prices and amenity values do affect migration decisions, but those are not usually considered in the models. In sum, using employment growth rate as a dependent variable will create an omitted variables bias in the estimation. However, using TFP as a dependent variable directly avoids these issues, and it directly fits the theoretical model (such as in equation 5-1). From the Japanese Annual Report on the Prefectural Accounts data for 1975 and 1995, Dekle calculated real regional-industry sector annual output values, which allowed him to calculate TFP growth. Controlling for employment growth, labor share, calculated capital share, and depreciation rates, the results show a strong MAR externality in the Finance, Wholesale and Retail sectors, but not in the Manufacturing sector; no Jacob's externality for any sector; and strong Porter externalities in the Services and Wholesale and Retail sectors. Dekle also compared results by using the TFP growth rate as a dependent variable and by using employment growth rates. He found the coefficients of the MAR externality either negatively significant or not significant at all. Compared to the most previous studies, Dekle found the opposite sign for the specialization externalities coefficient. This suggests that previous studies use employment growth as a dependent variable without controlling for output level, which creates an overestimated bias.

Glaeser and Mare (2001) examined agglomeration effects on wages, directly. They argued labor should be paid based on their marginal productivity, which not only comes from internal effects, such as education, work experience, etc., but also external effects, such as regional composition, i.e., agglomeration externalities. Their approach focuses on labor supply more than previous studies. For example, a person with a higher human capital would process the information flow faster, implying a higher marginal productivity labor, which should result in a higher wage premium. Glaeser and Mare adopted various datasets, such as the 1990 Census, the CPS (1990 March), Panel Study of Income Dynamics, PSID (1968-1985), and the National Longitudinal Survey of Youth

(NLSY) to examine from a cross-section and panel data perspective. Their results show by controlling for worker characteristics and regional fixed effect, workers who stay longer in a region will have a higher wage premium. Also, the larger the cities in which they live, the higher the wage premium they will get in the new cities. These results imply those workers who accumulate more "regional mysteries," i.e., dynamic externalities concept, would get a higher premium. So, there is a positive relationship between urbanization and wage premiums. [54]

Batisse (2002) argued different industry features and regional characteristics may have a different impact on region growth. He examined manufacturing industries by using data from China. Controlling for growth of capital per worker, regional GDP per capita, and geographical dummies, Batisse's results show diversity and competition have a positive impact on regional growth, but specialization has a negative impact on regional growth. Furthermore, he found different growth rates between coastal and interior provinces in China.

Gao (2004) took Batisse's (2002) approach and included local market conditions (i.e., quality of labor, transportation, telecommunication, industrial share of output and local market size), and Foreign Direct Investment (FDI). His results show competition has a positive impact on regional growth, but not specialization and diversity. Also, a better transportation system and FDI policy in the region enhance regional growth. Additionally, Gao also pointed out that the wage rate is endogenous in the estimation and most researchers estimated with a reduced-form equation. However, excluding the wage variable on the right-hand side will still potentially provide simultaneous bias, and a well-

[54] Another similar way to examine agglomeration is to use rent data. Theoretically, firms would be willing to pay higher rent in a region that has higher productivity for compensation. See Dekle and Eaton (1999) for empirical work in housing markets.

designed instrument variable or a structural simultaneous model can correct this bias.

Cingano and Schivardi (2004) argued that none of the previous analyses considered labor supply, which implies a strong assumption of a flat regional labor supply schedule in the estimation. In other words, a monotonic transformation between employment and output is needed to use employment growth as a dependent variable. However, this relationship may be broken when the factor price change does not totally respond to output price, i.e., inelastic demand, and when moving costs between regions and industries are not equal to zero. Moreover, from regional and urban economics viewpoints, the size of local economic activity and sector competition change may also cause the regional labor supply curve to shift. For example, larger regional economic activity is more likely to attract more people to migrate into the region because of a increased employment opportunity. However, this force may also create higher congestion (such as higher housing prices, pollution, etc.), which shifts the regional labor supply curve inward. Also, Simon (1998) mentioned a city with a more diversified environment will be better able to absorb sector shock. A specific industry that requires more specific skills, located in a higher specialization and more concentrated city, will need to provide higher wages to attract employees from outside the city. When a regional condition changes, it shifts the regional labor demand curve and regional labor supply curve simultaneously, and the net effect will be ambiguous. Nevertheless, as Chapter 2 shows the regional labor supply curve should be upward sloping, and when there is a regional condition change, it may also cause a regional labor supply curve shift.

Again, ignoring supply factors will create identification problems, and estimated results will be biased. Cingano and Schivardi used firm-level data from the Italian Local

Labor System (LLS) for years 1986 and 1998, and they compared the dynamic externality indices in TFP regression, wage regression, and employment regression, directly by controlling for employment, yearly earnings, firm characteristics, capital, and education level. Using TFP as a dependent variable and including labor supply factors, Cingano and Schivardi found specialization has a positive impact on regional growth, but not on diversity or competition. However, their employment growth regressions did not show similar results, which may suggest that employment growth is an ill-suited specification for productivity growth.

In sum, due to data limitations, or as some researchers believe a lag between the appearance of agglomeration effects and a firms' location decision and regional growth (i.e., because stock of specific knowledge takes time to accumulate), most researchers adopted Glaeser's two-point period approach. The long lag specialization, diversity and competition indices are used as dynamic externality concepts because the lag indices represent the historical economic composition, and those would affect the current growth. In sum, using the initial date of data as an instrument for regional dynamic externalities is considered reasonable for this group of studies. Overall, there are still no consistent results with regard to using either MAR, competition or diversity. None of the dynamic externalities has a consistent positive impact on industrial regional growth. Due to a lower data requirement for Glaeser's approach, this methodology is most popular and has been adopted in the last twenty years.

5.3.2 Henderson's Approach (Including Historical Data: Panel Data or Time Series Data)

The second approach includes all historical data in the study. Henderson (1997) argued contemporaneous and historical market and industrial conditions actually do have an impact on current industrial employment growth. However, most previous studies (two-point time period) that assume regional employment growth over time depends on deeply lagged levels of past dynamic externalities and regional conditions are problematic. Additionally, due to different characteristics and life cycles for each industry, timing, regional and industrial factors need to be considered simultaneously. The advantage of adopting panel data is to control for the time invariant fixed effect, which cannot be done in the a two-point time period model. Similarly, Zheng (2010) used a time series technique to analyze the dynamic externalizes on output growth for the Tokyo Metropolian area only.

Henderson (1997) used the County Business Pattern data between 1977 and 1990 for five private capital goods sectors to calculate dynamic externality indices over time, which permitted him to determine whether those externalities have a long or short term impact on regional growth. Including lag structure of dynamic externalities, other historical market, industrial conditions, and regional factors would factor out the fixed effect and identify the lag structure of dynamic externalities. Furthermore, owing to serial autocorrelation across years in error terms and heteroscedasticity issues, Henderson estimated regional growth with first difference variables using a Generalized Method of Moments (GMM) estimation, which allowed him to assume previous variables, ie., (t-2), to be exogenous (Hansen, 1982). The results showed lagged structure does matter in regional growth. MAR externalities dies out after six years, and diversity dies out after eight to nine years. For policy making, Henderson showed the presence of dynamic externalities takes several years to yield fully on regional growth.

Henderson (2003) undertook an analysis similar to the Henderson et al. 1995 research, evaluating static and dynamic externalities on regional growth with the confidential micro plant level data from the Longitudinal Research Database (LRD) for machinery and high-tech industries between 1977 and 1992. This rich data set allowed the study of details as follows: 1) How these dynamic externalities have been generated and how single plant firms and multi-plant firms have reacted to those externalities; 2) Whether productivity decreases as plant age increases; 3) Whether mature plants or new establishments create higher externalities in a region; 4) How current or historical regional industrial environment affects regional growth. Furthermore, Henderson adopted a number of local own industry plants as a localization index. The results show current and past localization have a positive effect on regional growth, especially for high technology single plants. However, diversity/urbanization does not exist in either machinery or high-tech industries. This study also confirmed that past regional environment does affect future productivity, which again proves dynamic externality matters in regional growth.

De Lucio et. al (2002) argued since knowledge spillovers vary across industries and regions, those dynamic externality indices should be calculated differently. For example, the information sector has a higher innovation flow rate than other sectors, and some regions, such as Silicon Valley have a higher innovation flow rate than other regions. They factor general specialization into two main groups: within region specialization and within industry specialization. Furthermore, including specialization square in the model allows them to examine if the effect of specialization effect will change over time. Using Spanish manufacturing data from 1978 to 1992, results show specialization has a negative impact on growth, but it becomes positive after a certain level, and competition and diversity have no impact on regional growth.

Bline et al. (2006) argued time is an important factor because it will affect policy implementation. If current regional structure matters for current employment, then a new regional policy should affect regional growth immediately. However, if employment growth takes time to manifest after a new policy, then historical regional structure does matter for current regional employment growth. Bline et al. used the German Federal Employment Agency data from 1980 to 2001 for 326 regions of West Germany. For determining whether timing is a crucial issue, they included contemporaneous and lag dynamic indices. Furthermore, by including natural wages, education level of an individual, and various lag dynamic externalities indices, the study shows current diversity environment, but not historical ones, would affect current employment growth for both manufacturing and service sectors. These results are similar to those found by Combes et. al (2004), but contrast with Henderson's (1997).

5.3.2.1 Time Series Approach (Continuous Time for One Region)

Zheng's (2010) is the first and only paper in the dynamic externalities literature to examine regional growth from a time series perspective only. He argued dynamic externalities and regional growth are both related to time perspective, so it is important to analyze this topic through a time series analysis. This allows those indices to affect the TFP growth during the whole period of time. Zheng used the same dataset as Dekle (2002), but focused only on one region's growth, the Tokyo Metropolitan area in Japan, due to dynamic externalities for one-digit industries from 1975 to 2003. By adopting cointegration methodology, Zheng examined whether TFP and agglomeration effects, specialization, diversity and competition, are cointegrated over time. If two factors are cointegrated over time, it implies dynamic externalities are important factors in determining regional growth. Furthermore, he also suggested including density of transportation over time as network dynamic externalities for estimation. The results show specialization and network dynamic externalities have positive impacts on TFP for manufacturing, finance, wholesale, and retail trade, and industry overall. Diversity has a positive impact on regional growth for the service sector only, and competition has no impact for all sectors. Comparing Zheng's results with Dekle's (2002) showed there is no specialization effect on regional growth from a cross-section perspective, but specialization is important at least for the Tokyo Metropolitan Area from a time-series perspective. This may suggest specialization is important at least for Tokyo but not for other regions. Also, since dynamic externality indices fluctuate over time, it would be more reasonable to include a period of time of index, which may affect empirical results.

In sum, Henderson's approach considered not only historical economic structure, but also current structure, which allows us to differentiate the externalities into static or dynamic concepts, or both, on regional growth. Furthermore, by controlling for the time invariant fixed effect, and historical and current economic composition, this approach may provide more precise results than Glaeser's.

5.3.3 Rosenthal and Strange's Entrepreneur Approach (New Establishment)

The third approach to examining dynamic externalities on regional growth is to focus on firm entry, i.e., establishment of new businesses and employment. Henderson

(1994) argued that an entrepreneur chooses a region to locate in only when profit exceeds a certain level in that region. The location choice of entrepreneurs is based on the regional condition/environment, such as natural resources, public construction, amenities, region size, access to markets, and dynamic externality factors, etc. When agglomeration effects in a region are higher, such as higher technology, profits will be higher compared to other regions. Over time, entrepreneurs would be attracted disproportionately to the most productive regions. The advantages of using this methodology are: (1) Regional conditions are exogenous for new entry entrepreneurs, which means, a new establishment will not be constrained by previous decisions and they take the current existing economic environment as exogenous; (2) In this model, capital, material costs, and land are not required (Rosenthal and Strange, 2003).[55]

Instead of using the number of firms in a region as a dependent variable, Rosenthal and Strange (2003) focused on whether the geographic scope would affect agglomeration externalities. They examined the determinants for new establishments, i.e., changing number of firms in a region, and new-establishment employment levels within different geographic areas. They argued that a region with a higher probability of profit would attract more new firms to a region per square km. Also, by focusing on new establishment entry and new employment for a specific geographical size, it is reasonable to treat regional economic conditions as exogenous variables from an entrepreneurs' perspective. Rosenthal and Strange used micro firm-level data from Dun and Bradstreet Marketplace database between 1996.4 and 1997.4 which allowed them to group data into various geographic areas by ZIP code, such as <1mile, 1-5 miles, 5-10 miles, and 10-15 miles.

[55] However, there is still a drawback to this approach because there may be no new establishments in a region over time. This would lead to econometrics issues, so the Tobit model was adopted by Rosenthal and Strange (2003b) instead.

Since the geographic area is small, data could be censored, i.e., some areas did not have any new establishments, and increase of new employment due to new establishments was zero. When the fixed effect Tobit model was used for estimation, they found agglomeration effects do change with distance. Within a short distance, the effect is strong, but these effects die out sharply.[56]

Combes et al. (2004) improved on Henderson's (1997) and Rosenthal and Strange's idea (2003) by assuming a Cournot competition framework. They believe the Cournot competition may be a better assumption than perfect competition. In constrast to the number of firms in a region being undefined under the perfect competition market setting, this conclusion does not exist in the Cournot model. By decomposing regional growth into average plant size in terms of internal growth and the number of firms in terms of external growth, Combes et al. adopted the Recursive Vector AutoRegressive model (RVAR) because the number of firms would affect average plant size but not the other way around. As they pointed out:

"…employment decisions are taken conditionally on the number of active plants. It is indeed reasonable to assume that plant employment adjustments are far less costly than plant creations or destructions. Hence, if there exists an instantaneous causality between average firm size and number of establishments, it is likely to be directed from the number of establishments to firm size (p. 230)."

Also, Combes et al. investigated whether the agglomeration effect has a long- or short-term impact on average plant size and number of firms. Using 1984 to 1993 yearly French plant data for 36 industries and 341 areas, this study shows regional dynamic externalities would affect the number of plants, but weakly affect average plant size. It also shows current dynamic externalities matter, rather than historical ones, which is

[56] Comparing less than 1 mile with 2-5 miles, the shorter distance has an effect from 10 to 1000 times the effect at 2-5 miles.

similar to the results obtained by Belin et al. (2006).

In sum, Rosenthal and Strange's approach is different from Glaeser's and Henderson's because they stay away from a perfect competition assumption. From an individual firm's perspective, regional condition, specialization, diversity and competition, become exogenous. In addition, Rosenthal and Strange's approach requires less data compared to Glaeser's and Henderson's.

Overall, there are various ways to examine the agglomeration effect on regional growth. Previous empirical studies have shown inconsistent results, some evidence of urbanization in several industries, some evidence of localization in other industries, and some evidence of both urbanization and localization in some industries. Glaeser et al. (1992) show that diversity, but not specialization, encourages growth; Henderson (1995) shows that specialization encourages growth for manufacturing, and diversity encourages growth for high-technology industries. Likewise, Rosenthal and Strange (2003) show that diversity encourages new firm creation. Some empirical results are consistent with Jacobs, some are consistent with MAR, and some are consistent with both. This may suggest the need to include specialization, diversity and competition simultaneously in the model. Furthermore, since there is considerable heterogeneity among industries, and most previous studies also show inconsistent results across industries and regions, it indicates the process of agglomeration varies, and we have to estimate each industry separately.

After reviewing some related studies, the next section will summarize the current challenge for estimation, providing a better picture for later estimation comparisons.

5.4 Main Issues of Estimating Agglomeration

There are several main issues/challenges when estimating agglomeration effects on regional growth: lack of output data, omitted variables, timing, and endogeneity and simultaneity issues. The following section will discuss these factors in detail.

5.4.1 Lack of Output Data

According to Glaeser et al.'s (1992) original theoretical model, the best way to estimate agglomeration economies is to directly estimate productivity growth. For doing so, it is necessary to have production output data as a dependent variable; however, owing to data limitations, the majority of researchers use employment growth instead (Combes, 2000; Combes et al., 2004; Glaeser, et al., 1992; Henderson et al., 1995 & Henderson, 1997; Rosenthal and Strange, 2002). Employment data is the easiest to get at either aggregate or disaggregate levels (including different industry classifications or geographic definition levels) since Bureaus of Labor Statistics around the world provide data sets including employment number, hours worked, and sometimes proxies for skill levels (e.g., education for Germany). Dekle (2002) and Cingano and Schivardi (2004) argued that using employment growth to replace output growth requires a monotone relationship assumption between those two variables. In other words, it is a strong assumption that most productivity gains come from a labor demand shift only, and results in proportional employment increase. Cingano and Schivardi (2004) examined productivity output regression and employment regression with the same independent variables and econometric techniques. They found the opposite coefficient signs of dynamic externality indices between the two models, which showed employment growth is an ill-suited measurement for estimation. In contrast to major related literature that suggests diversity is more important for regional growth, Dekle (2002) and Cingano and Schivardi (2004) found specialization positively affects the productivity of high-tech industry, while urbanization has no effect.

5.4.2 Omitted Variables (Material Costs, Capital Costs or Regional Labor Supply Factors)

There are two main issues for omitted variables: 1. lack of material costs and capital costs; and 2. lack of regional labor supply factors. To directly estimate the regional labor demand curve, which is derived from the production side, employment, land, capital and materials will be needed. However, typically, material costs and capital costs are not available in most data sets. Omitting these variables will make the coefficient estimation either upward or downward biased (Henderson, 2003, and Rosenthal and Strange, 2003). For example, if an industry is more capital intensive in a city but capital costs do not exist, it will lead to an upward bias in the estimation (Moomaw, 1983). Henderson (2003) used the confidential Longitudinal Research Database (LRD) micro plant-level data, which contains detailed information on factor inputs, and by doing this, his study comes closer to the original theoretical model, and it provides a better understanding of agglomeration.

Furthermore, regional labor supply factors were usually ignored in most of the previous agglomeration studies. Ignoring supply factors implies a strong assumption of a flat regional labor supply schedule in the estimation. From Chapter 2, when a regional condition changes, a regional labor supply curve shift also occurs. For example, a congestion externality (i.e., heavy traffic, higher housing prices etc.) for a region may shift the regional labor supply curve inward (Fujita, 1989). Simon (1988) showed that in a city with a higher specialization industrial sector, workers have a higher incentive to move somewhere else to lower unemployment risks. Also, the cost for attracting specific skilled employees to specialized industry from outside the city increases as the degree of specialization due to congestion externalities and higher risk of unemployment as structural change. Specialized industry employers need to raise wages higher than in other cities. This suggests that a city with a higher specialization industry may shift the regional labor demand curve outward; however, this specialized force may also shift regional labor supply curve inward. Also, Glaeser and Mare (2001) found a positive urbanization effect on wages while controlling for labor supply side factors: demographic data, education, work experience, etc. Therefore, in order to get a more accurate estimation, labor supply factors will also be included in the empirical model. In sum, since moving costs between locations and industrial sectors is not zero for firms or employees, the slope of a regional labor supply curve should be positive, instead of a flat one. Also, a regional condition change will not only shift the regional labor demand curve but also the regional labor supply curve (also has shown in Chapter 2). The net effect on employment growth gains/losses will depend on the slopes of both the regional labor demand and the supply curve. As Cingano and Schivardi (2004) suggested:

> "One would need to construct a structural model in which agglomeration effects and local industrial structure are jointly determined."

Again, one goal of this study is to build a more complete data set, so a structural model can be estimated. This will include labor demand and labor supply factors simultaneously for the Denver area.

5.4.3 Timing

The time periods chosen have an important/critical effect on the empirical results, and Figure 3-7 and 3-8 in section 3.5.3 have shown the fluctuations of Glaeser, Dekle and Krugman HHI over time. The economic environment and industry structures actually change over time. Glaeser et al. (1992) calculated agglomeration externalities indices for 1956 only (deeply lagged levels of past condition), and examined how the agglomeration externality environment in 1956 impacted regional employment growth for the year of 1987. They used deeply lagged variables as regressors and composition of employment in the area for estimating long term employment changes to remove fixed factor effects, i.e., capital was treated as a variable factor over 32 years, and all establishments were relatively new (Rosenthal and Strange, 2003). In other words, they treat agglomeration externalities as constant over time, which is not reasonable. Since traveling costs and communication costs have declined significantly, and production methods have changed tremendously, agglomeration externalities have also changed over time.

The other issue when using two-point time periods for estimation is the empirical results will be sensitive to the choice of time periods. For example, Figure 3-8 indicates that if we pick 1999 as the starting year (the lowest value between 1990 and 2009), instead of year 1991 (these highest point between 1990 and 2000), empirical results would be impacted significantly. Furthermore, the HHI index value is used to describe the composition of employment share in a region. Comparing the value of HHI itself between 1991 and 1999 shows the employment share structure in the Denver area is sensitive to timing choice.

Some current studies, such as Bline et al. (2006), Combes et al. (2004), Henderson

(1997 & 2003), consider the historical and current economic environment structure/change in regional growth by including agglomeration externality indices over time in their studies. Also, by including lagged externality indices, Bline et al. (2006) and Combes et al. (2004) found current and very recent diversity has a greater positive effect on employment growth than historical ones for the manufacturing and service sectors; however, Henderson (1997) found the historical environment is critical in regional employment growth, current specialization will have an impact on employment levels 7 years afterward, and diversity will have an impact 5 to 6 years afterward.

For overcoming the above issues, I include output and material costs, and supply factors over time to estimate these dynamic externalities on regional growth for the Denver area with a structural model. This was done not only to accurately specify econometrics models which provide correct estimations but also to provide policy makers with insight as to whether interventions will have immediate impacts on employment growth or if the results will take several years to develop.

5.5 Various Econometrics Techniques

One of the main goals of this study is to estimate dynamic externalities on regional growth with a structural model (based on the theoretical model in Chapter 2). This study reproduces the various econometric techniques which have been used in previous literature, including Glaeser's Ordinary Least Square (OLS) (Glaeser, 1992 and Lee et al., 2005); Recursive Vector Auto Regression (RVAR) (Combes et al, 2004); Dynamic Estimation (DE), (Bline, 2006); and Simultaneous Equations Model (SEM) for regional labor markets. Each empirical model is estimated separately from the Construction, Manufacture, Wholesale, Retail, Information, Finance, Health, and Profession, since most previous researchers have shown dynamic externalities exist differently across industries and regions.

Then, the empirical results of various diversity indices will be compared across four different econometrics models (including Glaeser's OLS, Beline's DE, Comb's RVAR and simultaneous equation models, which will be discussed in the next section). These four different econometrics techniques can be divided into two groups: structural models (Comb's RVAR and simultaneous equation model), and reduced from models (Glaeser's OLS, Beline's DE). The next section is organized in the following way: first, it explains each econometric technique in more detail. Second, it explains the different set-ups between structural models and reduced form models. Table 5-5 summarizes the comparison of model assumptions, specifications, estimations, and concerns among these four models. Theoretically, if each model can be specified correctly, then each diversity index should provide consistent results across different econometrics techniques. This may highlight the reasons why the results are not consistent across the different models.

5.5.1 Ordinary Least Square (OLS)

OLS has been used in many previous studies, such as Glaeser (1992); Dekle (2002), and Cingano and Schivardi (2004) etc. The estimation equation is as follows:

$$\alpha \log\left(\frac{\overline{Emp}_{t+l}}{\overline{Emp}_t}\right) = -\log\left(\frac{w_{t+l}}{w_t}\right)$$
$$+g(Special, Div, Comp, Initial\ Condistion) \qquad (5\text{-}5)$$

Local employment growth[57] can be represented as a function of the wage growth rate, the

[57] Some studies use total productivity as a dependent variable, but the basic structure is the same.

national component growth rate[58] and regional dynamic externalities, which consider the specialization, *Spe*, of the industry in the region, diversity, *Div*, measures the variety of activities of that region, competition, *Comp*, evaluates the competition level of the industry in a region, and controls the regional effect by including *Initial Condition*. Further, all dynamic externalities indices are assumed to be exogenous variables.[59]

Since this study is based on a time series perspective for the Denver Area. This OLS logic is used to examine the impact of dynamic externalities on regional growth for the Denver area over time. Instead of a long time lag initial dynamic externality index, one time period lag indices will be used for considering the previous economic composition.[60] Also, the ARMA process will be included in the estimation, allowing us to consider/distinguish static and dynamic externalities. Though many different specifications of equation (5-4) have been examined, only the most parsimonious specifications and robust results will be reported (Appendix B). Finally, residual plots and Durbin Watson tests will be examined after estimation to ensure the remaining residual is white noise.

The coefficient of AR(1) indicates the growth rate of employment over time involving the dynamics concept. If the coefficient of AR(1) is greater than 0, then MAR externalities are observed. However, it also implies an explosive employment growth over time in the Denver Area, i.e., infinite employment expansion, which would not be a reasonable situation when a geographic area is fixed over time. If the coefficient of AR(1) is between 0 and 1, it indicates average employment growth rates will converge in the

---

[58] Including nationwide technology shifts in the industry.
[59] However, estimation with OLS, gives results that may not be efficient due to serial correlation in the residuals.
[60] Including only long lag initial regional conditions creates econometrics challenges because there are only two observations in each regression.

long run, i.e., the mean-reversion phenomenon. Then, the value of AR(1) will become critical. If the coefficient of AR(1) is fairly small, really close to 0, then there is no growth in employment, i.e., no MAR externalities effect. Or, if the coefficient of AR(1) is relatively large but smaller than 1, perhaps 0.7, then it indicates previous employment growth has some effect on current employment growth, and it has an accumulated effect on employment over time in that region (which indicates history matters), i.e., non explosive dynamics.[61] This situation can be interpreted as evidence of MAR externalities, and not an explosive employment growth.

In addition, the coefficients of the other contemporaneous and lag dynamic externalities indices are used to examine the impact of the current and/or historical regional environment on regional employment growth. In a short time lag, one lag period, externalities indices indicate a short historical regional economic structure would impact current regional growth. This could be interpreted as evidence of statics externalities, urbanization and localization, in the middle-run.

5.5.2 Recursive Vector Auto Regression (RVAR)

Following Combes et al.'s (2004) argument and framework of imperfect competition, with Cournot competition, the individual employer's employment decisions will depend on the number of active plants in the region. If there is a contemporaneous causality between average employment ($\overline{Emp}_{s,t}$) and the number of firms ($n_{s,t}$), it is more likely nz, s, t will have an impact on $\overline{Emp}_{s,t}$, but not $\overline{Emp}_{s,t}$ on $n_{s,t}$, due to employment adjustment costs being lower than a firm's creation and destruction costs.

[61] If the coefficient of AR(1) is a positive number, it indicates past employment growth influences current employment growth.

Then, the RVAR model becomes a suitable model for estimating (Equation 5-5), which includes the average plant size and number of plants.

$$\overline{Emp}_{st} = \rho_1 \overline{Emp}_{s,t-1} + \alpha_{10} n_{s,t} + \alpha_{11} n_{s,t-1} + \beta_{10} Dy_{s,t} + \beta_{11} Dy_{s,t-1} + u_{1,s} + \varepsilon_{1,s,t}$$

$$n_{st} = \rho_2 n_{s,t-1} + \alpha_{21} \overline{Emp}_{s,t} + \alpha_{22} \overline{Emp}_{s,t-1} + \beta_{20} Dy_{s,t} + \beta_{21} Dy_{s,t-1} + u_{2,s} + \varepsilon_{2,s,t}$$

(5-6)

Where random shocks $\varepsilon_{1,s,t}$ and $\varepsilon_{2,s,t}$ are not correlated and these two equations can be estimated separately. $Dy_{s,t}$ are various dynamic externality indices, and they are assumed to be exogenous variables.

Furthermore, first difference each variable allows for eliminating the time-invariant effect and ensuring the data is stationary. Then, lagged level variables become valid instrumental variables for estimation (Arellano, 2003 and Hsiao, 2003). The choice of instrumental variables will depend on the assumption of correlation between independent variables, $\overline{Emp}_{s,t}$, $n_{s,t}$ and $X_{s,t}$, and residuals, $E\left(\varepsilon_{s,t} \middle| n_{s,t}, X_{s,t}, n_{s,t-1}, X_{s,t-1}, \ldots\right)$. The most parsimonious specification[62] is ARMA(2,1) which provides the most stable results (Appendix B). Then, further lag variables, (t-2), become valid instrument variables. Finally, the logarithmic and first differences functional form allows the coefficients to be interpreted as growth rate.

Interpretation of lag dependent variable coefficients is similar to Glaeser's OLS model. For example, the autoregressive coefficient in both equations, the lag dependent variable, should be between 0 and 1, and the size of this coefficient indicates the amount of knowledge accumulation, MAR, over time. Other dynamic externality indices, which only include contemporaneous and one lag period indices, inspect the role of static

[62] Detailed estimation procedure and specification tests can be found in Combes et. al. (2004).

externalities on regional growth.

5.5.3 Dynamic Estimation (DE)

Following Bline's (2006) methodology, the dynamic estimation equation will be used as follows[63]:

$$\overline{Emp}_{s,t} = \sum_{l=1}^{m} \rho_l \overline{Emp}_{s,t-l} + \sum_{l=1}^{m} \beta_l X_{z,s,t-l} + \sum_{l=1}^{m} \alpha_l Dy_{z,s,t-l} + D_t + \varepsilon_{z,s,t}$$

(5-7)

Where $X_{z,s,t}$ are additional control variables for controlling industrial sector effect, labor pooling, education and wage. All variables in this equation are first difference for ensuring those variables are stationary, except dynamic externality indices. Following Arellano and Bond (1991), lagged variables are valid instrumental variables with GMM estimation, and this provides consistent estimators. The interpretation of each coefficient is similar to Glaeser's approach.

5.5.4 Simultaneous Equations Model (SEM)

Due to the data limitation (described in Section 5.4), all previous related studies estimate dynamic externalities on regional growth with a reduced form model. One main contribution of this chapter is to apply the spatial equilibrium theoretical model (described in Chapter 2), and adopt a more complete data set for the Denver area (described in Chapter 3), to estimate the impact of dynamic externality on regional growth with a structural model, i.e., SEM with regional labor demand and supply equations. The advantage of estimating a structural model is it allows us to analyze the

[63] Since this study is focused on the Denver County area, the regional fixed effect is ignored.

impact of dynamic externalities on regional labor demand and supply separately. This simultaneous equations method is also used to estimate many sector-specific regional labor markets in this chapter. The general econometric model is specified as follows:

$$\overline{Emp}_{s,t}^{Demand} = f_d\left(w_{s,t}, n_{s,t}, X_{s,t}^{Demand}; A_d(Dy)\right) + u$$
$$\overline{Emp}_{s,t}^{Supply} = f_s\left(w_{s,t}, n_{s,t}, X_{s,t}^{Supply};\ A_s(Dy)\right) + \epsilon \qquad (5\text{-}8)$$

Where $X_{s,t}$ are exogenous variables and $A_s(Dy)$ and $A_d(Dy)$ are dynamic externalities indices on labor demand and labor supply. $\overline{Emp}$ and *w* are endogenous variables, and *X* and *n* are exogenous shifts for regional labor demand and supply, *u* is an error term for labor demand; ε is an error term for labor supply. The collection of explanatory variables used in SEM are as follows: total output, material costs, interest rate, and housing price index for labor demand equation; income, race, gender, age and total population for labor supply equation. In the next subsection, I will discuss those explanatory variables in detail.

Since $\overline{Emp}$ and *W* are simultaneously determined by the interaction of workers and employers, an Ordinary Least Square (OLS) estimation will generate biased, inconsistent and inefficient results, i.e., $Cov(\epsilon, u) \neq 0$. In structural models, 2SLS (Two Stage Least Square) and 3SLS (Three Stage Least Square) are chosen because they are consistent and have been shown to have the most robust results compared with other estimators. As Simon (1998) points out, a regional economic environment would affect employee's migration decisions. And the interpretation of each coefficient is similar to Glaeser's approach. Also, doing so will allow us to separate dynamic externality effects on either regional demand or supply. To ensure this has the correct specification, a Durbin-Watson test and a residual plot will be used to check for autocorrelation in the residuals of the model. The next subsection will discuss the collection of explanatory variables used in SEM.

5.5.4.1 Specifications for Simultaneous Equations Models

This section will emphasize the static and dynamic externalities indices that have been recognized from previous related studies, and how they are applied and interpreted in these models, first. Following previous related studies, all externality indices, including specialization, diversity and compeititon, are assumed to be exogenous, and they will include both regional labor demand and supply side. Other variables, such as output, material costs, and demographic variables are also assumed exogenous. Finally, all predetermined variables are also assumed exogenous.

5.5.4.1.1 Specialization

According MAR theory, specialization measures the benefit that firms receive from the information spillover within their own industry in a specific region. In general, this type of information spillover arises through either the turnover of skilled labor within the same industry, or face-to-face communications within the industry during daily life. In this study both static and dynamic specialization concepts will be considered. For the static concept, i.e., localization, contemporary relative employment share will be used. Typically, the industrial employment share of a city is used to measure specialization; however, this use needs to be viewed with some caution (Combes, 2000b).[64]

[64] For example, Henderson et al. (1995) and Dekle (2002) attempted to control for sector employment and employment share simultaneously within in a region; however when holding sector employment constant, the only way to see an increase in specialization is for the city to simultaneously see an decrease in size. This situation is not seen within the data, and there are instances where specialization increases when there

In this study, both static and dynamic concepts will be considered. For the static concept, i.e., localization, relative employment share at time *t* (equation 3-6) will be used to measure specialization. This formula has greater power to capture specialization since the formula used is much better at identifying the match between employee and employer at a certain point in time. For the dynamic concept, i.e., MAR, lagged average employment (auto-regressive coefficient, AR(1), which has been discussed in the previous section) will be used. This auto-regressive coefficient indicates whether an industry is currently experiencing faster growth than in the past. The interpretations of these variables is the same as in Glaeser's OLS approach, discussed in the previous econometrics section.

5.5.4.1.2 Diversity

As Jacob (1969) suggested, the most important knowledge spillovers for promoting regional growth actually come from other industrial sectors rather than within an industry. Diversity measures benefits received by firms from inter-sectoral information spillovers in a region. In addition, various diversity indices will be used in this study to determine if the empirical results are sensitive to the choice of index formula. Various ways of measuring diversity in a region have been discussed in Chapter 3. Both static and dynamic externalities will be examined by the same criteria as specialization.

5.5.4.1.3 Local Competition

There are two main arguments regarding the effect of local competition on

---

is not a simultaneous decrease in city size. Combes suggested that by controlling for total employment with employment share instead of sector employment, this situation could be avoided.

knowledge spillovers. First, following Porter's (1990) argument, for firms to survive in the market, they must undertake adequate research and development due to higher competition forces, which ultimately enhances productivity. However, if the competition force is too strong, there is a decrease in the return of new innovation, indicating that a higher competition does not necessarily enhance innovation (Sutton, 1996). Unclear property rights will also reduce the incentive for innovation because of the potential for loss of profits (Glaeser et al., 1992). Following Glaeser et al.'s definition, the relative number of employees per establishment in a region compared to the nation will be used. For Glaeser's, Bline's and the simultaneous equation approach, the smaller number derived from this calculation, the higher the local competition, which implies an enhancement of regional growth. For Rosenthal and Strange's entrepreneurial approach, a negative significant coefficient is interpreted as to how local competition will affect new arrivals in the same industry.

5.5.4.1.4 Size of the Local Economy/ Total Regional Employment

The size of the local economy will affect the size of agglomeration. Own industry scale is usually measured as the local employment of own industry and is also a proxy for localization (Henderson, 1997; Rosenthal and Strange, 2003). Total employment in a region is used as a proxy for urbanization and is also used as a global component to capture general technology changes, which can be treated as exogenous variables from the regional perspective (Lucio et al., 2002).[65]

Furthermore, since this study focuses on the Denver Area only, and the geographic

[65] Only when the number of firms and potential complementary sectors are high enough, will knowledge spillover be sufficiently important (Combe, 2000).

area does not change during the study period, then total region employment can be interpreted as employment density over time, which is frequently used to control for labor market pooling (Ciccone and Hall, 1996). In addition, the size of the local economy will also catch a dispersion force since a higher density over time implies higher land rents. Finally, a set of lagged dynamic externalities indices have been introduced in the equations due to the lagged structure of the economy where the past structure of the economy could affect current regional growth (Henderson, 1994).

5.5.4.1.5 Other Variables

Other variables included in the structural model are output, material costs, seasonal dummies, housing price index and demographic variables.

Output affects regional labor demand curve, since the higher the output level, the higher the labor demand. Material costs consider overall input factor costs, including substitute or complement factors, for production, which would also affect labor demand decisions. Housing prices control for the general housing market since this is one important factor for migration decisions.

For the demographic data, education level is used to measure the general human capital in the region. The higher the education level, the higher the expected productivity, which implies the lower labor demand given the same level of output. For gender, previous literature shows females typically earn lower wages than males. In a region with a higher proportion of female laborers, the regional labor supply curve will be lower. Since age and work experience are highly correlated, the employee who has more work experience would expect a higher wage, shifting the regional labor supply curve inward, provided other factors are equal. For income, the higher the income, the higher the demand for leisure, which implies a lower the labor supply (Dunlevy and Ballante, 1983; Mathur and Stein, 1993).

Of course, more variables could have been included in this type of study, such as general amenities and natural resources advantage. However, since the focus of this study is only on the Denver Area over time, it is reasonable to assume that those variables do not change much over time; therefore, geographic scope issue is not considered.

5.5.4.1.6 Expected Signs for Dynamic Externalities Indices and Interpretations

Table 5-5 summarizes the expected signs for various static and dynamic externalities indices in each model when there is positive economic growth. According to the urbanization theory, when contemporaneous diversity has a positive impact on regional growth, then the coefficients of Dy_t will be positive (except Krugman diversity index) which would shift the regional labor demand curve and supply curve to the right. According to localization theory, when contemporaneous specialization has a positive impact on regional growth, then the coefficients of Spe_t will also be positive, which would shift both regional labor demand and supply curves outward. According to MAR theory, when specialization has a positive impact on regional growth, the coefficient of the lagged dependent variable will be positive and between zero and one. Also, according to Porter's theory, when competition has a positive impact on regional growth, the coefficient of $Comp_{t-l}$ will be positive, which would shift both curves outward. Finally, according to Jacobs' theory, when diversity has a positive impact on regional growth, then the coefficient of Div_{t-l} will be positive, which would shift both regional labor demand and supply curves to the right.

5.5.5 Structural Model and Reduced Form Model

The majority of previous empirical studies listed above are reduced form models. However, according to the spatial equilibrium model (in Chapter 2), it is reasonable to estimate with a structural model, i.e., consider both supply and demand side factors when estimating the regional labor market. Before jumping to a conclusion about the results, it is critical to understand the advantages and disadvantages of reduced form models and structural models, and the differences between the four econometrics models.

There are pros and cons for adopting a structural model. The advantages of estimating with structural model are follows. First, estimated equations are based on theoretical models, such as the Spatial General Equilibrium Model (as shown in Chapter 2). Based on that theory, wage and employment are endogenous variables since they are determined inside the system. The other variables are determined from outside the system, either at this point in time or in the past, and the lag endogenous variables are assumed to be exogenous variables. Second, it allows researchers to separate the impact of dynamic externalities on both demand and supply simultaneously, instead of showing only the total impact on wage and employment. Third, finding a good instrument variable is an *art*. Even a valid instrument variable does not necessarily guarantee identification of the parameters. Fourth, with a correct specification, a structural model would provide a lower confidence interval for the estimated coefficients than a reduced form model. For example, the VAR model contains more variables than a structural model (Freeman et al., 1989).

Table 5-4 Expected Signs for Various Dynamic Externalities Indices and Various Econometrics models for a Positive Economic Growth

		Structural Model (2SLS and 3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
		Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (Δ N_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
Dynamic	MAR			AC [a]	AC [a]	AC1 [a]	AR(1)
Static	Specialization	+	+	+	+	+	+
	Competition	+	+	+	+	+	+
	HHI	-	-	-	-	-	-
	Krugman	+	+	+	+	+	+
	Dekle	-	-	-	-	-	-
	Glaeser	-	-	-	-	-	-

Note:

a: Combe et al. (2004) proves that share employment is perfectly collinear with employment level. Lagged employment growth is used as an alternative specialization index, i.e., Autoregressive Coefficient, AC, and if the coefficient is greater than 1 (implying an explosive growth path), there is an increasing specialization of own industry on the local industry growth. If the coefficient is between 0 and 1, it implies a mean reversion in the long run, which indicates a specialization effect will converge in the long run

However, there are also some limitations with a structural model estimation, as follows. 1) There may be other competing theories, which cannot be nested out from estimation. For example, Jarrow and Protter (2004) compared the results of structural vs. reduced form credit risk models due to different fundamental assumptions between two models' set-up. Structural models assume perfect information on a firm's assets and liabilities among firms, and reduced form models assume imperfect information among firms and markets due to the time needed to observe market outcomes. So the information is only available for analysis when it is observable in the market.2) The determination of endogenous or exogenous variables is based on economic theory (Zellner and Palm, 1974). However, unless the theories are well-developed, there are always debates about other possibilities. 3) Predetermined endogenous variables are assumed as exogenous variables. 4) The decision to include some exogenous variables or lag endogenous variables is based on hypothesis tests, which may lead to overconfidence results. For this reason, Sims (1980) argued some lag variables are usually omitted in structural models due to the theoretical base which produced an omitted variable bias. 5) Structural models usually forecast poorly compared to reduced models, which affects policy analysis significantly (Brandt and Williams, 2007; Freeman et al., 1989; Rust, 2010; Zellner and Palm, 1974).

Before turning to the empirical results (for detailed output, see Appendix B) and implications, it is important to understand the differences between the four econometric techniques, Glaeser's OLS, Bline's GMM, Combes' RVAR and the simultaneous model. Glaeser's OLS model is a reduced form model, and it only considers regional labor demand effects. Using a time series data set up and including lag dependent variables in this model would consider both static and dynamic externalities concepts.

Glaeser's approach does not include any supply factors or regional dynamic structure over time, which could result in an omitted variable bias and inefficiency due to potential heteroskedasticity. Also, including wages at the right hand side could result in an endogeneity or simultaneous bias. Bline's dynamic estimation is also a reduced form model. This model excludes supply factors, but generates a neutral wage range, as an instrument variable for wage, to overcome the endogeneity issue. In addition, Combes' model is based on the Cournot competition which allows estimation of the number of firms and average employment, instead of employment only. This model is a structural model. Both Bline and Combes models are estimated with GMM, which makes (t-2) variables valid instruments, and the empirical results are efficient. However, neither methodology can avoid an omitted variables bias. Again, Bline and Combes considered static and dynamic externalities concepts. Finally, the simultaneous equation model considers both demand and supply factors. Based on the spatial equilibrium model, it is a structural model and treats wage and employment as endogenous variables. All other variables, including lag dependent and independent variables, are exogenous. 2SLS and 3SLS are used to estimate this model with 2SLS and 3SLS to avoid simultaneous and omitted variable bias.

Table 5-5 provides the summary and comparison of each model. In sum, each econometrics model has different assumptions and set-up which may affect empirical results. The following sections use Denver County data for examining whether those models provide consistent results.

Table 5-5 Summary of Four Different Econometric Models

	Reduced model		Structural model	
Model	Glaeser's OLS	Bline's DE	Comb's RVAR	Simultaneous Equation
Market Assumption	Perfect competition	Perfect competition	Cournot competition	Perfect competition
Considers	Demand	Demand	Demand	Demand and Supply
Dependent variable	• Employment growth	• Employment growth	• Number of Firms • Average Employment	• Average Employment
Specification	Uses long term lag dynamic externalities indices as instrumental variable	Uses lag level data as instrumental variable and estimate neutral wage to avoid endogenity	Uses lag level data as instrumental variable	According to theory to make assumptions of endogenous and exogenous variables
Estimation	OLS	GMM	GMM	2SLS and 3SLS
Hypothesis Testing	Individual coefficients and R^2	Group of coefficients and tests for exogeneity	Group of coefficients and tests for exogeneity	Individual coefficients and R^2
Concerns	• Omitted variable bias • Endogenity • Inefficiency	• Omitted variable bias	• Omitted variable bias	

Sources: Brandt and Williams (2007), Freeman et al. (1989), and Greene (2000), and this study

5.6 Results

Several points are addressed in the results. To determine if diversity externality indices provide consistent explanations for regional employment growth, the criteria for this research examine (1) if different diversity indices give different results over time (which has been described in section 3.5), and (2) if there are consistent results when using different econometric techniques, when compared to SEM. If the regional supply curve has an upward sloping.

The following discussion will focus on specialization, competition and HHI diversity results of SEM, first. Then, the results across various econometric models will be comparing with SEM, by looking at Table 5-6A to Table 5-13A. Doing so will allow us to check for omitted variable bias and endogeneity issues. Then, by examining Tables 5-6B to Table 5-13B, results from four different diversity indices will be compared across these four models, allowing us to determine whether different indices provide consistent results. Table 5-6A to Table 5-13B summarize the results of various indices and econometric models, and complete results can be found in the Appendix B.

5.6.1 Construction (NAICS 23)

In the Construction sector, in SEM, I find that a downward sloping regional labor demand curve and an upward sloping regional labor supply curve are found for HHI diversity model. The results of dynamic externalities on regional employment growth are varued. It shows specialization and competition have a negative impact on regional growth, but diversity helps from a regional labor demand perspective. From a labor supply perspective, diversity helps, but competition hurts regional growth. Furthermore, by comparing specialization, competition and HHI diversity indices across different econometric techniques using SEM, the results show inconsistent signs for diversity, specialization, and competition coefficients, which may suggest omitted variables in Glaeser's OLS, Bline' DE and Combes' RVAR models (look horizontally at Table 5-6A). However, by using Krugman Diversity (the coefficients of the second row of Table 5-6B), diversity helps regional growth on both the demand and supply side, which is contradictory to the results from HHI diversity. Furthermore, looking at the size of coefficients across different formula of diversity using SEM (compare the vertically coefficients of Table 5-6B), there is still substantial variation among HHI diversity, Dekle's and Glaeser's diversity results, which may suggest the empirical results are heavily dependent on the choice of diversity index formula. From the SEM perspective, regional labor supply does have an effect on regional growth, which suggests we should not assume a horizontal supply curve or ignore labor supply side factors. Overall, for dynamic externalities, there is a positive MAR effect on regional growth for Glaeser's OLS model. In addition, from the static externalities perspective, localization and competition hurt growth, but diversity actually helps growth.

In sum, for the Construction sector, Table 5-6B shows the results across various diversity indices, in each econometric model, and indicates diversity indices give mixed results for economic growth. For Dekle and Krugman diversity, 50% of the models have the same sign; for HHI Diversity, the results are consistent across the models, and for Glaeser's diversity, 75% of the models have consistent results. These results suggest that the HHI Diversity index is the most stable across different econometric techniques (Table 5-6B).

5.6.2 Manufacturing (NAICS 31-33)

The results for the Manufacturing Sector (NAICS 31-33) are shown in Table 5-7A and 5-7B. Regarding SEM, the results show diversity does help regional growth for both the demand and supply sides, but not for specialization and competition. This result is consistent with Henderson's (1997) and Batisse's (2002) conclusion. Comparing the results from SEM across different econometric techniques to the results from Glaeser's OLS and Combes' GMM in Table 5-7A, the significant differences suggesting omitted bias issues. Looking vertically at Table 5-7B, the results are not consistent across various diversity formulas, which again suggests the sensitivity of index choice.

From a static perspective, most contemporaneous regional diversity hurts regional growth in perfect competition market set-ups (including a structural simultaneous model, Bline and Glaeser). However, the results are opposite for Combes' model which suggests specialization and competition help growth. Combes' average employment growth rate equation suggests that the contemporaneous causality between average employment and number of firms exists due to strong structural change over time in manufacturing. A negative coefficient in establishment suggests an inverse relationship between the number of firms and average employment. Over time, the number of establishments increases indicating that average employment is decreasing, i.e., moving from a Cournot to perfect competition market structure. Furthermore, none of the diversity indices give consistent results across the different econometric models, which again suggests the sensitivity of index choice (Table 5-7B). From the dynamic externalities perspective, specialization and competition enhance economic growth in most models, but not diversity. This finding is similar to the Construction sector.

5.6.3 Wholesale (NAICS 42)

For the Wholesale sector (NAICS 42), using SEM, a downward sloping and a upward sloping were obtained. Also, the results show specialization and competition enhance regional growth from the labor demand, but not for the labor supply. Also, by adopting same dynamic externality indices across various econometric techniques, the results do not provide consistent results across those indices. For example, specialization has no effect on the labor demand, but it hurts on the labor supply in the structural model; however, the results show specialization helps in Bline's and Glaeser's model (Table 5-8A). Similarly, there are inconsistent results for competition and diversity across various econometrics models.

When examining at various diversity indices of a SEM model (Table 5-8B), it is found that not all diversity indices provide consistent results. For example, the first two columns of Table 5-8B show, diversity hurts supply when Krugman formula is adopted, but a positive effect is shown for typical HHI, Dekle HHI and Glaeser's diversity in general. Similar inconsistent results were obtained in Beline's models (by comparing the results vertically in Table 5-8B). Furthermore, comparing different diversity formulas across various econometric techniques (Table 5-8B, horizontally), there is no such consistent results. For example, by using Krugman diversity, the results show diversity helps in Combes' model, but diversity hurts in SEM and Glaeser' models. Same results can be reached by using either Dekle's and Glaeser's diversity indices. In sum, from Table 5-8A, it shows there are no consistent results across various econometric techniques, while Table 5-8B shows no consistent results across various diversity formulas.

5.6.4 Retail Trade (NAICS 44-45)

Retail Trade sector (NAICS 44-45) shows no consistent results for externalities indices across models across various econometrics techniques (Table 5-9A) from the static and dynamic externalities perspective. In SEM, competition hurts regional growth in labor supply and neither specialization nor diversity has an impact on regional growth. In Combes' model, specialization, competition, and diversity externalities are found in the number of firms equation, which suggests the higher the level externalities attract more new firms would like to locate in the Denver area. However, in Bline's model, specialization and competition hurt, but diversity helps regional growth; while in Glaeser's model, only competition helps. Again, there are no consistent results across different econometric models.

Table 5-9B shows the results of various diversity indices across different econometrics specification. By comparing the results between HHI and Krugman in SEM, there is no effect on regional growth when HHI is used; while there is a negative effect when Krugman is used. Similar inconsistent results also show when using either Dekle or Glaeser index in SEM. Furthermore, by focusing on the Krugman index (Table 5-9B), the results show diversity helps in Combes' average size and Bline's model; while diversity hurts in SEM supply side, Combes' number of firms equation, and Glaeser's model. Similar inconsistent results are show when using Dekle diversity (third row of Table 5-9B).

In sum, Table 5-9A shows no consistent results across various econometric techniques, and Table 5-9B shows no consistent results across various diversity formulas.

5.6.5 Information (NAICS 51)

For the Information sector (NAICS 51), diversity helps regional growth, but competition hurts regional growth in both demand and supply in SEM. However, specialization helps in Combes', Bline's and Glaeser's model. Similarly, there are also inconsistent results of compeititon and diversity across different econometrics techniques (Table 5-10A).

The results show complete contradictory in HHI (Table 5-10B), when Krugman diversity is adopted. Furthermore, comparing the results between Dekle's and Glaeser's model, the signs of the coefficients are consistent, though some are significant, while others are not. When comparing the signs of each diversity index across various econometrics techniques, once more, it is found only Dekle's diversity provides consistent results across various models.

5.6.6 Finance and Insurance (NAICS 52)

For the Finance and Insurance sector (NAICS 52), specialization and competition hurt regional growth in SEM (Table 5-11A). However, specialization is positively important in Bline's and Combes' establishment model. Similarly, there are no consistent results for competition or diversity effect on regional growth.

When various diversity indices are compared across different econometrics models (Table 5-11B), no consistent results are provided by any diversity indiex. For example, Krugman's formula shows that diversity helps in SEM, while it hurts in either Combes' or Glaeser's model. Again, there are still no consistent results when using Dekle or Glaeser index.

5.6.7 Health Care and Social Assistance (NAICS 62)

The Health Care and Social Assistance sector (NAICS 62) indicates diversity has a positive impact on regional growth on labor demand; however, specialization and competition hurt in SEM, while in Bline's and Combes's model, specialization has no impact on regional growth (Table 5-13A). Furthermore, there is no consistent HHI result across the different econometric models (a negative effect appears in Glaeser' model). By comparing various indices across the four econometrics techniques,again, there is no consistent results (Table 5-13B).

In sum, from these preliminary results, we can conclude that different econometric techniques can provide different empirical results, using the same index for a specific industry. Also, by comparing the signs of different diversity indices for various sectors, none of the diversity indices give consistent results across various econometric models, which suggests the sensitivity of the index choice.

Furthermore, the regional labor supply curve shows an upward slope for the Manufacturing, Wholesale Trade, Retail, and Information sectors in the simultaneous equation models.[66] This result suggests we should not ignore labor supply factors or assume a horizontal regional supply curve as most previous studies have. Furthermore, the empirical results do show externalities have impacts on the regional supply, but these externality effects vary across different sectors. In general, specialization and competition shift the regional labor supply curve inward, which again suggests a regional condition change that would affect migration decisions. This result is consistent with results that have been shown in Simon (1998) and Cingano and Schivardi (2004).

---

[66] For other sectors, the coefficients of real wage for regional supply curve are not significant at a 10% level. However, the coefficients are still positive.

5.7 Policy Implication and Conclusions

5.7.1 Policy Implication

According to the empirical results of SEMs from the previous section, this section will review the ideas behind the diversity and specialization index definitions and provides several possible policy implications for the Denver Area.

Recall that the diversity index considers not only the own industry, but also all other industry employment shares in the region. By looking at the diversity index formula, most are calculated from the combination of industrial employment share for the specific region. As in the example discussed in Section 3.6.1, the more evenly distributed employment share is the highest diversity environment. When employment share is identical among the three industries, i.e., 0.33 for each industry sector, HHI is 0.5, which is also the upper bound of HHI.

SEMs results show dynamic externalities do account for a significant part of labor demand and supply for most industrial sectors.[67] For diversity, the three largest coefficients are Information, Construction and Health Care and Social Assistant. For a policy maker, the empirical results suggest diversity helps regional growth, suggesting the goal is to enhance employment share even more in the Denver Area over time. To encourage industrial employment growth, city policy makers may provide incentives, such as a reduction in property tax or provide employment training, to enhance employment growth. By setting zoning districts on the developable land or resource usage, it will control employment growth for other sectors

Given data for the Denver Area, the Health Care and Social Assistant sector has a

[67] Various econometrics techniques have been examined for comparing different specifications propose in previous sections; however, SEM is a more complete model from theoretical perspective. Policy implications will only focus on SEMs results.

relatively high average HHI over time. This is due to the employment share of this sector that dominates all other sectors, and the other largest employment share sectors are relatively even. For policy makers to enhance environment diverse, it is reasonable to stimulate industries with relatively lower employment shares, such as Finance, Information and Manufacturing[68]. For example, policies that provide tax cuts for advanced manufacturing sectors will be beneficial since this sector is highly related to the health industry because this sector is tightened to manufacturing, information and health. Building a medical research park in the Denver area would be another possible way since this will increase employment in Information, Construction and Health Care and Social Assistant.

Recall that the specialization index measures the relative industrial employment share in the region to the national level. Furthermore, a positive specialization coefficient shows that the current industrial employment share growth is higher when compared its growth in the past. In other words, there is growth in the employment share for that sector in the Denver Area. To encourage industrial employment growth, the city policy makers may also provide similar incentives as in the diversity policies by reducing property tax, employment training or setting national parks.

Given the data of the Denver Area, the SEMs results show that the top three industries with the highest specialization are Health Care and Social Assistant (demand and supply), Wholesale (demand only), and Construction (demand and supply). Specialization has a positive effect on both demand and supply for Health Care and Social Assistant and Construction.

---

[68] Of course, from HHI formula, the highest HHI will bounded when all employment share is identical. However, some sectors will not be ideal to stimulate due to the current whole economy structure such as mining and lodging.

From the specialization perspective, if there is only limited funding for enhancing growth for policy makers, Health Care and Social Assistant should be the first choice, Wholesale and Construction will be the second and third choice. For Health Care and Social Assistant, not only due to size of the coefficient, i.e., it has the greatest accumulated effect among all industry sectors, but also because it requires specific trained staff and information, it has the effect on both labor demand and supply side.

The Wholesale sector is very widespread since it connects information, communication, service and other sectors. Wholesale also optimizes the information flow of goods and services between producers and consumers. So, specialization in Wholesale will not only enhance its own sector, but also boost other sectors.

The next specialization choice will be Construction. These results are due to Denver's renovation and redevelopment since the late 80'. For policy makers, specialization in Construction is usually a task for regional redevelopment policy. Furthermore, for the surrounding cities of Denver, policy makers can also consider stimulating Health Care and Social Assistant as a key driver for regional development since it has the greatest spillover effect among other sectors.

Overall, the results appear to the policy maker that there is a need of policy for both diversified (various knowledge across different sectors, i.e., vertical perspective) and specialization (similar knowledge in similar sectors, i.e., horizontal perspective) employment composition at the same time in the Denver Area. Not only hierarchical knowledge transmission will be beneficial, but also an emphasis on simplifiers of that specific knowledge, which can be used vertically across industries, will be valuable for regional growth. This may suggest that the policy makers can focus on stimulating an industry, which will be a key driving force for the whole region, with a strong network relation with other industries. More specifically, the results show that diversity and specialization of the Health Care and Social Assistant sector would enhance regional growth. This implies that the policy maker could provide a possible expansion for a knowledge center and address the strengths and usefulness which can be adopted by the wide range of industries. Since specialization and diversity co-exist, bridging knowledge between industrial sectors will be a key to driving regional growth in the long run, such as bridging medical with engineering, and commercial manufacturing.

In sum, this study shows diversity will enhance regional growth for most sectors in the Denver area. Policy makers can create a wide range knowledge center, which would combine and merge various bodies of knowledge to benefit the public. Combining various hierarchical and horizontal knowledge bases, such as Health Care and Social Assistant will be the most effective at this moment to improve regional growth in the Denver area. Furthermore, these empirical results may also be generalized to other cities, which have the similar size cities, such as Salt Lake city.

5.7.2 Conclusions

The contribution of this study is to build a better data set for the Denver Area and examine the various dynamic externalities on regional growth. First, the time pattern chosen for the research gives different conclusions. In Chapter 3, Figure 3-7 and Figure 3-8 show two important aspects: first, the fluctuations of Dekle and Krugman HHI over time suggest that a random choice of a starting point for a two time period study will affect empirical results. Second, different diversity indices provide inconsistent conclusions over time, which again suggests the inconsistent results across various indices definitions. In addition, the results show that the choice of dynamic externalities index affects empirical results (Table 5-6 to Table 5-13). This indicates inconsistent results across diversity indices. Finally, with the time series data, using the Denver area as an example, different econometrics techniques provide mixed results for most diversity indices. HHI Diversity has the most consistent results (though not always) across industries and econometric models.

5.8 Future work

1. Different diversity formulas provide different empirical results. However, which is better has not yet been examined. Forecasting may provide a good idea about which index is a better fit for economic growth. If HHI provides better results for forecasting, then it may suggest diversity is a more local perspective. If Krugman diversity provides better results for forecasting, it may suggest the diversity concept need to consider the national level employment structure.
2. One contribution of this study is building a better data set, including material costs and demographic data for the Denver area. However, due to data limitations, aggregate data was adopted. More accurate results could be provided with a microfoundation data set in the Denver area (which was also suggested by Rosenthal and Strange, 2003).
3. Some studies adopted a panel data set, including across industries and regions over time, which allows for control of the spatial effect, fixed effect and random effect. However, obtaining detailed microfoundation data for both demand and

supply factors to estimate a structural model would be challenging at this stage due to confidentiality issues.

4. Of course, it is possible a better specification for this structural model could be developed, but this would require more detailed data, such as capital, individual material costs, output, etc. However, employee and employer matched data, Longitudinal Research Data (LRD) are confidential and can only be accessed at the U.S. Census Bureau stations. Again, this would be really challenging at this stage, as well.

Table 5-6A Dynamic Externality Indices for Construction (NAICS 23)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg Emp)	Supply (Avg Emp)	Average Size (Δ Avg Emp Growth)	Number of Firms (Δ N growth)	Emp Growth (Δ Emp Growth)	Emp Growth (Δ Emp growth)
Specialization	-1.8947 (16.413)	4.8219 (10.793)	-0.8752 (1.032)	2.7862*** (0.666)	-5.9520*** (1.78)	39.676 (38.54)
Competition	-78.6398*** (18.702)	-42.6293*** (11.397)	0.0333 (0.024)	0.0290** (0.012)	-0.0420 (0.027)	0.6046 (0.735)
HHI Diversity	7.4792*** (2.658)	4.3350** (1.778)	0.4199*** (0.125)	0.0686 (0.084)	0.0018 (0.158)	4.6394 (3.768)

Table 5-6B Various Diversity Indices for Construction (NAICS 23)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg Emp)	Supply (Avg Emp)	Average Size (Δ Avg Emp Growth)	Number of Firms (Δ N growth)	Emp Growth (Δ Emp Growth)	Emp Growth (Δ Emp growth)
HHI Diversity	7.4792*** (2.658)	4.3350** (1.778)	0.4199*** (0.125)	0.0686 (0.084)	0.0018 (0.158)	4.6394 (3.768)
Krugman Diversity	-66.9169*** (21.659)	-48.1708*** (1.7913)	3.8223*** (0.456)	0.5422 (1.1830)	-4.1444 (3.542)	78.9980*** (29.445)
Dekle Diversity	-1028.66*** (345.5)	-569.319*** (237.87)	-61.663*** (13.852)	0.1213 (7.911)	-108.107*** (15.072)	-563.29 (469.68)
Glaeser Diversity	-186.963*** (45.129)	-102.091*** (19.580)	-1.4857 (2.049)	-1.5246** (0.645)	-1.4478* (0.839)	49.5921 (63.521)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level. **: 5% Significant level. *: 10% Significant level.

Table 5-7A Dynamic Externality Indices for Manufacture (NAICS 31-33)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
Specialization	-14.5531 (2.976)	-116.556*** (26.598)	5.9119*** (0.877)	0.5782*** (0.126)	-0.2533*** (0.056)	18.368 (22.31)
Competition	-11.5438 (19.120)	-108.381*** (20.515)	5.6206*** (0.755)	0.5427*** (0.1067)	-0.5012*** (0.035)	29.719* (17.41)
HHI Diversity	4.4570*** (1.858)	6.9700** (2.670)	-0.291*** (0.081)	-0.0290* (0.014)	0.0580*** (0.006)	3.0105 (2.349)

Table 5-7B Various Diversity Indices for Manufacture (NAICS 31-33)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
HHI Diversity	4.4570*** (1.858)	6.9700** (2.670)	-0.291*** (0.081)	-0.0290* (0.014)	0.0580*** (0.006)	3.0105 (2.349)
Krugman Diversity	-50.8910*** (12.843)	-108.339*** (21.206)	1.0018 (0.719)	0.1384** (0.076)	-0.3692*** (0.053)	-21.5708 (21.465)
Dekle Diversity	-694.54*** (287.05)	-1063.81** (405.543)	37.297* (23.43)	4.6001** (2.079)	-4.0378*** (0.515)	-459.96 (356.81)
Glaeser Diversity	117.521*** (30.366)	150.517*** (41.339)	11.4261*** (1.159)	0.0854 (0.219)	0.5380*** (0.165)	5.4242 (45.494)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level; **: 5% Significant level; *: 10% Significant level

Table 5-8A Dynamic Externality Indices for Wholesale (NAICS 42)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (Δ N_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
Specialization	20.5737*** (3.416)	-6.3741 (7.162)	0.1497*** (0.025)	-0.0735 (0.094)	0.4683*** (0.138)	7.5570* (4.159)
Competition	29.5819*** (7.767)	-9.7981 (20.222)	-0.5239*** (0.095)	-0.0206 (0.256)	-0.6493*** (0.236)	29.824*** (8.572)
HHI Diversity	1.1824 (0.853)	2.3729* (1.405)	-0.0137** (0.006)	-0.0361 (0.024)	-0.0773*** (0.025)	-0.8028 (1.227)

Table 5-8B Various Diversity Indices for Wholesale (NAICS 42)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (Δ N_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
HHI Diversity	1.1824 (0.853)	2.3729* (1.405)	-0.0137** (0.006)	-0.0361 (0.024)	-0.0773*** (0.025)	-0.8028 (1.227)
Krugman Diversity	4.8053 (5.357)	-35.1258*** (6.572)	0.5400*** (0.130)	0.0927 (0.1045)	-0.095 (0.348)	-18.2443** (9.017)
Dekle Diversity	-177.88 (125.61)	-354.67* (213.24)	2.0810** (0.926)	5.4928 (3.599)	11.670*** (3.723)	122.099 (185.67)
Glaeser Diversity	-38.0593** (16.098)	-88.7878*** (13.387)	-0.3471** (0.131)	0.2877 (0.276)	1.8022*** (0.548)	13.3274 (21.428)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level; **: 5% Significant level; *: 10% Significant level.

Table 5-9A Dynamic Externality Indices for Retail Trade (NAICS 44-45)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
Specialization	-16.8372 (20.895)	-19.1600 (12.158)	0.5849 (0.454)	1.0477*** (0.233)	-1.0389*** (0.229)	5.1031 (12.61)
Competition	-10.7674 (10.752)	-41.8655*** (4.254)	-0.2308 (0.208)	0.4964*** (0.167)	-1.4249*** (0.384)	18.578*** (8.161)
HHI Diversity	0.7200 (0.934)	0.1205 (0.689)	-0.0951*** (0.019)	0.0369* (0.022)	0.0318*** (0.010)	-0.9539 (1.049)

Table 5-9D Various Diversity Indices for Retail (NAICS 44-45)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
HHI Diversity	0.7200 (0.934)	0.1205 (0.689)	-0.0951*** (0.019)	0.0369* (0.022)	0.0318*** (0.010)	-0.9539 (1.049)
Krugman Diversity	-9.5793 (11.793)	-18.1677** (6.904)	0.7389*** (0.226)	-0.5652*** (0.099)	0.6076*** (0.172)	-20.3462** (10.022)
Dekle Diversity	-103.61 (138.45)	19.642 (101.92)	13.906*** (2.782)	10.254*** (2.047)	-4.7428*** (1.483)	144.967 (154.86)
Glaeser Diversity	-44.0828*** (15.211)	-15.6485 (14.973)	0.2957 (0.687)	-1.1993*** (0.252)	0.1466 (0.362)	-14.5741 (16.190)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level; **: 5% Significant level; *: 10% Significant level

Table 5-10A Dynamic Externality Indices for Information (NAICS 51)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
Specialization	29.8620 (30.645)	9.5072 (28.587)	0.0874 (3.839)	0.1650*** (0.055)	0.3295*** (0.079)	106.71*** (38.830)
Competition	-105.613** (48.336)	-143.597*** (34.601)	-27.8522*** (8.056)	0.9184*** (0.071)	-1.2796*** (0.093)	90.250* (53.35)
HHI Diversity	23.9989*** (6.803)	28.4804*** (3.485)	3.4804*** (1.045)	-0.0954*** (0.012)	0.1183*** (0.016)	40.487*** (6.043)

Table 5-10B Various Diversity Indices for Information (NAICS 51)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
HHI Diversity	23.9989*** (6.803)	28.4804*** (3.485)	3.4804*** (1.045)	-0.0954*** (0.012)	0.1183*** (0.016)	40.487*** (6.043)
Krugman Diversity	-26.0026 (80.759)	-258.732*** (37.564)	1.0886 (10.192)	0.5690*** (0.116)	-0.0669 (0.128)	-183.3260** (74.237)
Dekle Diversity	-3232.2*** (915.51)	-3922.7*** (478.29)	-474.049*** (140.18)	5.1624 (3.297)	-16.557*** (2.329)	-5477.7*** (829.2)
Glaeser Diversity	-338.337*** (121.567)	-678.323*** (94.980)	-31.7879** (15.944)	0.5576* (0.340)	-2.6879*** (0.317)	-647.0323*** (162.143)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level; **: 5% Significant level; *: 10% Significant level.

Table 5-11A Dynamic Externality Indices for Finance and Insurance (NAICS 52)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
Specialization	-35.6713*** (7.463)	-33.3494*** (4.557)	0.0997 (0.929)	0.6399*** (0.034)	0.2179*** (0.033)	-9.9088 (8.899)
Competition	-72.5905*** (10.501)	-45.6210*** (8.322)	-2.8726** (1.245)	0.9515*** (0.059)	-1.5649*** (0.049)	-19.557 (17.00)
HHI Diversity	-3.3317** (1.622)	-0.4100 (1.127)	0.4374 (0.428)	0.0616*** (0.012)	0.0087 (0.007)	0.5099 (2.423)

Table 5-11B Various Diversity Indices for Finance and Insurance (NAICS 52)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
HHI Diversity	-3.3317** (1.622)	-0.4100 (1.127)	0.4374 (0.428)	0.0616*** (0.012)	0.0087 (0.007)	0.5099 (2.423)
Krugman Diversity	37.7365*** (13.384)	27.2927*** (11.067)	5.4860** (2.279)	-0.1881*** (0.053)	0.1732 (0.127)	-50.0103** (19.895)
Dekle Diversity	492.82** (238.91)	70.818 (167.26)	-61.125 (64.23)	-9.1561*** (1.780)	-3.7560*** (0.987)	-67.017 (357.7)
Glaeser Diversity	65.4886** (24.491)	37.4197* (20.727)	-4.5966 (5.917)	-1.1586*** (0.267)	1.0213*** (0.171)	48.5000 (51.464)

Note: 1. Standard errors of parameter estimates are in parentheses. *** 1% Significant level; **: 5% Significant level; *: 10% Significant level

Table 5-12A Dynamic Externality Indices for Health Care and Social Assistance (NAICS 62)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (Δ N_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
Specialization	30.3107*** (8.447)	51.4012*** (12.009)	-3.1250 (2.113)	0.0204 (0.061)	0.1206* (0.072)	42.847* (25.195)
Competition	24.6128* (15.054)	-4.2831 (15.985)	2.5500 (8.292)	0.5889*** (0.062)	-1.1754*** (0.103)	47.947 (37.05)
HHI Diversity	4.6340** (1.719)	4.5721*** (1.010)	-0.4012 (0.573)	-0.0441*** (0.008)	0.0351*** (0.007)	-0.6972 (3.259)

Table 5-12B Various Diversity Indices for Health Care and Social Assistance (NAICS 62)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (Δ Avg_Emp_Growth)	Number of Firms (Δ N_growth)	Emp Growth (Δ Emp_Growth)	Emp Growth (Δ Emp_growth)
HHI Diversity	4.6340** (1.719)	4.5721*** (1.010)	-0.4012 (0.573)	-0.0441*** (0.008)	0.0351*** (0.007)	-0.6972 (3.259)
Krugman Diversity	39.1412** (17.192)	22.6765 (28.283)	5.6841 (3.588)	0.9212*** (0.081)	0.2844*** (0.100)	-43.9260 (41.936)
Dekle Diversity	-831.39*** (307.04)	-834.07*** (180.863)	72.512 (103.07)	7.6239*** (1.367)	-1.0142 (1.1123)	121.20 (573.1)
Glaeser Diversity	41.0784 (56.452)	-33.9948 (51.552)	7.3906 (8.454)	-0.7916*** (0.076)	0.1582 (0.117)	-224.2251*** (66.937)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level; **: 5%Significant level; *: 10% Significant level.

Table 5-13A Dynamic Externality Indices for Professional, Scientific and Technical Service (NAICS 54)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
Specialization	-19.6100** (7.839)	-22.4850*** (4.699)	-0.2293 (0.489)	0.0571 (0.051)	-0.0427 (0.054)	4.9042 (4.560)
Competition	-36.7523*** (11.372)	-46.4452*** (8.317)	-1.3347*** (0.614)	0.4823*** (0.057)	-0.6003*** (0.053)	6.3142 (6.001)
HHI Diversity	2.4127** (0.956)	1.4967 (1.037)	0.0319 (0.082)	0.0313*** (0.008)	0.0546*** (0.011)	-2.7508*** (0.887)

Table 5-13B Various Diversity Indices for Professional, Scientific and Technical Service (NAICS 54)

	Structural Model (3SLS)		Combes (2004) (GMM)		Bline (2006) (GMM)	Glaeser (1992) (OLS)
	Demand (Avg_Emp)	Supply (Avg_Emp)	Average Size (ΔAvg_Emp_Growth)	Number of Firms (ΔN_growth)	Emp Growth (ΔEmp_Growth)	Emp Growth (ΔEmp_growth)
HHI Diversity	2.4127** (0.956)	1.4967 (1.037)	0.0319 (0.082)	0.0313*** (0.008)	0.0546*** (0.011)	-2.7508*** (0.887)
Krugman Diversity	30.9593*** (8.729)	-6.9394 (10.019)	0.3717 (0.673)	-0.1024 (0.112)	-1.3175*** (0.159)	-23.6397*** (7.793)
Dekle Diversity	-364.71*** (156.48)	-233.79 (169.15)	-4.1210 (13.089)	6.9248*** (1.869)	-8.8001*** (1.730)	441.50*** (140.79)
Glaeser Diversity	-3.3721 (21.525)	-16.6930 (21.227)	-9.3526*** (1.552)	-1.3222*** (0.265)	-1.3997*** (0.241)	38.8770** (18.541)

Note: 1. Standard errors of parameter estimates are in parentheses. ***:1% Significant level; **: 5% Significant level; *: 10% Significant level

REFERENCES

Arellano, M. (2003) *Panel Data Econometrics*, Oxford UP, Oxford.

Arellano, M. and Bond, S. R. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, *58*, 227-297.

Arrow, K. (1962). The economic implications of learning by doing. *The Review of Economic Studies*, *29*(3), 173, 155.

Austrian, Z., & Rosentraub, M. S. (2002). Cities, sports, and economic change: A retrospective assessment. *Journal of Urban Affairs*, *24*(5), 549-563.

Baade, R. (1996). Professional sports as catalysts for metropolitan economic development. *Journal of Urban Affairs*, *18*(1), 1-17.

Baade, R. A. (1994). Stadiums, professional sports, and economic development: Assessing the reality. *Heartland Policy Study*, *62*(28), 1-39.

Baade, R. A., & Dye, R. F. (1988). Sports stadiums and area development: A critical review. *Economic Development Quarterly*, *2*(3), 265-275.

Baade, R. A., & Dye, R. F. (1990). The impact of stadium and professional sports on metropolitan area development. *Growth and Change, 21*(2), 1-14.

Baade, R. A., & Sanderson, A. R. (1997). The employment effect of teams and sports facilities. *Sports, Jobs and Taxes: The Economic Impact of Sports Teams and Stadiums*, 92–118.

Batisse, C. (2002) Dynamic externalities and local growth: a panel data analysis applied to Chinese provinces. *China Economic Review*, *13*, 231-251.

Beaudry, C., & Schiffauerova, A. (2009). Who's right, Marshall or Jacobs? The localization versus urbanization debate. *Research Policy*, *38*(2), 318-337.

Blien, U., Suedekum, J., & Wolf, K. (2006). Local employment growth in West Germany: A dynamic panel approach. *Labour Economics*, *13*(4), 445-458.

Blomquist, G. C., Berger, M. C., & Hoehn, J. P. (1988). New estimates of quality of life in urban areas. *The American Economic Review*, 89-107.

Borts, G., & Stein, J. (1964). *Economic Growth in a Free Market*. Columbia University Press, New York.

Brandt, P. T. & Williams, J. T. (2007). *Multiple Time Series Models*. Sage Publications, Inc.

Carlino, G., & Coulson, N. E. (2004). Compensating differentials and the social benefits of the NFL. *Journal of Urban Economics*, *56*(1), 25-50.

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

Cingano, F., & Schivardi, F. (2004). Identifying the sources of local productivity growth. *Journal of the European Economic Association*, *2*(4), 720-742.

Coates, D., & Humphreys, B. R. (1999). The growth effects of sport franchises, stadia, and arenas. *Journal of Policy Analysis and Management*, 601-624.

Coates, D., & Humphreys, B. R. (2001). The economic consequences of professional sports strikes and lockouts. *Southern Economic Journal*, *67*(3), 737-747.

Coates, D., & Humphreys, B. R. (2003). The effect of professional sports on earnings and employment in the services and retail sectors in US cities. *Regional Science and Urban Economics*, *33*(2), 175-198.

Combes, P. (1997). Industrial agglomeration under Cournot competition. *Annales d'Économie et de Statistique*, *45*, 161-182.

Combes, P. (2000a). Marshall-Arrow-Romer externalities and city growth. *CERAS Working Paper*.

Combes, P. (2000b). Economic structure and local growth: France, 1984-1993. *Journal of Urban Economics*, *47*(3), 329-355.

Combes, P., Magnac, T., & Robin, J. (2004). The dynamics of local employment in France. *Journal of Urban Economics, 56*(2), 217-243.

Cota, J. E. M. (2002). Agglomeration economies and urban manufacturing growth in the northern border cities of Mexico. *Economia Mexicana*. *11*(1), 163-190.

De Lucio, J.J., Herce, J.A., & Goicolea, A. (2002). The effects of externalities on productivity growth in Spanish industry. *Regional Science and Urban Economics*, *32*, 241-258.

Dekle, R. (2002). Industrial concentration and regional growth: Evidence from the prefectures. *The Review of Economics and Statistics, 84*(2), 310-315.

Dekle, R., and Eaton, J. (1999). Agglomeration and land rents: evidence from the prefectures. *Journal of Urban Economics*, *46*(3), 200–214.

Deller, S. C., Tsung-Hsiu (Sue) Tsai, David W. Marcouiller, & Donald B. K. English. (2001). The role of amenities and quality of life in rural economic growth. *American Journal of Agricultural Economics*, *83*(2), 352-365.

Dissart, J. C. *(*2003). Regional economic diversity and regional economic stability: research results and agenda*.* *International Regional Science Review,* 26, 423–446.

Dunlevy, J. A. & Bellante, D. (1983). Net migration, endogenous incomes and the speed of adjustment to the North-South differential. *The Review of Economics and*

Statistics, *65*(1), 66-75.

Duranton, G., & Puga, D. (2000). Diversity and specialization in cities: Why, where and when does it matter? *Urban Studies*, *37*(3), 533.

Ellison, G., and Glaeser, E. (1997). Geographic concentration in U.S. manufacturing industries: a dartboard approach. *Journal of Political Economy*, *105*, 889-927.

Enrico Moretti. (2003). *Human Capital Externalities in Cities*. National Bureau of Economic Research, Inc.

Freeman, J. R., Williams, J. T. & Lin, T. M. (1989). Vector autoregression and the study of politics. *American Journal of Political Science*, *33,* 842-877.

Fujita, M. (1989). *Urban Economic Theory. Land Use and City Size.* Cambridge University Press.

Fujita, M., & Thisse, J. (2002). *Economics of agglomeration*. Cambridge University Press.

Gao, T. (2004). Regional industrial growth: evidence from Chinese industries. *Regional Science and Urban Economics*, *34*, 101-124.

Glaeser, E. & Mare, D.C. (2001). Cities and skills. *Journal of Labor Economics*, *19*(2), 316-342.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., & Shleifer, A. (1992). Growth in cities. *Journal of Political Economy*, *100*(6), 1126-1152.

Gottlieb, P. D. (1995). Residential amenities, firm location and economic development. *Urban Studies*, 32(9), 1413-1436.

Greene, W. H. (2000). *Econometrics Analysis*. Prentice Hall.

Gyourko, J., & Tracy, J. (1991). The structure of local public finance and the quality of life. *Journal of Political Economy*, *99*(4), 774-806.

Hamermesh, D. S. (1996). *Labor Demand*. Princeton University Press.

Hansen, L.P., (1982) Large sample properties of generalized method of moments estimators. *Econometrica*, *50*, 1029-1054

Henderson, V. (1994). Where does an industry locate? *Journal of Urban Economics*, *35*, 83-104.

Henderson, V. (1997). Externalities and Industrial Development. *Journal of Urban Economics*, *42*(3), 449-470.

Henderson, V. (2003). Marshall's Scale Economies. *Journal of Urban Economics*, *53*(1), 1-28.

Henderson, V., Kuncoro, A. & Turner, M. (1995). Industrial Development in Cities. *The Journal of Political Economy*, *103*(5), 1067-1090.

Howard, D. R., & Crompton, J. L. (1995). *Financing sport*. Fitness Information Technology Morgantown.

Hsiao, C. (2003). *Analysis of Panel Data*. Cambridge University Press, Cambridge.

Hudson, I. (1999). Bright Lights, Big City: Do professional sports teams increase employment? *Journal of Urban Affairs*, *21*(4), 397-408.

Jacobs, J. (1969). *The Economies of Cities*. Random House, New York.

Jarrow, R. & Protter, P. (2004). Structural versus reduced form models: a new information based perspective. *Journal of Investment Management*, ***2***, 1–10.

Johnson, B. K., Groothuis, P. A., & Whitehead, J. C. (2001). The value of public goods generated by a major league sports team: The CVM approach. *Journal of Sports Economics*, *2*(1), 6.

Keane, M. (2010). Structural vs. atheoretic approaches to econometrics, *Journal of Econometrics*, *156*(1), 3-20.

Knapp, T. A., & Philip E. Gravest. (1989). On the role of amenities in models of migration and regional development. *Journal of Regional Science, 29*(1), 71-87.

Lee, B. S., Sosin, K., & Hong, S. H. (2005). Sectoral manufacturing productivity growth in Korean regions. *Urban Studies*, *42*(7), 1201-1219.

Lyne, J. (1988). Quality of life factors dominate many facility location decisions. *Site Selection Handbook*. *33*, 868-870.

Mack, E., Grubesic, T. H., & Kessler, E. (2007). Indices of industrial diversity and regional economic composition. *Growth and Change, 38*(3), 474-509.

Marshall, A. (1890). *Principles of Economics*. MacMillan, London.

Mathur, V. K., & Sheldon H. Stein. (1993). The Role of Amenities in a General Equilibrium Model of Regional Migration and Growth. *Southern Economic Journal*, *59*(3), 394-409.

Mathur, V., & Song, F. (2000). A labor market based theory of regional economic development. *The Annals of Regional Science*, *34*, 131-145.

Meek, A. (1997). An estimate of the size and supported economic activity on the sports industry in the United States. *Sport Marketing Quarterly, 6*(4), 15-21.

Miller, P. A. (2002). The Economic Impact of Sports Stadium Construction: The Case of the Construction Industry in St. Louis, MO. *Journal of Urban Affairs*, *24*(2), 159-173.

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

Nelson, A. C. (2001). Prosperity or blight? A question of major league stadia locations. *Economic Development Quarterly*, *15*(3), 255-265.

Nelson, A. C. (2002). Locating major league stadiums where they can make a difference: Empirical analysis with implications for all major public venues. *Public Works Management & Policy*, *7*(2), 98.

Noll, R. G., & Zimbalist, A. S. (1997). *Sports, Jobs, and Taxes: The Economic Impact of Sports Teams and Stadiums*. Brookings Institution Press.

Nunn, S., & Rosentraub, M. S. (1997). Dimensions of interjurisdictional cooperation. *Journal of the American Planning Association*, *63*(2), 205-219.

Ottaviano, G. I., & Peri, G. (2006). The economic value of cultural diversity: evidence from US cities. *Journal of Economic Geographic*, *6*(1), 9-44.

Partridge, M. D. & Rickman, D. S. (1999). Static and dynamic externalities, industrial composition, and state labor productivity: A panel study of states. *Southern Economic Journal*, *66*(2), 319-335.

Pines, D. (2005). Economics of agglomeration: Cities, industrial location and regional growth. *Regional Science and Urban Economics*, *35*(5), 584-592.

Pitts, B. G., & Stotlar, D. K. (2002). *Fundamentals of sport marketing*. Fitness information technology.

Polzin, P. (1970). Regional labor markets: A simple analysis. *The Annals of Regional Science*, *4*(1), 137-145.

Porter, M. E., (1990). *The Competitive Advantage of Nations*. New York: Free Press.

Rappaport, J., & Wilkerson, C. (2001). What Are the Benefits of Hosting a Major League Sports Franchise? *Economic Review-Federal Reserve Bank of Kansas City*, *86*(1), 55-86.

Roback, J. (1982). Wages, rents, and the quality of life. *Journal of Political Economy*, *90*(6), 1257-78.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, *94*(5), 1002-37.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, *94*(5), 1002-1037.

Rosen, S. (1979). Wage-based indexes of urban quality of life. *Current issues in urban economics*, *3*.

Rosenthal, S., & Strange, W.C. (2003) Geography, industry organization and agglomeration. The Review of Economics and Statistics, *85*(2), 377-393.

Rosentraub, M. S. (2006). The local context of a sports strategy for economic development. *Economic Development Quarterly*, *20*(3), 278-291.

Rosentraub, M. S., Swindell, D., Przybylski, M., & Mullins, D. R. (1994). Sport and downtown development strategy: If you build it, Will jobs come? *Journal of Urban Affairs*, *16*(3), 221-239.

Rust, J. (2010). Comments on: structural vs. atheoretic approaches to econometrics by Michael Keane. *Journal of Econometrics*, *156*(1), 21-24.

Santo, C. (2005). The economic impact of sports stadiums: Recasting the analysis in context. *Journal of Urban Affairs*, *27*(2), 177-192.

Schmenner, R. (1982). *Making Business Location Decisions.* Englewood Cliff, NJ: Prentice-Hall.

Siegel, P.B., Alwang, J. & Johnson, T.G. (1995a) A structural decomposition of regional economic instability: A conceptual framework. *Journal of Regional Science*. *35*(3), 457-470.

Siegel, P.B., Johnson, T. G., & Alwang, J. (1995b) Regional economic diversity and diversification. *Growth and Change*, *26*(2), 261-284.

Siegfried, J., & Zimbalist, A. (2000). The Economics of Sports Facilities and Their Communities. *Journal of Economic Perspectives*, *14*(3), 95-114.

Sim, C. A. (1980). Macroeconomics and reality. *Econometrica*, *48*, 1-48.

Simon, C. J. (1988). Frictional unemployment and the role of industrial diversity. *The Quarterly Journal of Economics*, 715-728.

Tu, C. C. (2005). How does a new sports stadium affect housing values? The case of FedEx Field. *Land Economics*, *81*(3), 379-395.

van Oort, F. G., *van* Soest, D., and Gerking, S. D. (2005) Dynamic information externalities and employment growth in the Netherlands. In: R. Boschma & R. Kloosterman (eds.), *Learning From Clusters*. *A Critical Assessment from An Economic-geographical Perspective*. Berlin: Springer Verlag.

Vijay K. Mathur, & Frank M. Song. (2000). A labor market based theory of regional economic development. *The Annals of Regional Science*, *34*(1), 131-145.

Wanger, J. E. (2000). Regional economic diversity: action, concept or state of confusion. *The Journal of Regional Analysis and Policy*, *30*(2), pp. 1–22.

Wassmer, R. W. (2001). Metropolitan prosperity from major league sports in the CBD: Stadia locations or just strength of the central city? A Reply to Arthur C. Nelson. *Economic Development Quarterly*, *15*(3), 266-271.

Waltert, F. & Schlapfer, F. (2010), The role of landscape amenities in regional development: a survey of migration, regional economic and hedonic pricing studies. *Ecological Economics*, *70*(2), 141-152.

Zellner, A. & Palm, F. (1974). Time series analysis and simultaneous equation econometric models, *Journal of Econometrics*, *2***,** 17–54.

Zheng, X.P. (2010), A cointegration analysis of dynamic externalities. *Japan and World Economy*, *22*(2), 130-140.

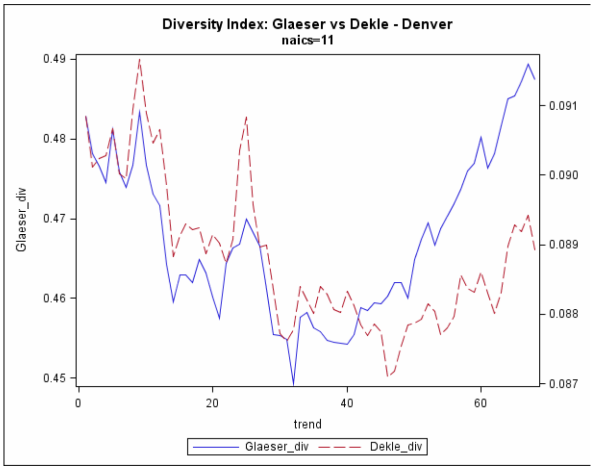
Zimbalist, A. (1998). The economics of stadiums, teams and cities. *Policy Studies Review*, *15*(1), 17–29.

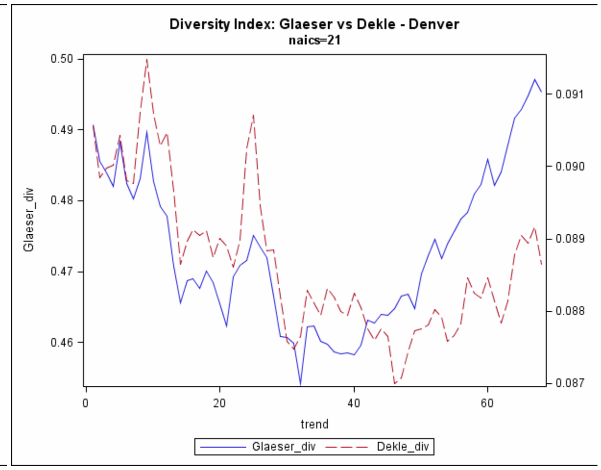
Zimbalist, A. S. (2006). *The Bottom Line: Observations And Arguments On The Sports Business*. Temple University Press.

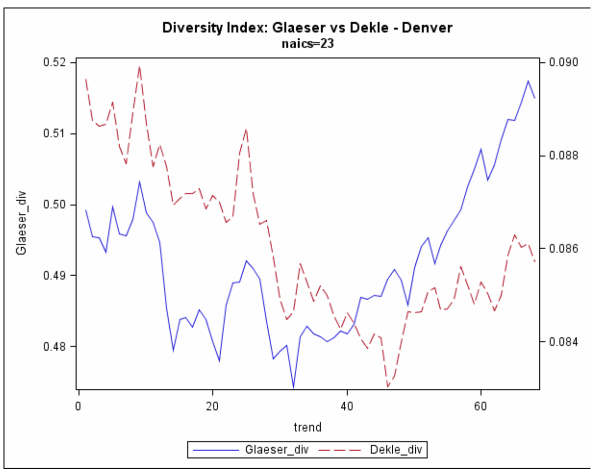
APPENDIX

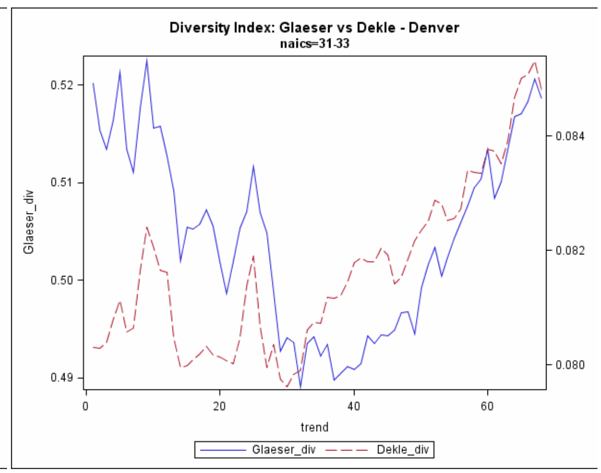
Appendix A

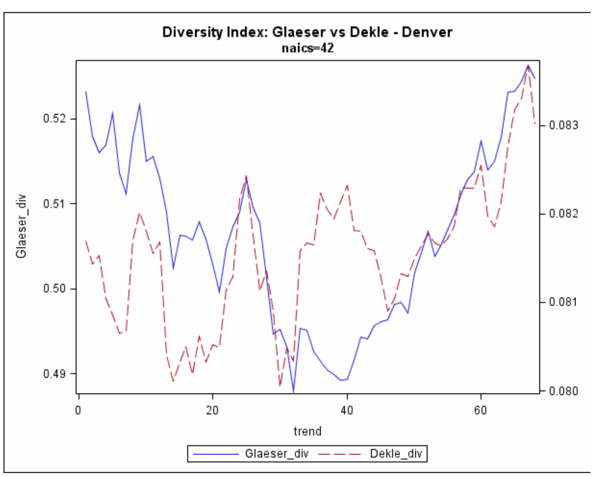
Diversity Index Comparison for Glaeser and Dekle (Denver County)

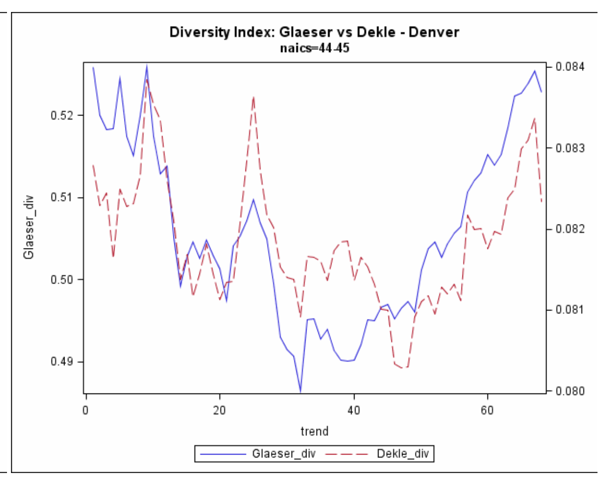




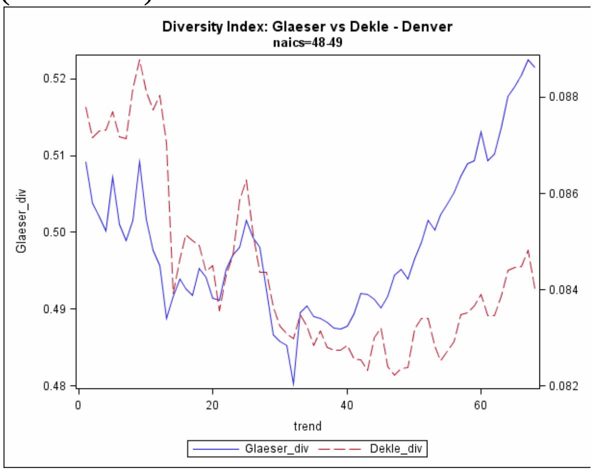


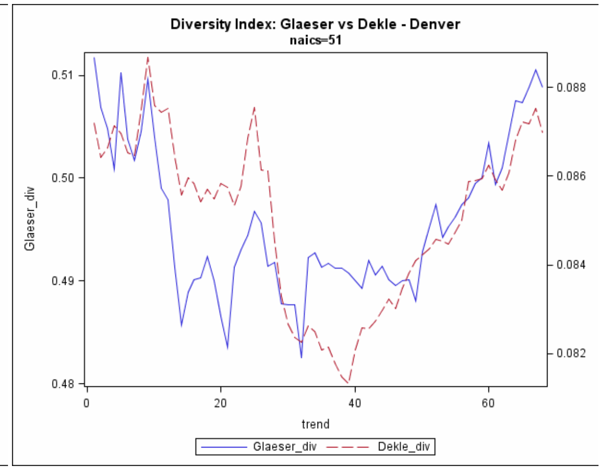


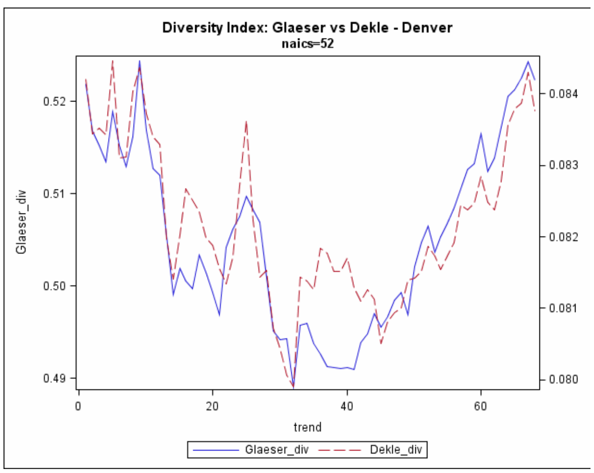


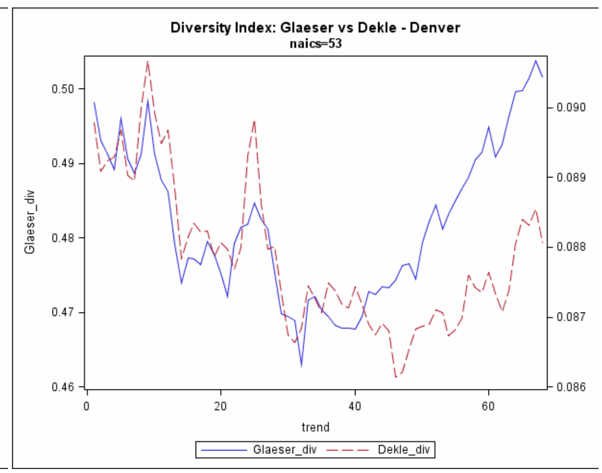


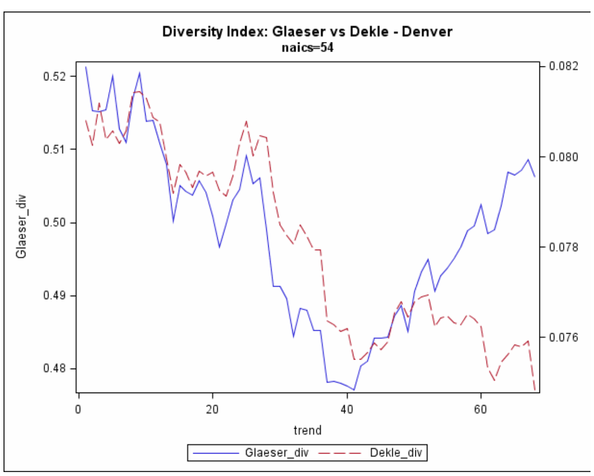
(Continued)

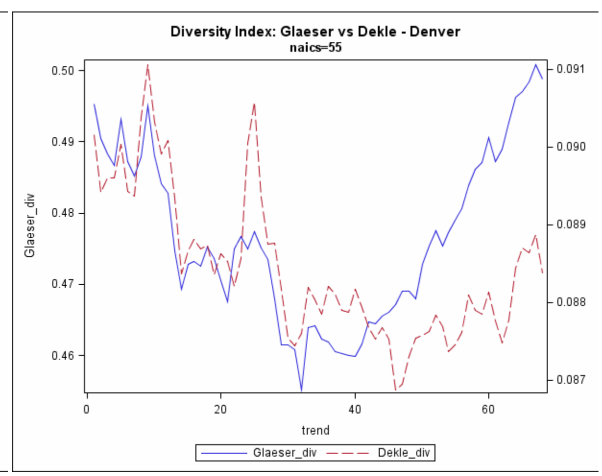

Diversity Index: Glaeser vs Dekle - Denver
naics=48-49
Glaeser_div
trend
Glaeser_div
Dekle_div


Diversity Index: Glaeser vs Dekle - Denver
naics=51
Glaeser_div
trend
Glaeser_div
Dekle_div

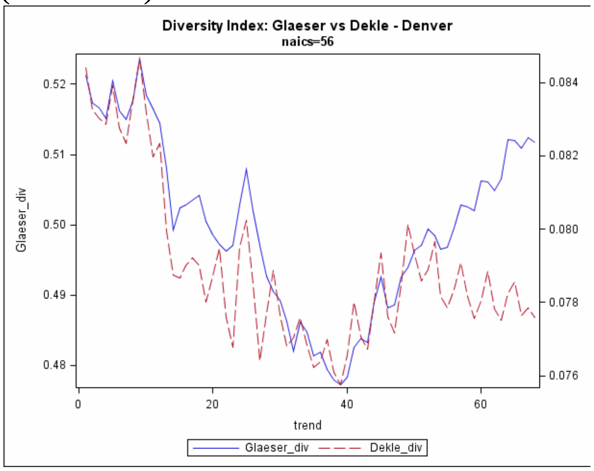

Diversity Index: Glaeser vs Dekle - Denver
naics=52
Glaeser_div
trend
Glaeser_div
Dekle_div

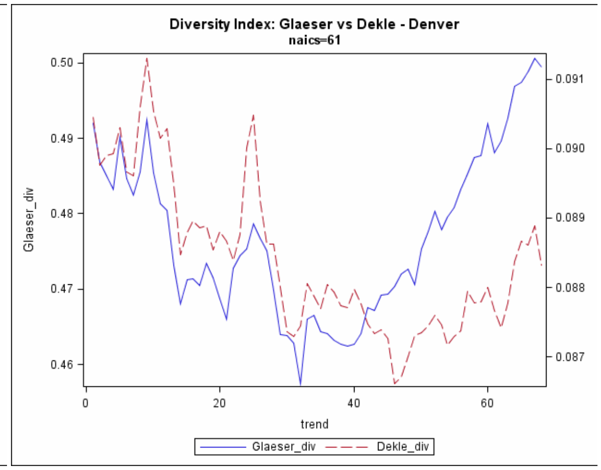

Diversity Index: Glaeser vs Dekle - Denver
naics=53
Glaeser_div
trend
Glaeser_div
Dekle_div

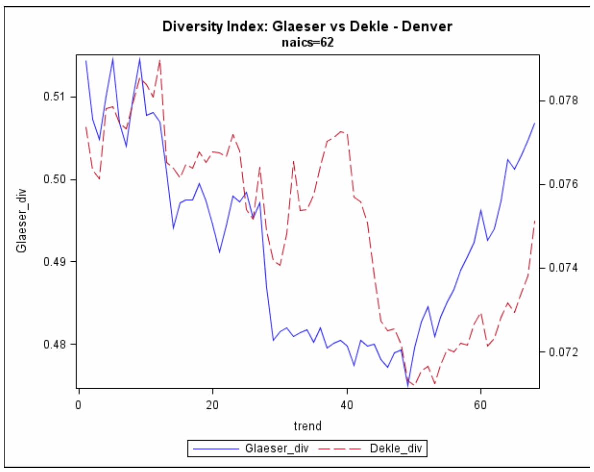

Diversity Index: Glaeser vs Dekle - Denver
naics=54
Glaeser_div
trend
Glaeser_div
Dekle_div

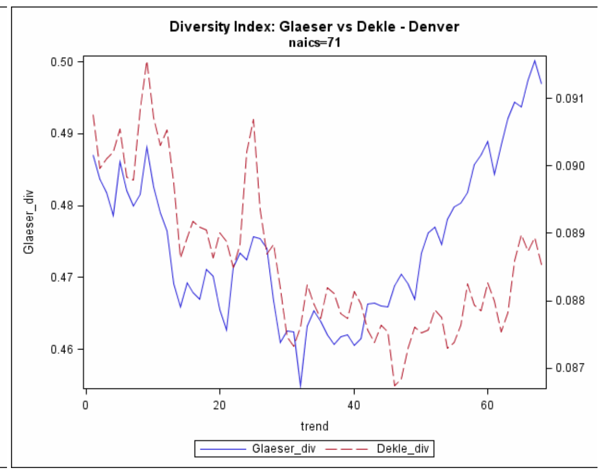

Diversity Index: Glaeser vs Dekle - Denver
naics=55
Glaeser_div
trend
Glaeser_div
Dekle_div

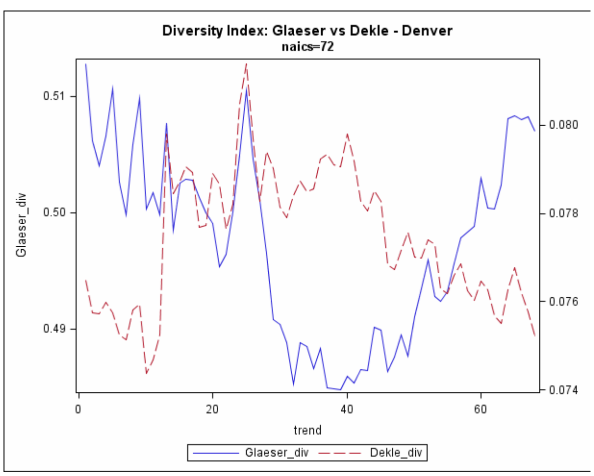
(Continued)

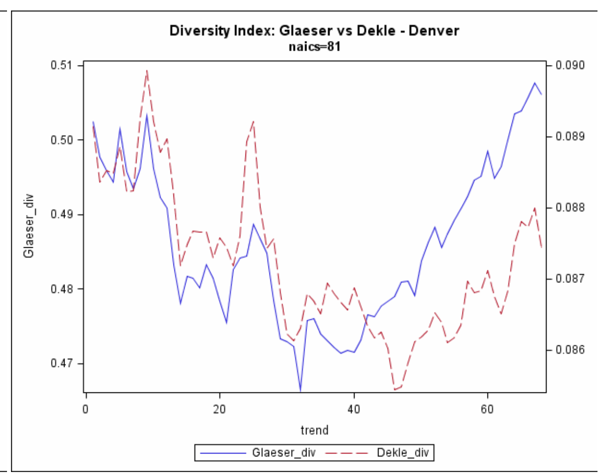

Diversity Index: Glaeser vs Dekle - Denver
naics=56
Glaeser_div
0.52
0.51
0.50
0.49
0.48
0.084
0.082
0.080
0.078
0.076
0
20
40
60
trend
Glaeser_div
Dekle_div


Diversity Index: Glaeser vs Dekle - Denver
naics=61
Glaeser_div
0.50
0.49
0.48
0.47
0.46
0.091
0.090
0.089
0.088
0.087
0
20
40
60
trend
Glaeser_div
Dekle_div

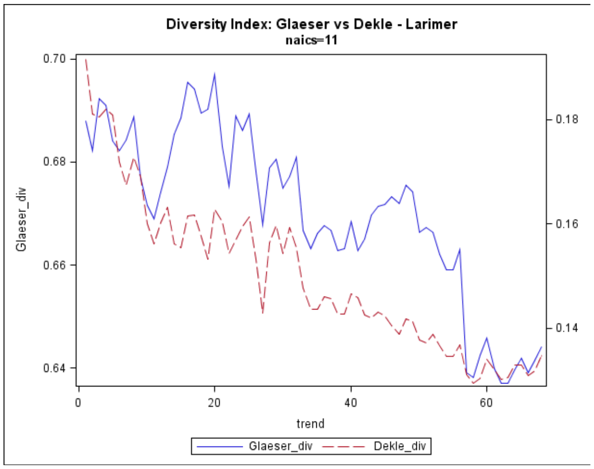

Diversity Index: Glaeser vs Dekle - Denver
naics=62
Glaeser_div
0.51
0.50
0.49
0.48
0.078
0.076
0.074
0.072
0
20
40
60
trend
Glaeser_div
Dekle_div

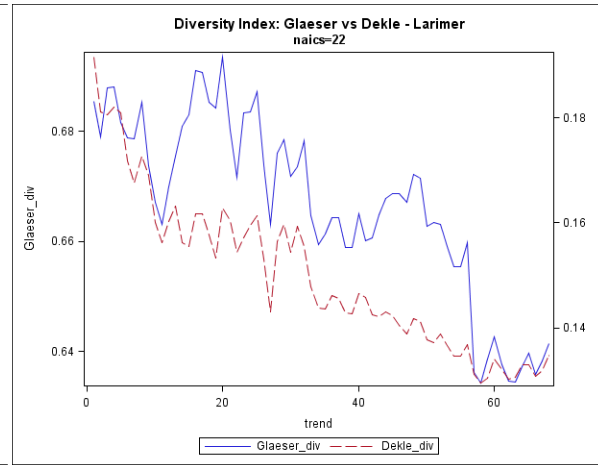

Diversity Index: Glaeser vs Dekle - Denver
naics=71
Glaeser_div
0.50
0.49
0.48
0.47
0.46
0.091
0.090
0.089
0.088
0.087
0
20
40
60
trend
Glaeser_div
Dekle_div

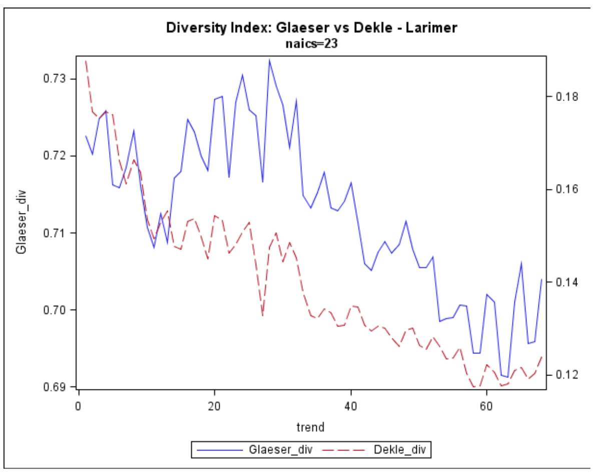

Diversity Index: Glaeser vs Dekle - Denver
naics=72
Glaeser_div
0.51
0.50
0.49
0.080
0.078
0.076
0.074
0
20
40
60
trend
Glaeser_div
Dekle_div

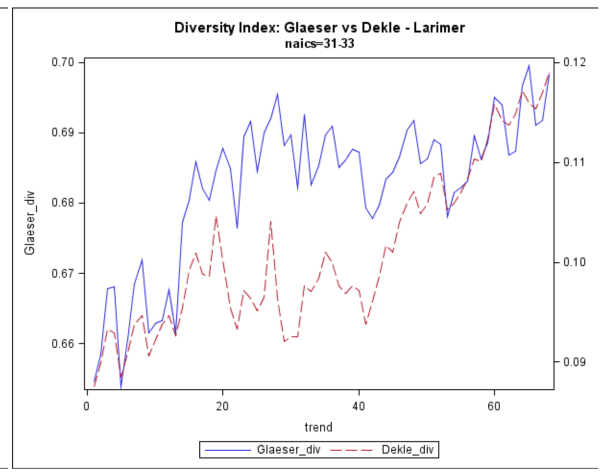

Diversity Index: Glaeser vs Dekle - Denver
naics=81
Glaeser_div
0.51
0.50
0.49
0.48
0.47
0.090
0.089
0.088
0.087
0.086
0
20
40
60
trend
Glaeser_div
Dekle_div

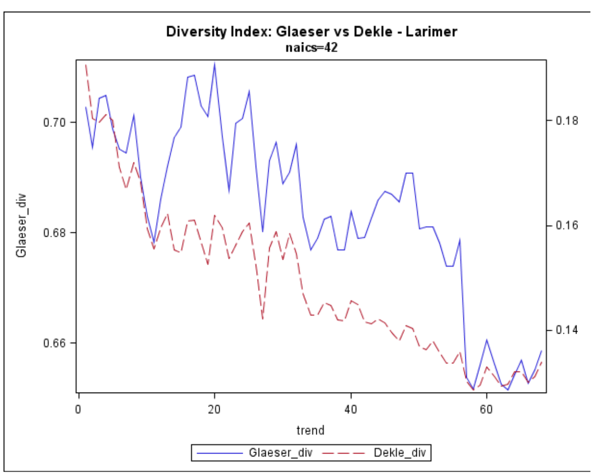
Diversity Index Comparison for Glaeser and Dekle (Larimer County)

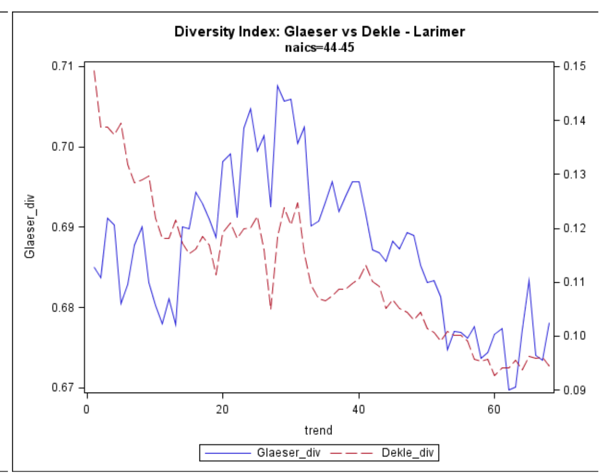




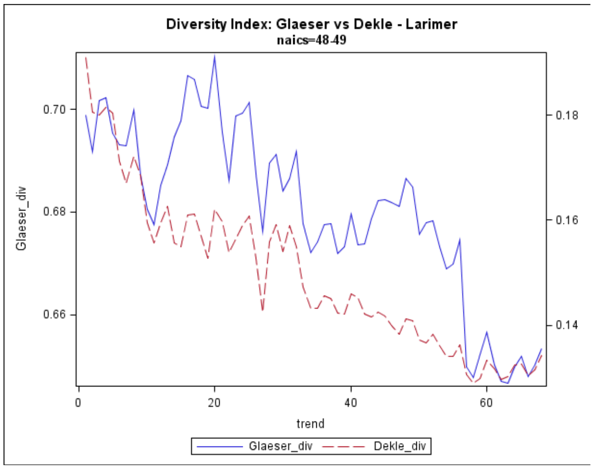


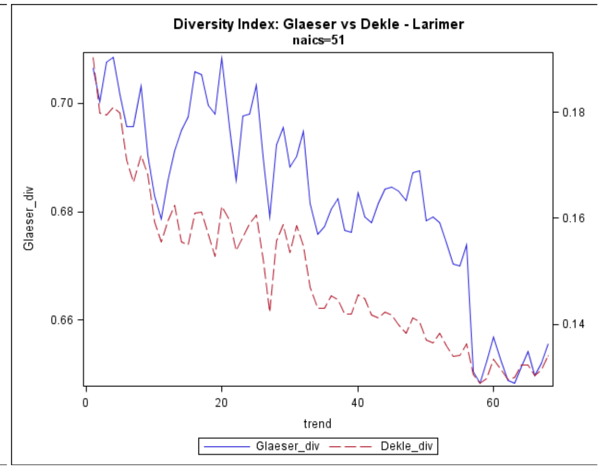


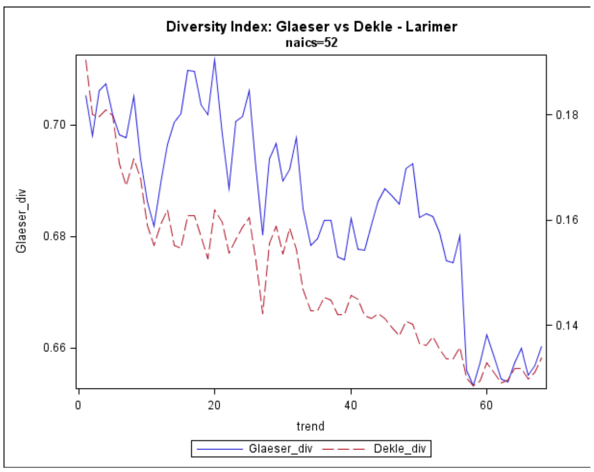


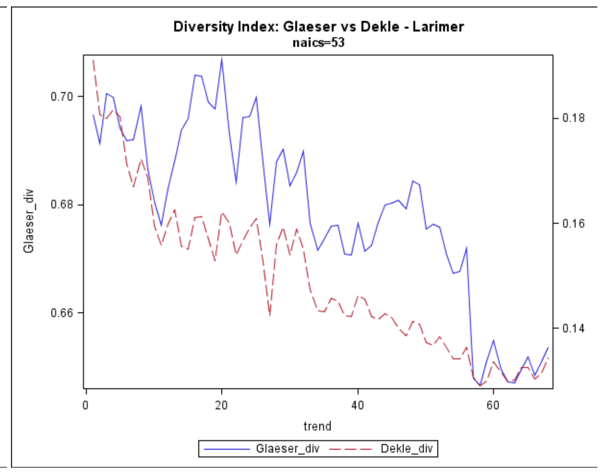


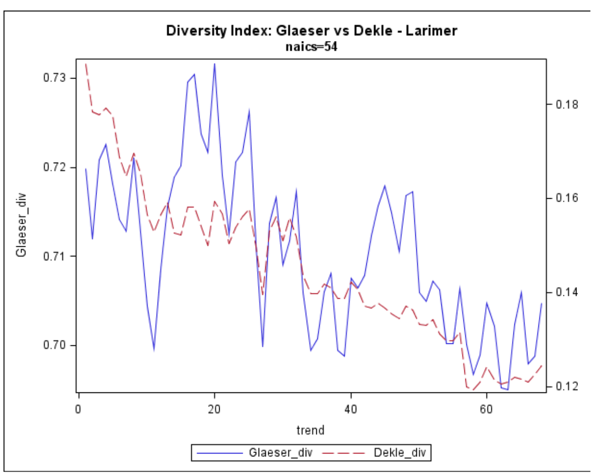
(Continued)

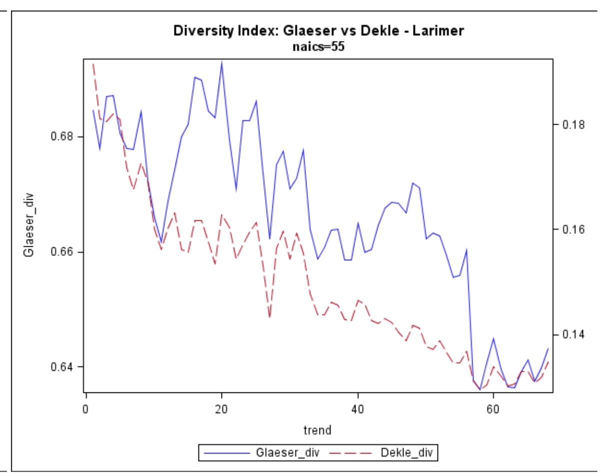

Diversity Index: Glaeser vs Dekle - Larimer
naics=48-49
Glaeser_div
0.66
0.68
0.70
0.14
0.16
0.18
0
20
40
60
trend
Glaeser_div
Dekle_div


Diversity Index: Glaeser vs Dekle - Larimer
naics=51
Glaeser_div
0.66
0.68
0.70
0.14
0.16
0.18
0
20
40
60
trend
Glaeser_div
Dekle_div

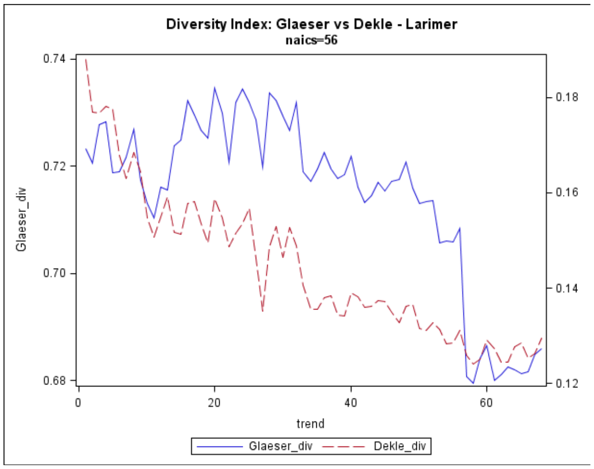

Diversity Index: Glaeser vs Dekle - Larimer
naics=52
Glaeser_div
0.66
0.68
0.70
0.14
0.16
0.18
0
20
40
60
trend
Glaeser_div
Dekle_div


Diversity Index: Glaeser vs Dekle - Larimer
naics=53
Glaeser_div
0.66
0.68
0.70
0.14
0.16
0.18
0
20
40
60
trend
Glaeser_div
Dekle_div

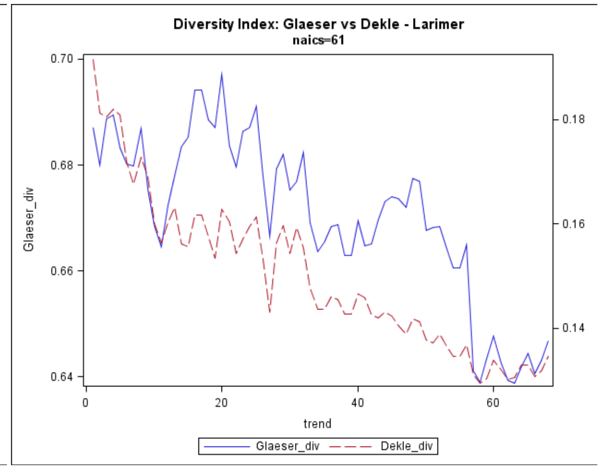

Diversity Index: Glaeser vs Dekle - Larimer
naics=54
Glaeser_div
0.70
0.71
0.72
0.73
0.12
0.14
0.16
0.18
0
20
40
60
trend
Glaeser_div
Dekle_div


Diversity Index: Glaeser vs Dekle - Larimer
naics=55
Glaeser_div
0.64
0.66
0.68
0.14
0.16
0.18
0
20
40
60
trend
Glaeser_div
Dekle_div

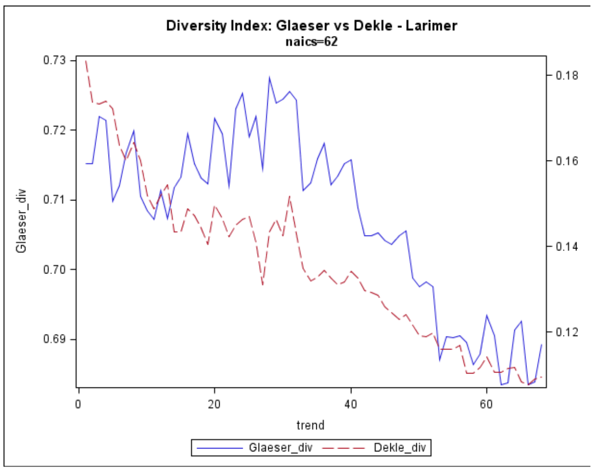
(Continued)



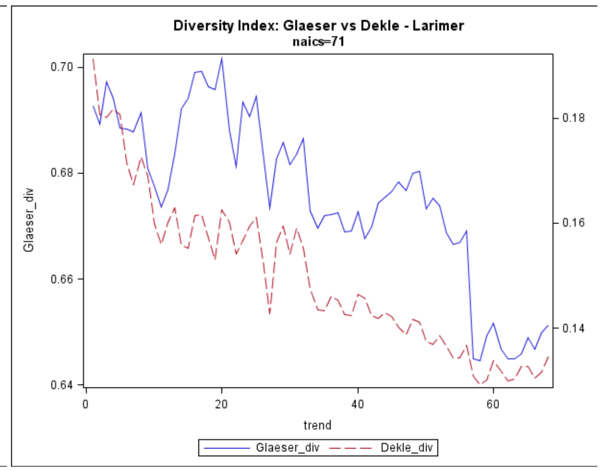
Diversity Index: Glaeser vs Dekle - Larimer
naics=56
Glaeser_div
0.74
0.72
0.70
0.68
0.18
0.16
0.14
0.12
0
20
40
60
trend
Glaeser_div
Dekle_div



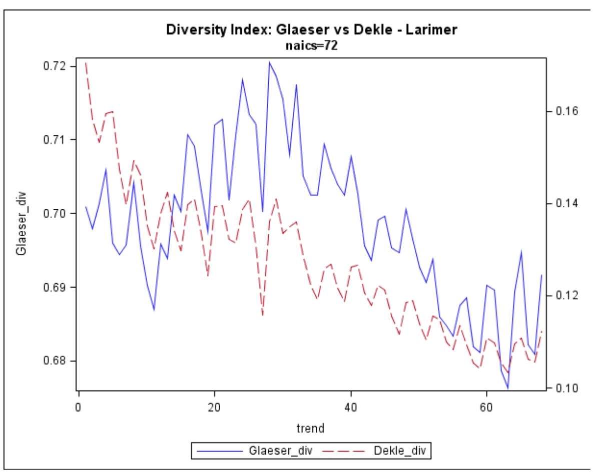
Diversity Index: Glaeser vs Dekle - Larimer
naics=61
Glaeser_div
0.70
0.68
0.66
0.64
0.18
0.16
0.14
0
20
40
60
trend
Glaeser_div
Dekle_div



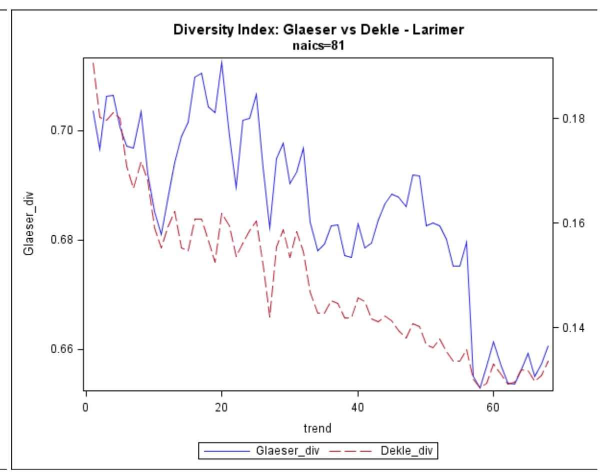
Diversity Index: Glaeser vs Dekle - Larimer
naics=62
Glaeser_div
0.73
0.72
0.71
0.70
0.69
0.18
0.16
0.14
0.12
0
20
40
60
trend
Glaeser_div
Dekle_div



Diversity Index: Glaeser vs Dekle - Larimer
naics=71
Glaeser_div
0.70
0.68
0.66
0.64
0.18
0.16
0.14
0
20
40
60
trend
Glaeser_div
Dekle_div

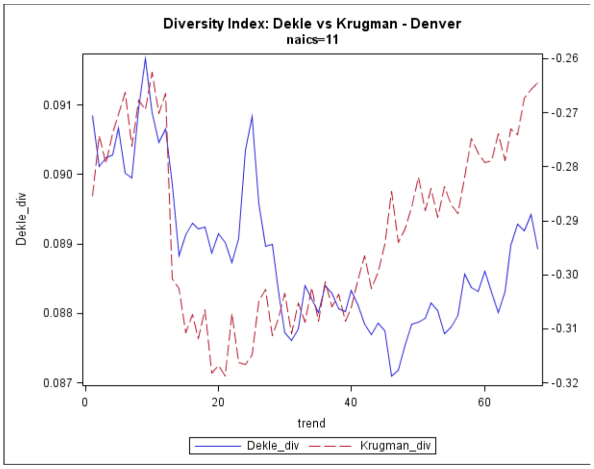


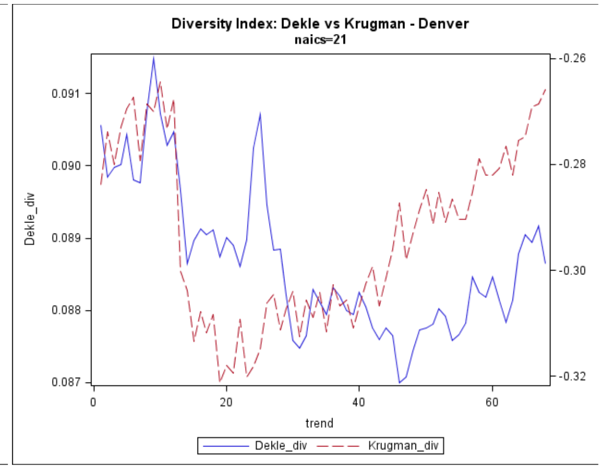
Diversity Index: Glaeser vs Dekle - Larimer
naics=72
Glaeser_div
0.72
0.71
0.70
0.69
0.68
0.16
0.14
0.12
0.10
0
20
40
60
trend
Glaeser_div
Dekle_div

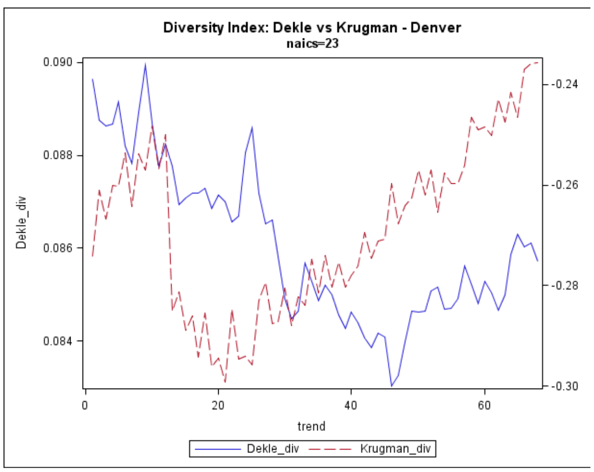


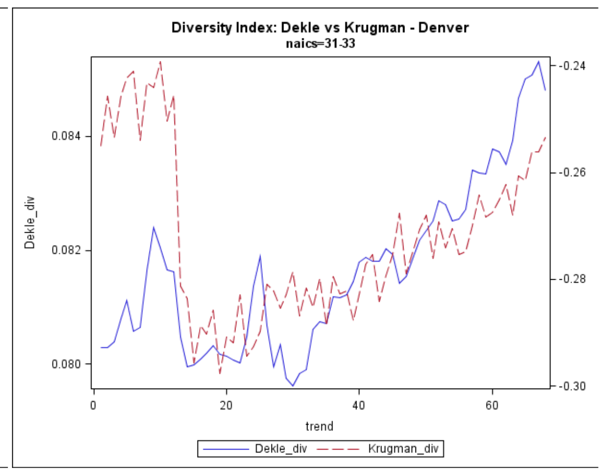
Diversity Index: Glaeser vs Dekle - Larimer
naics=81
Glaeser_div
0.70
0.68
0.66
0.18
0.16
0.14
0
20
40
60
trend
Glaeser_div
Dekle_div

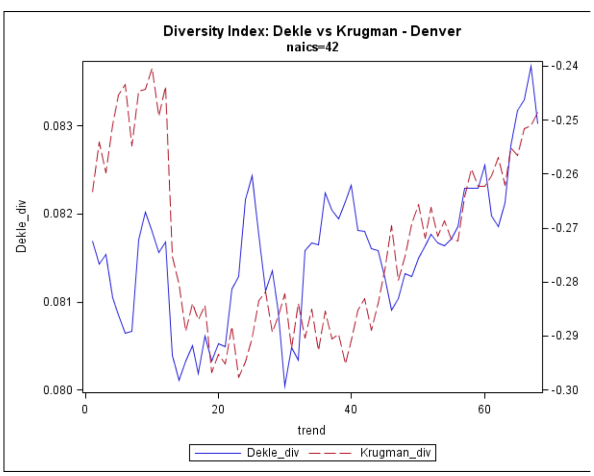
Diversity Index Comparison for Dekle and Krugman (Denver County)

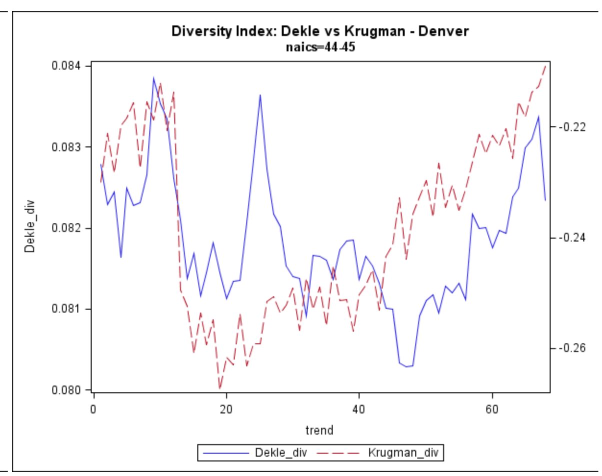




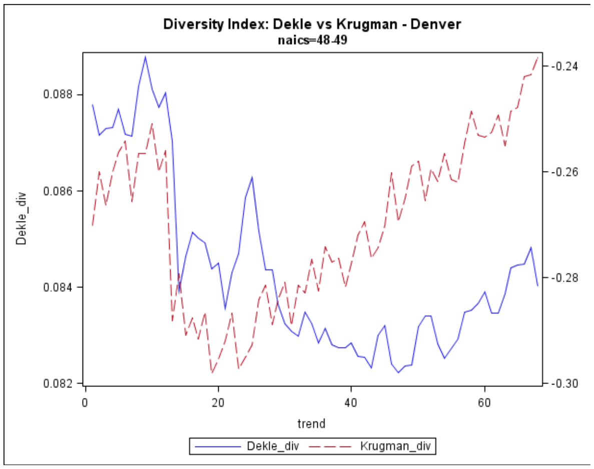


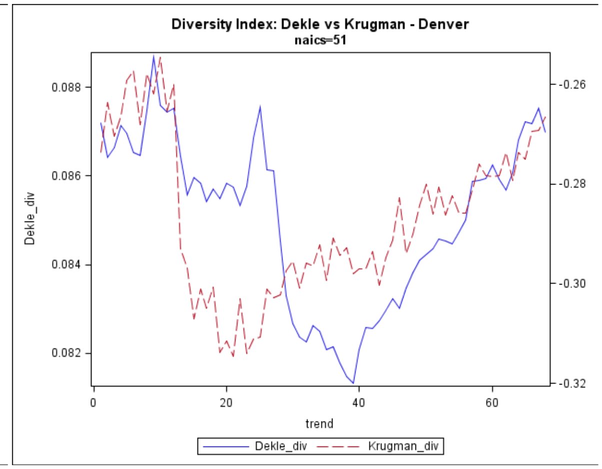


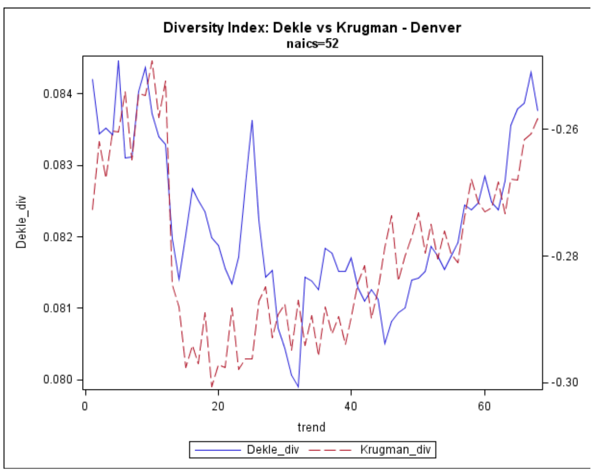


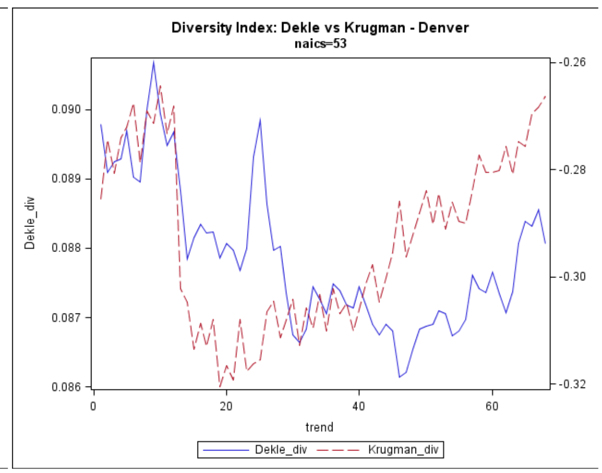


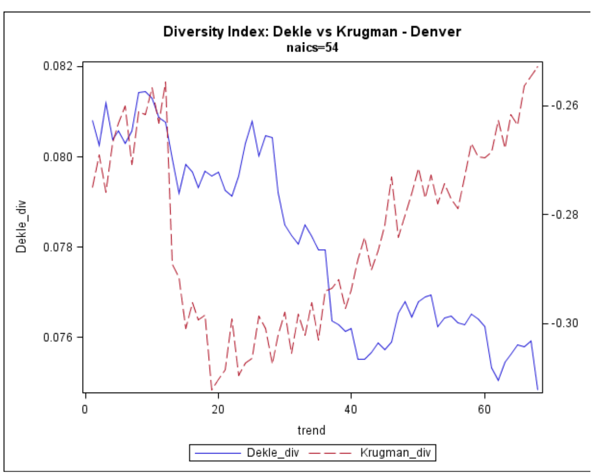
(Continued)

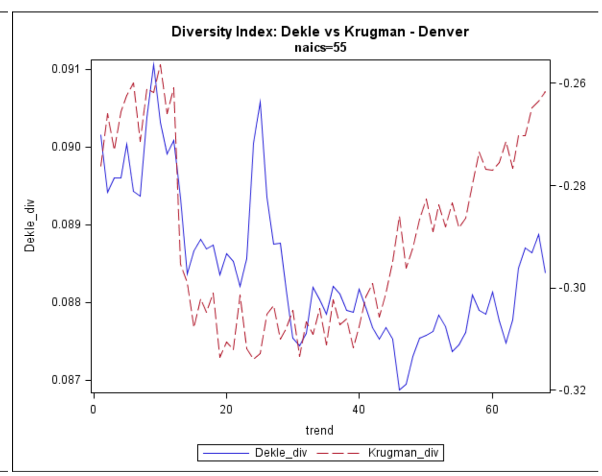

Diversity Index: Dekle vs Krugman - Denver
naics=48-49
Dekle_div
0.082
0.084
0.086
0.088
-0.24
-0.26
-0.28
-0.30
0
20
40
60
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Denver
naics=51
Dekle_div
0.082
0.084
0.086
0.088
-0.26
-0.28
-0.30
-0.32
0
20
40
60
trend
Dekle_div
Krugman_div

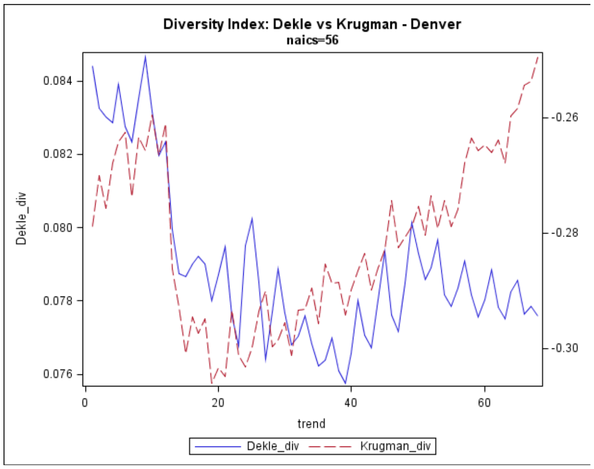

Diversity Index: Dekle vs Krugman - Denver
naics=52
Dekle_div
0.080
0.081
0.082
0.083
0.084
-0.26
-0.28
-0.30
0
20
40
60
trend
Dekle_div
Krugman_div

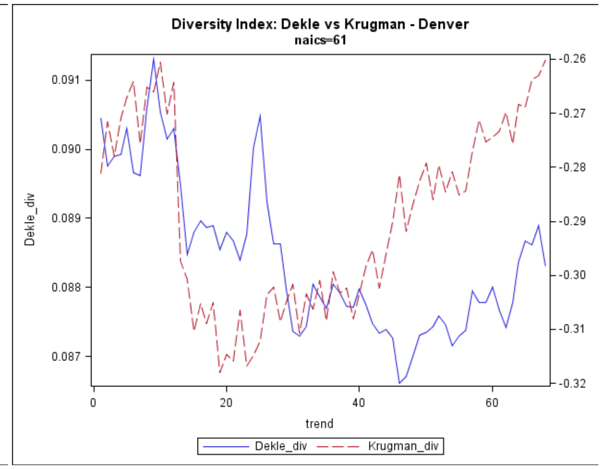

Diversity Index: Dekle vs Krugman - Denver
naics=53
Dekle_div
0.086
0.087
0.088
0.089
0.090
-0.26
-0.28
-0.30
-0.32
0
20
40
60
trend
Dekle_div
Krugman_div

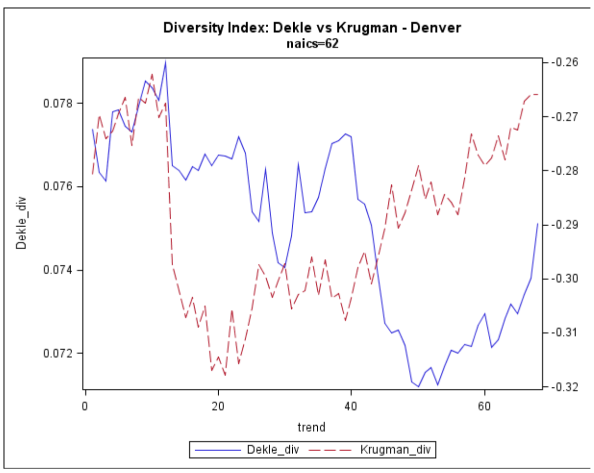

Diversity Index: Dekle vs Krugman - Denver
naics=54
Dekle_div
0.076
0.078
0.080
0.082
-0.26
-0.28
-0.30
0
20
40
60
trend
Dekle_div
Krugman_div

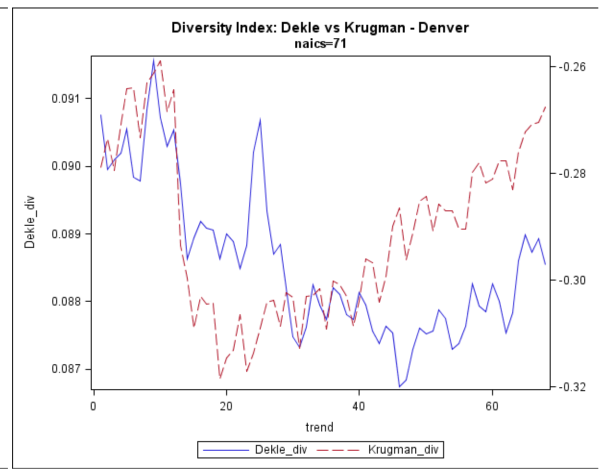

Diversity Index: Dekle vs Krugman - Denver
naics=55
Dekle_div
0.087
0.088
0.089
0.090
0.091
-0.26
-0.28
-0.30
-0.32
0
20
40
60
trend
Dekle_div
Krugman_div

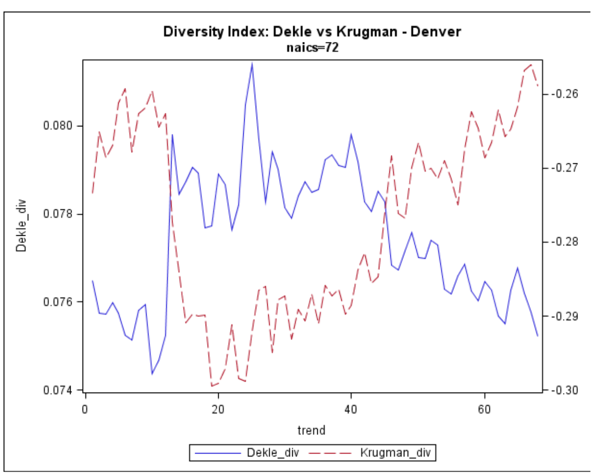
(Continued)

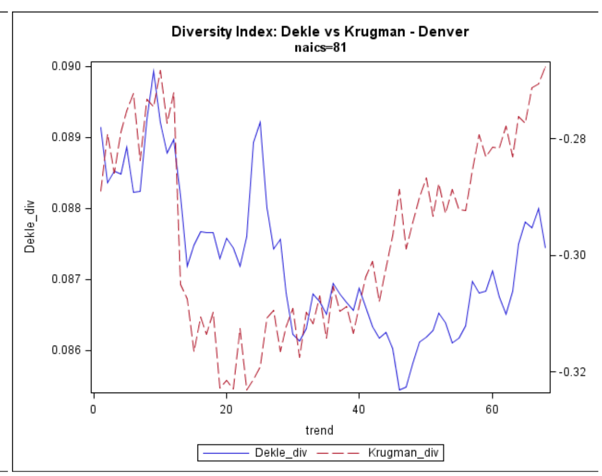

Diversity Index: Dekle vs Krugman - Denver
naics=56
Dekle_div
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Denver
naics=61
Dekle_div
trend
Dekle_div
Krugman_div

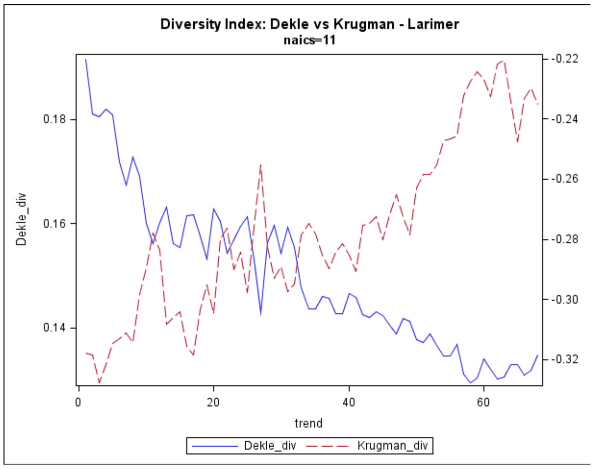

Diversity Index: Dekle vs Krugman - Denver
naics=62
Dekle_div
trend
Dekle_div
Krugman_div

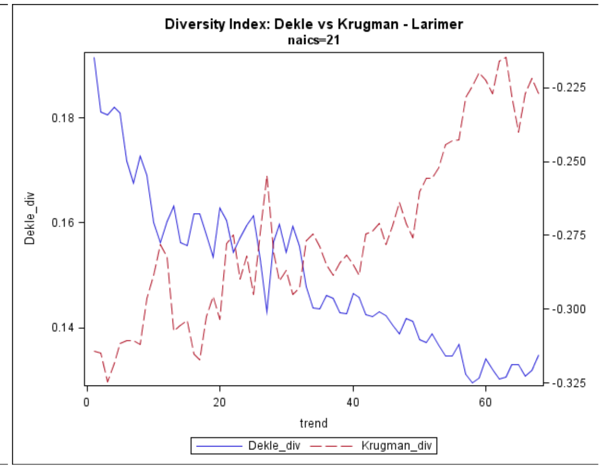

Diversity Index: Dekle vs Krugman - Denver
naics=71
Dekle_div
trend
Dekle_div
Krugman_div

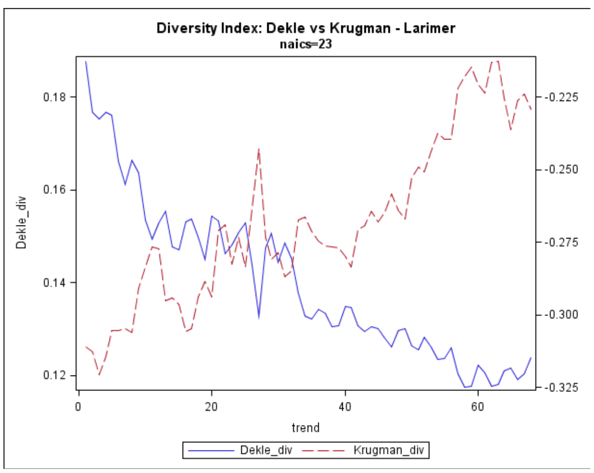

Diversity Index: Dekle vs Krugman - Denver
naics=72
Dekle_div
trend
Dekle_div
Krugman_div

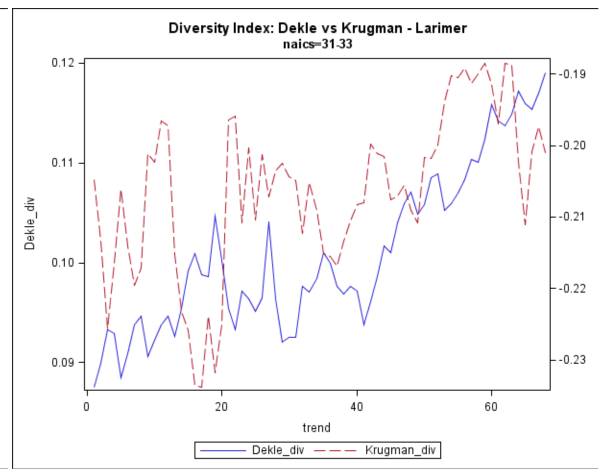

Diversity Index: Dekle vs Krugman - Denver
naics=81
Dekle_div
trend
Dekle_div
Krugman_div

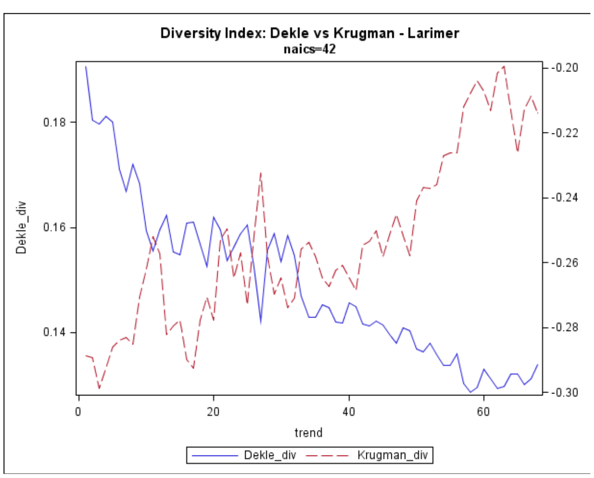
Diversity Index Comparison for Dekle and Krugman (Larimer County)

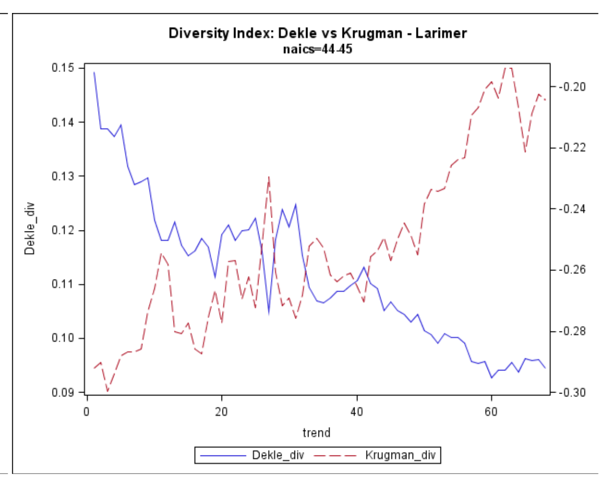




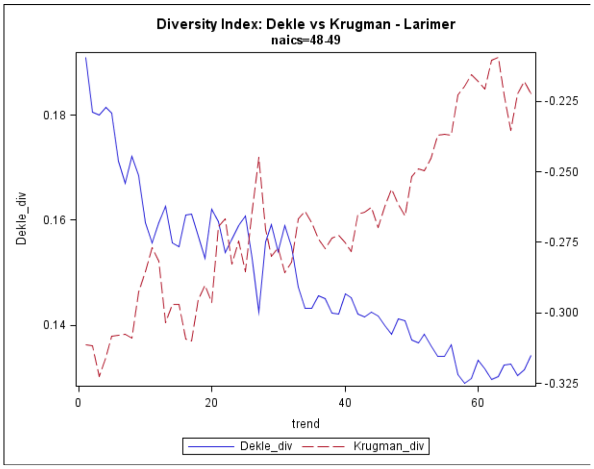


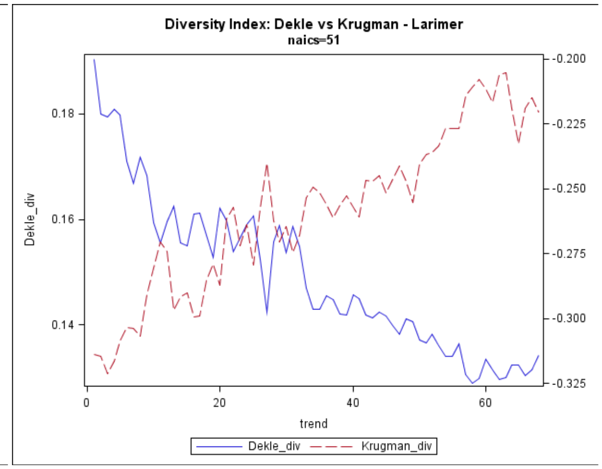


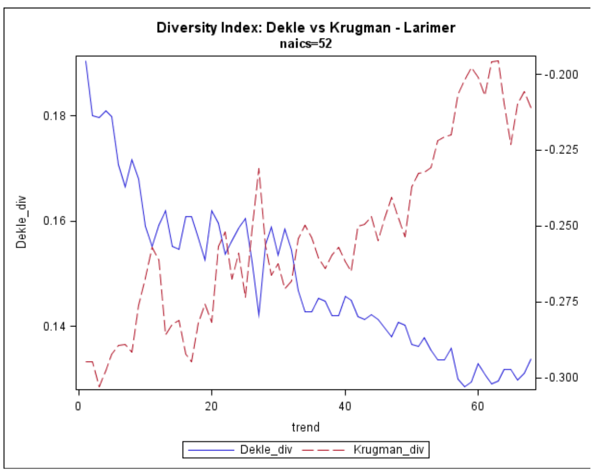


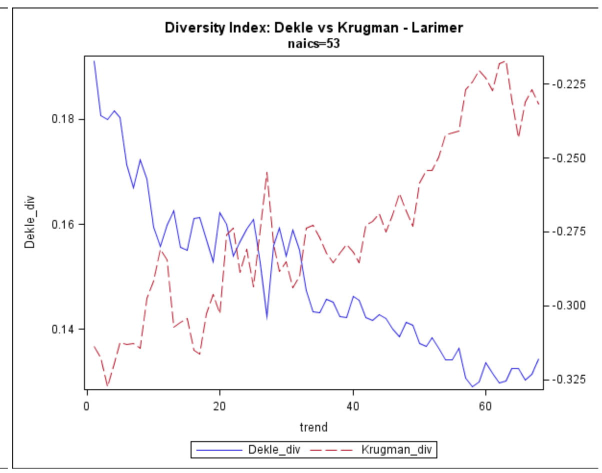


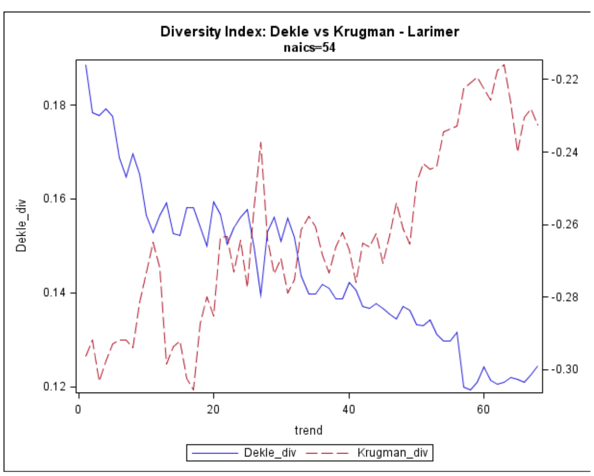
(Continued)

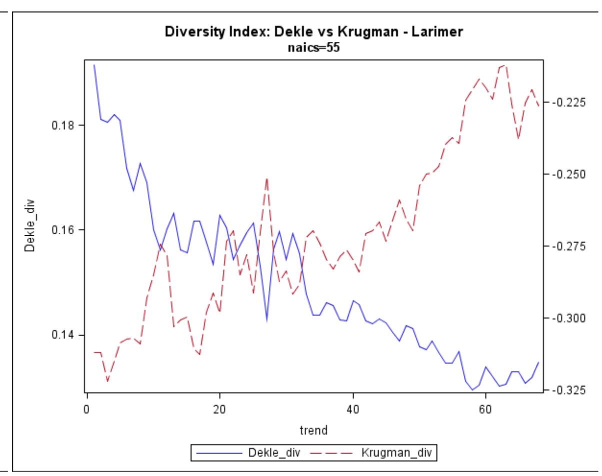

Diversity Index: Dekle vs Krugman - Larimer
naics=48-49
Dekle_div
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Larimer
naics=51
Dekle_div
trend
Dekle_div
Krugman_div

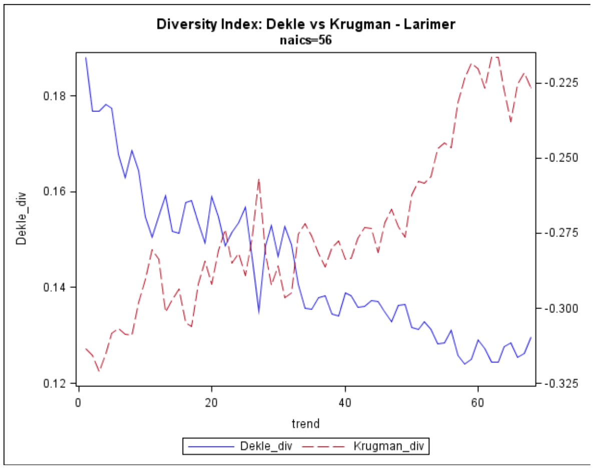

Diversity Index: Dekle vs Krugman - Larimer
naics=52
Dekle_div
trend
Dekle_div
Krugman_div

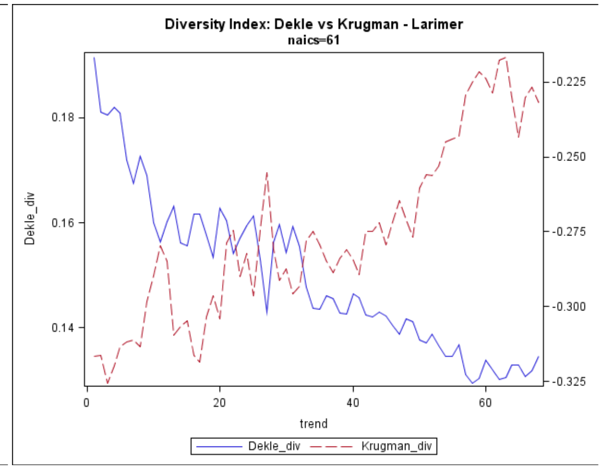

Diversity Index: Dekle vs Krugman - Larimer
naics=53
Dekle_div
trend
Dekle_div
Krugman_div

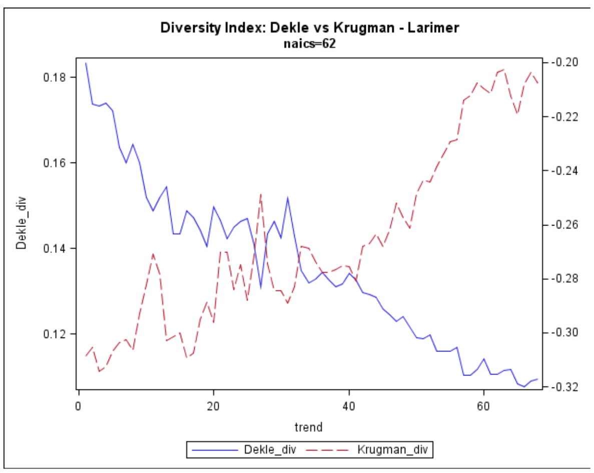

Diversity Index: Dekle vs Krugman - Larimer
naics=54
Dekle_div
trend
Dekle_div
Krugman_div

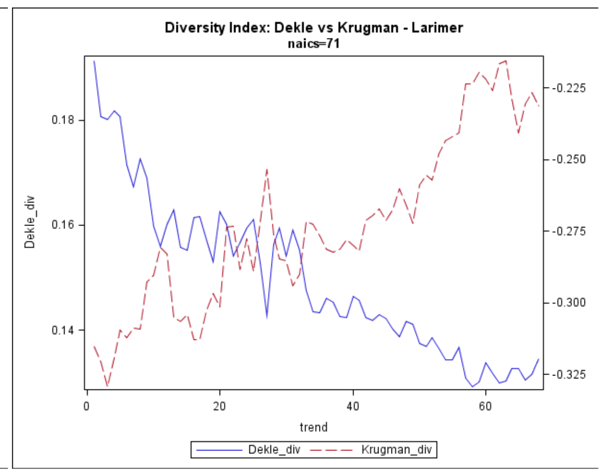

Diversity Index: Dekle vs Krugman - Larimer
naics=55
Dekle_div
trend
Dekle_div
Krugman_div

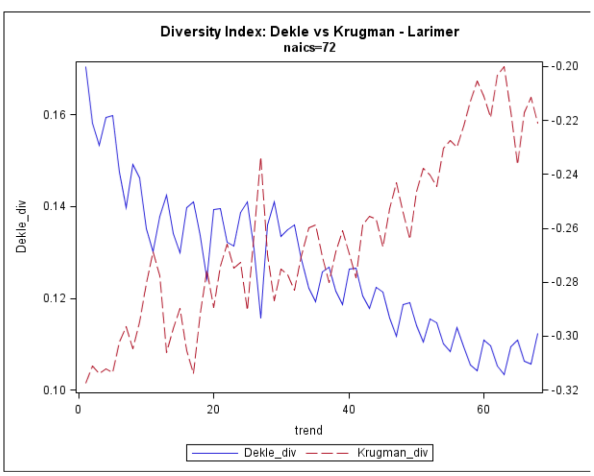
(Continued)

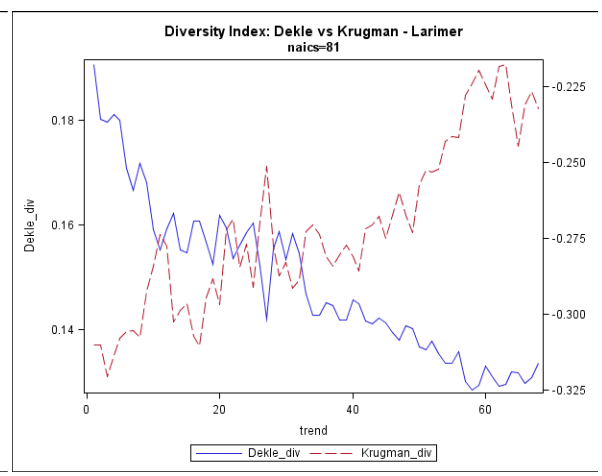

Diversity Index: Dekle vs Krugman - Larimer
naics=56
Dekle_div
0.18
0.16
0.14
0.12
-0.225
-0.250
-0.275
-0.300
-0.325
0
20
40
60
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Larimer
naics=61
Dekle_div
0.18
0.16
0.14
-0.225
-0.250
-0.275
-0.300
-0.325
0
20
40
60
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Larimer
naics=62
Dekle_div
0.18
0.16
0.14
0.12
-0.20
-0.22
-0.24
-0.26
-0.28
-0.30
-0.32
0
20
40
60
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Larimer
naics=71
Dekle_div
0.18
0.16
0.14
-0.225
-0.250
-0.275
-0.300
-0.325
0
20
40
60
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Larimer
naics=72
Dekle_div
0.16
0.14
0.12
0.10
-0.20
-0.22
-0.24
-0.26
-0.28
-0.30
-0.32
0
20
40
60
trend
Dekle_div
Krugman_div


Diversity Index: Dekle vs Krugman - Larimer
naics=81
Dekle_div
0.18
0.16
0.14
-0.225
-0.250
-0.275
-0.300
-0.325
0
20
40
60
trend
Dekle_div
Krugman_div

Appendix B

HHI

OLS with HHI

	Construction	**Manufacture**	**Wholesale**	**Retail**
Constant	3.6639 (45.034)	19.046 (37.400)	29.378 (18.622)	51.635*** (19.161)
Wage (-1)	-0.4209*** (0.124)	-0.3823*** (0.130)	-0.0220 (0.046)	0.0161 (0.117)
Establishment	-0.0077 (0.007)	-0.0117 (0.013)	-0.0064*** (0.003)	-0.0117*** (0.003)
Specialization(-1)	39.676 (38.54)	18.368 (22.31)	7.5570* (4.159)	5.1031 (12.61)
Competition(-1)	0.6046 (0.735)	29.719* (17.41)	29.824*** (8.572)	18.578*** (8.161)
HHI(-1)	4.6394 (3.768)	3.0105 (2.349)	-0.8028 (1.227)	-0.9539 (1.049)
Season 1				-1.4623*** (0.116)
Season 2				-1.3107*** (0.134)
Season 3				-1.1251*** (0.113)
	AR(1)	AR(1)	AR(1)	AR(1)

OLS with HHI

	Information	**Finance**	**Health**	**Professional**	**Pool**
Constant	-501.90*** (94.024)	-1718.20 (8198)	98.701 (264.6)	76.550*** (18.710)	-86.602*** (20.413)
Wage	-0.0508 (0.145)		-0.4104*** (0.169)		
Wage (-1)	0.0508*** (0.146)	-0.0371 (0.027)	-0.1651 (0.172)	-0.0302*** (0.009)	-0.2541** (0.114)
Establishment	-0.1318*** (0.024)	-0.0146** (0.007)	-0.0191 (0.017)	-0.0058*** (0.001)	-0.0153*** (0.002)
Specialization(-1)	106.71*** (38.830)	-9.9088 (8.899)	42.847* (25.195)	4.9042 (4.560)	21.184*** (7.825)
Competition(-1)	90.250* (53.35)	-19.557 (17.00)	47.947 (37.05)	6.3142 (6.001)	-49.560*** (5.645)
HHI(-1)	40.487*** (6.043)	0.5099 (2.422)	-0.6972 (3.259)	-2.7508*** (0.887)	15.974 (1.603)
Others					
Wage	-0.0508 (0.145)		-0.4104*** (0.169)		
Structure	-15.293*** (2.006)				
	AR(1)	AR(1),AR(2)	AR(1),AR(2)	AR(1),AR(2)	Fixed Effect Time/Sector

GMM Methodology with HHI Diversity

		Construction	Manufacture	Wholesale	Retail
Constant		1.6373*** (0.460)	-0.2080*** (0.011)	-0.1816* (0.102)	-0.0214** (0.011)
Log(emp)	t-1	0.3204 (0.259)	-0.8359*** (0.073)	-0.4977*** (0.118)	-0.0503 (0.137)
Wage	t	0.5174 (0.390)	0.0115* (0.007)	0.1945*** (0.056)	0.0008 (0.039)
	t-1	-0.3016 (0.491)	-0.0115* (0.007)	0.1219*** (0.041)	-0.0126 (0.316)
Sector	t	-0.0001 (0.001)	0.0001* (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	-0.0001*** (0.000)	0.0001*** (0.000)	-0.0001*** (0.000)	0.0001 (0.001)
Size	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001 (0.001)	-0.0001*** (0.000)
	t-1	0.0001** (0.000)	-0.0001 (0.001)	-0.0001 (0.001)	0.0001 (0.001)
Specialization	t	-5.9520*** (1.78)	-0.2533*** (0.056)	0.4688*** (0.138)	-1.0389*** (0.229)
	t-1	-0.9592 (1.491)	0.4524*** (0.036)	-0.1355 (0.173)	-0.5640*** (0.193)
Competition	t	-0.0420 (0.027)	-0.5012*** (0.035)	-0.6493*** (0.236)	-1.4249*** (0.084)
	t-1	-0.0430** (0.022)	-0.2938*** (0.056)	0.1777 (0.424)	-0.1603 (0.172)
HHI	t	0.0018 (0.158)	0.0580*** (0.006)	-0.0773*** (0.025)	0.0318*** (0.010)
	t-1	-0.1473 (0.180)	0.0001 (0.003)	0.0712** (0.028)	-0.0027 (0.015)
Education	t	-0.1303*** (0.033)	0.0122*** (0.000)	0.0128 (0.008)	-0.0039** (0.001)
	t-1	-0.0005 (0.013)	0.0030*** (0.000)	-0.0001 (0.001)	0.0055*** (0.002)
			AR(1) AR(2)		

All variables are first difference, except education

GMM Methodology with HHI Diversity

		Information	**Finance**	**Health**	**Professional**
Constant		0.0042 (0.023)	-0.0428*** (0.011)	0.0074 (0.018)	-0.0188*** (0.004)
Log(emp)	t-1	0.3317*** (0.044)	-0.1614*** (0.057)	-0.2609*** (0.085)	-0.1741 (0.123)
Wage	t	-0.0068 (0.008)	-0.0221*** (0.005)	0.0284** (0.012)	0.0142 (0.011)
	t-1	0.0875*** (0.007)	0.0044 (0.005)	0.0591*** (0.018)	-0.0330** (0.012)
Sector	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	-0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
Size	t	-0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001 (0.001)
	t-1	0.0001** (0.000)	0.0001 (0.001)	0.0001 (0.001)	0.0001 (0.001)
Specialization	t	0.3295*** (0.079)	0.2179*** (0.033)	0.1206* (0.072)	-0.0427 (0.054)
	t-1	-0.1993** (0.084)	0.4435*** (0.037)	0.2530*** (0.051)	0.4568*** (0.079)
Competition	t	-1.2796*** (0.093)	-1.5649*** (0.049)	-1.1754*** (0.103)	-0.6003*** (0.053)
	t-1	0.2802** (0.139)	0.3369** (0.129)	-0.2864** (0.110)	0.1028 (0.073)
HHI	t	0.1183*** (0.016)	0.0087 (0.007)	0.0351*** (0.007)	0.0546*** (0.011)
	t-1	0.0097 (0.014)	-0.0521*** (0.008)	-0.0533*** (0.010)	0.0078 (0.010)
Education	t	0.0168*** (0.002)	0.0085*** (0.001)	0.0052*** (0.002)	0.0001 (0.001)
	t-1	-0.0172*** (0.002)	-0.0071*** (0.001)	-0.0070*** (0.002)	0.0002 (0.001)
		AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference, except education

Combes' Methodology (Recursive VAR) with HHI Diversity

	Construction	**Manufacture**	**Wholesale**	**Retail**
Employment Regression				
Constant	-0.0125*** (0.006)	0.0014 (0.004)	-0.0017*** (0.001)	0.0014 (0.001)
Establishment	-0.0227*** (0.000)	-0.0748*** (0.001)	-0.0154*** (0.000)	-0.0167*** (0.000)
Log(Emp)	35.1007 (0.237)	82.0878*** (0.458)	36.6897*** (0.050)	37.0086*** (0.080)
Specialization	-0.8752 (1.032)	5.9119*** (0.877)	0.1497*** (0.025)	0.5849 (0.454)
Competition	0.0333 (0.024)	5.6206*** (0.755)	-0.5239*** (0.095)	-0.2808 (0.208)
HHI	0.4199*** (0.125)	-0.291*** (0.081)	-0.0137** (0.006)	-0.0951*** (0.019)
Average Emp (-1)	-0.0166*** (0.004)	-0.0016 (0.001)	-0.0119*** (0.001)	-0.0027 (0.003)
Establishment (-1)	-0.0001 (0.000)	-0.0020*** (0.001)	-0.0022 (0.000)	0.0002 (0.001)
Specialization (-1)	10.5598*** (0.489)	1.8889*** (0.608)	-0.1792*** (0.040)	-0.7062** (0.382)
Competition (-1)	0.1489*** (0.017)	3.6471*** (0.553)	-0.7713*** (0.086)	-0.0058 (0.314)
HHI (-1)	0.3073** (0.147)	-0.1334 (0.086)	0.0914*** (0.009)	-0.0388 (0.025)
	AR(1) AR(2) AR(3)	AR(1) AR(2) AR(3)	AR(1) AR(2) AR(3)	AR(1) AR(2)
Establishment Regression				
Constant	0.0083** (0.004)	-0.0037*** (0.000)	0.0012 (0.001)	-0.0025* (0.001)
Average Emp (-1)	-0.2899*** (0.071)	-0.1102*** (0.025)	0.3238*** (0.111)	0.3351*** (0.101)
Log(Emp)	0.2958*** (0.085)	0.5311*** (0.055)	0.9050*** (0.140)	0.2487*** (0.059)
Specialization	2.7862*** (0.666)	0.5782*** (0.126)	-0.0735 (0.094)	1.0477*** (0.233)
Competition	0.0290** (0.012)	0.5427*** (0.1067)	-0.0206 (0.256)	0.4964*** (0.167)
HHI	0.0686 (0.084)	-0.0290* (0.014)	-0.0361 (0.024)	0.0369* (0.022)
Log (Estab (-1))	-10.4600*** (2.613)	-9.1020*** (2.150)	11.5545*** (3.931)	12.3734*** (3.786)
Average Emp (-2))	0.0045*** (0.002)	0.0021** (0.000)	0.0097*** (0.002)	0.0030* (0.002)
Log(Emp (-1))	10.5644*** (2.575)	8.6883*** (2.020)	-12.2637*** (4.029)	-12.347*** (3.797)
Specialization (-1)	-1.1654** (0.596)	0.0743 (0.143)	0.0770 (0.093)	-1.2724*** (0.335)
Competition (-1)	-0.0228** (0.009)	-0.1027 (0.089)	-0.5612** (0.234)	-0.5551*** (0.2022)
HHI (-1)	0.0170 (0.072)	-0.0514*** (0.017)	-0.0281 (0.022)	0.0281** (0.014)

Structure	-0.0028 (0.006)	-0.0018 (0.002)	-0.0070*** (0.002)	0.0037 (0.003)
	AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference

IV: Lag level variables

Combes' Methodology (Recursive VAR) with HHI Diversity

	Information	**Finance**	**Health**	**Professional**
Employment Regression				
Constant	-0.0944** (0.040)	-0.0097 (0.002)	-0.0312*** (0.010)	-0.0436*** (0.001)
Establishment	-0.1540*** (0.009)	-0.0315*** (0.000)	-0.0399*** (0.005)	-0.0067*** (0.000)
Log(Emp)	92.7931*** (2.758)	49.6278*** (1.302)	72.6614*** (5.767)	26.91022*** (0.309)
Specialization	0.0874 (3.839)	0.0997 (0.929)	-3.1250 (2.113)	-0.2293 (0.489)
Competition	-27.8522*** (8.056)	-2.8726** (1.245)	2.5500 (8.292)	-1.3347*** (0.614)
HHI	3.4804*** (1.045)	0.4374 (0.428)	-0.4012 (0.573)	0.0319 (0.082)
Average Emp (-1)	-0.0532** (0.021)	-0.0522*** (0.019)	0.0048 (0.065)	0.0128 (0.013)
Establishment (-1)	0.0130** (0.005)	-0.0009 (0.001)	0.0019 (0.001)	0.0003*** (0.000)
Specialization (-1)	7.2169 (4.556)	0.8606 (0.931)	-1.8692 (2.361)	-0.7276** (0.347)
Competition (-1)	-7.3581 (7.934)	1.4215 (1.633)	-0.1792 (5.263)	-0.1360 (0.426)
HHI (-1)	1.3276 (0.819)	0.6078*** (0.203)	0.2486 (0.697)	0.1653*** (0.047)
Structure				0.0700*** (0.005)
	AR(1)	AR(1)		AR(1)
Establishment Regression				
Constant	0.0032*** (0.000)	0.0084*** (0.002)	0.0006 (0.001)	0.0012*** (0.000)
Average Emp (-1)	0.1407*** (0.001)	0.0154* (0.008)	-0.0402*** (0.011)	-0.1141*** (0.014)
Log(Emp)	0.3489*** (0.023)	-0.1737*** (0.048)	0.3657*** (0.042)	0.1904*** (0.037)
Specialization	0.1650*** (0.055)	0.6399*** (0.034)	0.0204 (0.061)	0.0571 (0.051)
Competition	0.9184*** (0.071)	0.9515*** (0.059)	0.5889*** (0.062)	0.4823*** (0.057)
HHI	-0.0954*** (0.012)	0.0616*** (0.012)	-0.0441*** (0.008)	0.0313*** (0.008)
Log (Estab (-1))	2.1716*** (0.119)	0.8637* (0.469)	-2.1349** (0.832)	-3.4280*** (0.390)
Average Emp (-2))	-0.0002** (0.000)	0.0021** (0.001)	0.0010*** (0.000)	-0.0018 (0.001)
Log(Emp (-1))	-1.6650*** (0.117)	-0.8916** (0.410)	2.6379*** (0.806)	3.4807*** (0.380)
Specialization (-1)	-1.0199*** (0.081)	-0.0379 (0.091)	-0.3457*** (0.053)	0.1071*** (0.044)
Competition (-1)	-1.5467*** (0.133)	0.2719 (0.183)	-0.1668* (0.099)	0.4590*** (0.074)
HHI (-1)	0.0879***	0.0238	0.0273***	0.0129

	(0.023)	(0.150)	(0.010)	(0.010)
Structure	-0.0048*** (0.001)			
	AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)

All variables are first difference

IV: Lag level variables

Krugman

OLS with Krugman

	Construction	**Manufacture**	**Wholesale**	**Retail**
Constant	93.9845*** (19.349)	83.7657 (35.151)	16.4988 (11.979)	37.6549** (14.334)
Wage (-1)	-0.5417*** (0.115)	-0.3454*** (0.134)	-0.0140 (0.041)	0.0875 (0.122)
Establishment	-0.0141* (0.007)	-0.0062 (0.013)	-0.0062** (0.003)	-0.0119*** (0.003)
Specialization(-1)	35.6570 (34.837)	12.5203 (25.435)	5.9947* (3.472)	6.1229 (12.657)
Competition(-1)	0.9264 (0.673)	23.9983 (19.347)	28.9530*** (7.293)	15.7577** (7.906)
KRUGMAN(-1)	78.9980*** (29.445)	-21.5708 (21.465)	-18.2443** (9.017)	-20.3462** (10.022)
Season 1				-1.3920*** (0.120)
Season 2				-1.2177*** (0.130)
Season 3				-0.9846*** (0.132)
	AR(1)	AR(1)	AR(1)	AR(1) MA(1)

OLS with Krugman

	Information	**Finance**	**Health**	**Professional**	**Pool**
Constant	-262.5353** (110.022)	65.6313 (50.982)	98.0403 (597.199)	33.2698** (12.925)	314.9896*** (27.503)
Wage	0.0607 (0.186)		-0.4491** (0.168)		
Wage (-1)	0.6158*** (0.194)	-0.0288 (0.026)	-0.1391 (0.150)	-0.0102 (0.009)	-0.0945 (0.116)
Establishment	-0.0486* (0.026)	-0.0128* (0.007)	-0.0161 (0.017)	-0.0049*** (0.001)	-0.0131*** (0.001)
Specialization(-1)	200.8459*** (50.180)	-10.8410 (8.333)	41.6140* (24.868)	0.9934 (4.958)	7.7513 (7.214)
Competition(-1)	101.068 (69.096)	-5.2155 (17.796)	50.2597 (35.504)	7.0321 (6.217)	-59.4359*** (6.455)
Krugman (-1)	-183.3260** (74.237)	-50.0103** (19.895)	-43.9260 (41.936)	-23.6397*** (7.793)	692.5148*** (75.561)
Season 1					
Season 2					
Season 3					
Structure	-9.7681*** (3.356)				
		AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)	Fixed Effect Time/Sector

GMM Methodology with Krugman Diversity

		Construction	Manufacture	Wholesale	Retail
Constant		0.6406** (0.287)	-0.1330*** (0.012)	-0.1895 (0.148)	-0.0411** (0.019)
Log(emp)	t-1	-0.2024 (0.383)	-0.7269*** (0.068)	-0.7409*** (0.173)	0.3860** (0.148)
Wage	t	2.0636** (0.780)	0.1804*** (0.009)	0.1826* (0.097)	-0.1610*** (0.059)
	t-1	-0.0834 (1.072)	0.1522*** (0.012)	0.0698 (0.068)	-0.2968*** (0.050)
Sector	t	0.0001 (0.001)	0.0001*** (0.000)	0.0001** (0.000)	0.0001*** (0.000)
	t-1	-0.0001** (0.000)	0.0001*** (0.000)	-0.0001 (0.001)	-0.0001*** (0.000)
Size	t	0.0001 (0.001)	0.001*** (0.000)	-0.0001 (0.001)	-0.0001 (0.001)
	t-1	0.0001 (0.001)	-0.0001*** (0.000)	0.0001 (0.001)	0.0001** (0.000)
Specialization	t	-8.1025** (4.153)	-0.0399 (0.054)	0.3342 (0.228)	-0.3186* (0.194)
	t-1	2.4951 (3.722)	-0.5408*** (0.052)	0.1307 (0.162)	-0.4876** (0.249)
Competition	t	-0.0601 (0.051)	-0.9952*** (0.046)	-0.2172 (0.384)	-1.2358*** (0.119)
	t-1	0.0032 (0.024)	-0.6101*** (0.054)	0.2098 (0.482)	0.5832*** (0.196)
Krugman	t	-4.1444 (3.542)	-0.3692*** (0.053)	-0.095 (0.348)	0.6076*** (0.172)
	t-1	3.7702 (2.756)	-0.4271*** (0.039)	-0.4161 (0.262)	0.9766*** (0.197)
Education	t	-0.0614** (0.030)	0.0216*** (0.000)	0.0157 (0.012)	-0.011*** (0.002)
	t-1	0.0085 (0.024)	-0.0122*** (0.000)	-0.0023 (0.005)	0.0143*** (0.002)
			AR(1) AR(2)		

All variables are first difference, except education

GMM Methodology with Krugman Diversity

		Information	Finance	Health	Professional
Constant		0.1391*** (0.037)	-0.0815*** (0.019)	0.0803*** (0.017)	-0.0065** (0.004)
Log(emp)	t-1	0.5769*** (0.063)	-0.3239*** (0.096)	0.3637*** (0.060)	-0.0278 (0.052)
Wage	t	0.0936*** (0.016)	0.0535*** (0.015)	-0.072*** (0.015)	0.1362*** (0.009)
	t-1	0.0736*** (0.010)	0.0368*** (0.008)	-0.0047 (0.031)	0.0732*** (0.021)
Sector	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	-0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001 (0.001)
Size	t	-0.0001** (0.000)	0.0001** (0.000)	0.0001 (0.001)	0.0001 (0.001)
	t-1	-0.0001*** (0.000)	0.0001 (0.001)	0.0001 (0.001)	0.0001*** (0.000)
Specialization	t	0.8151*** (0.084)	0.7264*** (0.063)	-0.3353** (0.145)	0.5820*** (0.095)
	t-1	0.1538*** (0.049)	0.2965*** (0.038)	0.2606*** (0.064)	0.2177*** (0.063)
Competition	t	-1.0589*** (0.106)	-1.0333*** (0.087)	-2.0053*** (0.191)	-0.6127*** (0.079)
	t-1	1.1231*** (0.137)	0.0636 (0.141)	0.9248*** (0.107)	-0.3676*** (0.082)
Krugman	t	-0.0669 (0.128)	0.1732 (0.127)	0.2844*** (0.100)	-1.3175*** (0.159)
	t-1	-1.3946*** (0.150)	-0.0955 (0.143)	-0.3541*** (0.076)	0.4060*** (0.121)
Education	t	-0.0003 (0.003)	0.0011*** (0.002)	-0.0019 (0.002)	0.0018*** (0.001)
	t-1	-0.0010*** (0.003)	-0.0069*** (0.002)	-0.0035* (0.002)	-0.0027*** (0.000)
		AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference, except education

Combes' Methodology (Recursive VAR) with Krugman Diversity

	Construction	**Manufacture**	**Wholesale**	**Retail**
Employment Regression				
Constant	-0.0398*** (0.005)	0.0013 (0.004)	0.0030 (0.002)	-0.0006 (0.001)
Establishment	-0.0241*** (0.002)	-0.0744*** (0.000)	-0.0154*** (0.000)	-0.0168*** (0.000)
Log(Emp)	35.8645*** (0.175)	83.0296*** (0.441)	37.0937*** (0.126)	37.0128*** (0.138)
Specialization	-4.4455*** (0.672)	3.9565*** (0.836)	0.0095 (0.100)	1.0821 (0.696)
Competition	-0.0784*** (0.107)	1.7977** (0.671)	0.0322 (0.188)	0.4201* (0.241)
Krugman	3.8223*** (0.456)	1.0018 (0.719)	0.5400*** (0.130)	0.7389*** (0.226)
Average Emp (-1)	-0.0205*** (0.004)	-0.0034 (0.004)	-0.0005 (0.003)	-0.0058* (0.003)
Establishment (-1)	0.0002 (0.001)	-0.0035*** (0.000)	0.0001* (0.000)	0.0003*** (0.000)
Specialization (-1)	9.1518*** (0.350)	5.3394*** (0.720)	-0.0680 (0.109)	-1.3192** (0.591)
Competition (-1)	0.0341*** (0.012)	3.6159*** (0.572)	0.0061 (0.257)	-0.7688** (0.345)
Krugman (-1)	2.2466*** (0.440)	5.5473*** (0.711)	0.1459 (0.139)	-0.1725 (0.336)
	AR(1) AR(2) AR(3)	AR(1) AR(2) AR(3)	AR(1) AR(2) AR(3)	AR(1) AR(2)
Establishment Regression				
Constant	0.0124* (0.007)	-0.0030*** (0.000)	0.0012 (0.001)	-0.0019** (0.001)
Average Emp (-1)	-0.4634*** (0.168)	-0.0646*** (0.019)	0.3735*** (0.090)	0.2584*** (0.067)
Log(Emp)	0.6012*** (0.140)	0.4735*** (0.050)	0.5280*** (0.099)	0.1719** (0.078)
Specialization	0.5870 (0.563)	0.2792** (0.120)	0.0569 (0.087)	0.8279*** (0.215)
Competition	0.0046 (0.015)	0.1736** (0.071)	-0.0650 (0.221)	0.4548*** (0.114)
Krugman	0.5422 (1.1830)	0.1384** (0.076)	0.0927 (0.1045)	-0.5652*** (0.099)
Log (Estab (-1))	-17.3537*** (6.165)	-4.5269*** (1.526)	13.7333*** (3.243)	9.8365*** (2.506)
Average Emp (-2))	-0.0020 (0.003)	0.0012* (0.000)	0.0068*** (0.002)	0.0036*** (0.001)
Log(Emp (-1))	16.6941*** (5.940)	4.8182*** (1.491)	-14.0531*** (3.306)	-9.7265*** (2.511)
Specialization (-1)	-0.1280 (0.708)	-0.4174*** (0.106)	-0.1114 (0.077)	-1.0146*** (0.243)
Competition (-1)	-0.0234** (0.010)	-0.3676*** (0.085)	-0.6765*** (0.155)	-0.5184*** (0.129)
Krugman (-1)	-0.5395 (0.718)	-0.2020*** (0.074)	-0.0033 (0.121)	-0.1429 (0.116)

Structure	-0.0124 (0.015)	0.0009 (0.001)	-0.0082*** (0.002)	0.0026 (0.002)
	AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference

IV: Lag level variables

Combes' Methodology (Recursive VAR) with Krugman Diversity

	Information	**Finance**	**Health**	**Professional**
Employment Regression				
Constant	0.1055 (0.130)	0.0092 (0.020)	-0.0225 (0.016)	-0.0261*** (0.007)
Establishment	-0.1555*** (0.011)	-0.0314*** (0.000)	-0.0455*** (0.010)	-0.0068*** (0.000)
Log(Emp)	98.7318*** (2.747)	50.9502*** (1.096)	77.8645*** (10.625)	27.6240*** (0.301)
Specialization	7.3299 (6.030)	0.7198 (1.107)	-0.8194 (3.699)	0.4141 (0.424)
Competition	-4.7811 (10.987)	0.9340 (1.525)	15.1451 (19.148)	0.2952 (0.648)
Krugman	1.0886 (10.192)	5.4860** (2.279)	5.6841 (3.588)	0.3717 (0.673)
Average Emp (-1)	-0.0043 (0.031)	-0.0201 (0.015)	-0.0546 (0.106)	0.0132 (0.013)
Establishment (-1)	0.0018 (0.005)	0.0002 (0.007)	0.0026 (0.002)	0.0001 (0.001)
Specialization (-1)	6.8182** (3.478)	0.6856 (0.938)	-2.7786 (4.266)	-0.1490 (0.444)
Competition (-1)	-2.2112 (6.685)	1.7214 (1.529)	-8.9130 (15.369)	-0.0196 (0.602)
Krugman (-1)	-1.4725 (11.745)	3.6475* (2.017)	6.2056 (7.742)	2.1556** (1.001)
Structure				0.0565*** (0.006)
	AR(1)	AR(1)		AR(1)
Establishment Regression				
Constant	0.0144*** (0.003)	0.0072*** (0.001)	0.0025*** (0.000)	0.0186*** (0.002)
Average Emp (-1)	0.0164*** (0.004)	0.0197*** (0.003)	0.0024 (0.006)	-0.2533*** (0.041)
Log(Emp)	-0.0080 (0.078)	-0.1248** (0.057)	0.2108*** (0.022)	-0.0429 (0.083)
Specialization	0.7393*** (0.133)	0.4602*** (0.047)	0.0347 (0.058)	0.4660*** (0.074)
Competition	1.3223*** (0.120)	0.7434*** (0.066)	0.4093*** (0.046)	0.2482*** (0.079)
Krugman	0.5690*** (0.116)	-0.1881*** (0.053)	0.9212*** (0.081)	-0.1024 (0.112)
Log (Estab (-1))	1.8077*** (0.528)	1.3524*** (0.183)	-0.1574 (0.407)	-7.5442*** (1.121)
Average Emp (-2))	-0.0001 (0.001)	0.0026*** (0.000)	-0.0010*** (0.000)	0.0089*** (0.003)
Log(Emp (-1))	-1.8357*** (0.426)	-1.0708*** (0.166)	0.1723 (0.409)	7.3867*** (1.126)
Specialization (-1)	-0.0419 (0.111)	-0.1032** (0.048)	0.1687*** (0.041)	0.4173*** (0.078)
Competition (-1)	-0.1687 (0.150)	-0.0594 (0.110)	0.2848*** (0.065)	0.1396 (0.089)
Krugman (-1)	-0.0614	-0.2813***	1.1382***	-0.2233*

	(0.126)	(0.061)	(0.108)	(0.131)
Structure	-0.0306*** (0.005)			
	AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)

All variables are first difference

IV: Lag level variables

Dekle Diversity

OLS with Dekle Diversity

	Construction	**Manufacture**	**Wholesale**	**Retail**
Constant	106.127** (44.230)	93.743*** (51.948)	9.5551 (21.709)	28.066 (21.019)
Wage (-1)	-0.4224*** (0.124)	-0.3829*** (0.130)	-0.0220 (0.045)	0.0165 (0.117)
Establishment	-0.0078 (0.008)	-0.0118 (0.013)	-0.0064 (0.0031)	-0.0117*** (0.003)
Specialization(-1)	39.737 (38.54)	18.302 (22.316)	7.5530* (4.154)	5.1349 (12.597)
Competition(-1)	0.6053 (0.736)	29.6254 (17.410)	29.835*** (8.570)	18.571** (8.144)
Dekle Diversity (-1)	-563.29 (469.68)	-459.96 (356.81)	122.099 (185.67)	144.967 (154.86)
Season 1				-1.4621*** (0.116)
Season 2				-1.3116*** (0.134)
Season 3				-1.1254*** (0.113)
	AR(1)	AR(1)	AR(1)	AR(1) MA (1)

OLS with Dekle Diversity

	Information	Finance	Health	Professional	Pool
Constant	433.758*** (122.68)	-13221 (44171)	79.853 (250.60)	6.9129 (15.297)	326.884*** (29.578)
Wage	-0.0490 (0.145)		-0.4101** (0.169)		
Wage (-1)	0.5229*** (0.147)	-0.0372 (0.027)	-0.1650 (0.172)	-0.0298*** (0.009)	-0.2750** (0.114)
Establishment	-0.1289*** (0.024)	-0.0145** (0.007)	-0.0190 (0.017)	-0.0058*** (0.001)	-0.0159*** (0.002)
Specialization(-1)	110.02*** (38.982)	-9.8235 (8,893)	42.930* (25.222)	4.8957 (4.554)	19.997** (7.833)
Competition(-1)	90.362* (53.699)	-19.494 (17.00)	48.040 (36.998)	6.2579 (5.996)	-53.580*** (5.761)
Dekle Diversity (-1)	-5477.7*** (829.2)	-67.017 (357.7)	121.20 (573.1)	441.50*** (140.79)	-2586.9*** (284.33)
Structure	-15.378*** (2.019)				
Season 1					
Season 2					
Season 3					
		AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)	

GMM Methodology with Dekle Diversity

		Construction	Manufacture	Wholesale	Retail
Constant		0.1835 (0.189)	-0.0618*** (0.001)	-0.1834* (0.101)	-0.0217* (0.011)
Log(emp)	t-1	0.1506 (0.189)	-0.9512*** (0.025)	-0.4911*** (0.117)	-0.0498 (0.138)
Wage	t	0.1010 (0.416)	0.0337*** (0.005)	0.1936*** (0.056)	0.0001 (0.040)
	t-1	-0.0600 (0.226)	0.0689*** (0.006)	0.1206*** (0.040)	-0.0129 (0.031)
Sector	t	0.0001 (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	0.0001 (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001 (0.000)
Size	t	0.0001 (0.000)	0.0001*** (0.000)	0.0001 (0.000)	0.0001*** (0.000)
	t-1	0.0001 (0.000)	0.0001** (0.000)	0.0001 (0.000)	0.0001 (0.000)
Specialization	t	-1.8408 (1.334)	0.1283*** (0.043)	0.4608*** (0.138)	-1.0413*** (0.225)
	t-1	1.0473 (0.968)	0.2167*** (0.030)	-0.1339 (0.172)	-0.5618*** (0.192)
Competition	t	0.0676** (0.031)	-0.3735*** (0.030)	-0.6617*** (0.236)	-1.4271*** (0.085)
	t-1	0.0239* (0.012)	-0.4921*** (0.036)	0.1766 (0.423)	-0.1588 (0.172)
Dekle Diversity	t	-108.107*** (15.072)	-4.0378*** (0.515)	11.670*** (3.723)	-4.7428*** (1.483)
	t-1	68.251*** (18.025)	1.2556*** (0.521)	-10.609** (4.224)	0.4603 (2.159)
Education	t	-0.0359* (0.020)	0.0050*** (0.000)	0.0127* (0.008)	-0.0039** (0.002)
	t-1	0.0213 (0.189)	-0.0006*** (0.000)	0.0001 (0.000)	0.0055*** (0.002)
			AR(1) AR(2)		

All variables are first difference, except education

GMM Methodology with Dekle Diversity

		Information	**Finance**	**Health**	**Professional**
Constant		0.0039 (0.022)	-0.0658*** (0.008)	-0.0004 (0.012)	-0.0188*** (0.004)
Log(emp)	t-1	0.3460*** (0.044)	-0.0329 (0.091)	0.1035 (0.066)	-0.1570 (0.125)
Wage	t	-0.0052 (0.008)	-0.0102* (0.005)	0.0322*** (0.009)	0.0157 (0.011)
	t-1	0.0879*** (0.007)	0.0194*** (0.005)	0.0218 (0.013)	-0.0302** (0.013)
Sector	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
Size	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001 (0.000)
	t-1	0.0001** (0.000)	0.0001 (0.000)	0.0001*** (0.000)	0.0001 (0.000)
Specialization	t	0.3180*** (0.081)	0.2963*** (0.042)	0.1740*** (0.054)	-0.0445 (0.053)
	t-1	-0.2110** (0.086)	0.4415*** (0.000)	0.3213*** (0.051)	0.4432*** (0.078)
Competition	t	-1.2942*** (0.095)	-1.5513*** (0.052)	-1.3438*** (0.079)	-0.6048*** (0.052)
	t-1	0.2948** (0.143)	0.3021 (0.219)	0.2721** (0.105)	0.1045 (0.076)
Dekle Diversity	t	-16.557*** (2.329)	-3.7560*** (0.987)	-1.0142 (1.1123)	-8.8001*** (1.730)
	t-1	-1.2186 (1.901)	9.2289*** (0.825)	9.2449*** (1.757)	-1.4112 (1.613)
Education	t	0.0171*** (0.002)	0.0161*** (0.001)	0.0047*** (0.001)	0.0001 (0.000)
	t-1	-0.0175*** (0.002)	-0.0131*** (0.001)	-0.0057*** (0.001)	0.0001 (0.000)
		AR(1)	AR(1)		AR(1)

All variables are first difference, except education

Combes' Methodology (Recursive VAR) with Dekle Diversity

	Construction	**Manufacture**	**Wholesale**	**Retail**
Employment Regression				
Constant	-0.0103 (0.007)	-0.0128* (0.005)	-0.0017*** (0.000)	0.0014 (0.001)
Establishment	-0.0235*** (0.000)	-0.0755*** (0.002)	-0.0154*** (0.000)	-0.0167*** (0.001)
Log(Emp)	35.693*** (0.259)	80.894*** (0.908)	36.692*** (0.051)	37.005*** (0.080)
Specialization	-0.2593 (0.918)	5.2451*** (1.381)	0.1526*** (0.025)	0.6096 (0.457)
Competition	-0.0203 (0.015)	3.9271*** (0.943)	-0.5137*** (0.094)	-0.2682 (0.208)
Dekle Diversity	-61.663*** (13.852)	37.297* (23.43)	2.0810** (0.926)	13.906*** (2.782)
Average Emp (-1)	-0.0040 (0.004)	-0.0020 (0.004)	-0.0119*** (0.001)	-0.0027 (0.003)
Establishment (-1)	0.0003* (0.000)	-0.0001 (0.001)	-0.0002*** (0.000)	0.0002 (0.000)
Specialization (-1)	12.049*** (0.854)	-1.0701 (1.042)	-0.1811*** (0.040)	-0.7418** (0.362)
Competition (-1)	0.0822*** (0.015)	0.4037 (0.864)	-0.7761*** (0.087)	-0.0261 (0.315)
Dekle Diversity (-1)	27.987** (12.205)	-15.251 (17.097)	-13.838*** (1.435)	5.8121 (3.575)
	AR(1), AR(2), AR(3)	AR(1)	AR(1), AR(2), AR(3)	AR(1), AR(2)
Establishment Regression				
Constant	0.0167*** (0.005)	-0.0037*** (0.001)	0.00128 (0.001)	0.0064*** (0.001)
Average Emp (-1)	-0.1459*** (0.052)	-0.1105*** (0.025)	0.3256*** (0.111)	0.4935*** (0.114)
Log(Emp)	0.4987*** (0.063)	0.5325*** (0.055)	0.9020*** (0.142)	-0.2131*** (0.042)
Specialization	1.1460*** (0.278)	0.5777*** (0.126)	-0.0707 (0.095)	0.6649*** (0.180)
Competition	0.0012 (0.007)	0.5455*** (0.106)	-0.0197 (0.255)	0.0010 (0.142)
Dekle Diversity	0.1213 (7.911)	4.6001** (2.079)	5.4928 (3.599)	10.254*** (2.047)
Log (Estab (-1))	-5.338*** (1.845)	-9.1453*** (2.182)	11.622*** (3.938)	18.235*** (4.235)
Average Emp (-2))	0.0038** (0.002)	0.0021** (0.000)	0.0098*** (0.002)	0.0017 (0.001)
Log(Emp (-1))	5.2079*** (1.843)	8.7219*** (2.052)	-12.331*** (4.037)	-18.311*** (4.259)
Specialization (-1)	0.2759 (0.344)	0.0781 (0.143)	0.0740 (0.093)	-0.4918* (0.258)
Competition (-1)	-0.0108** (0.005)	-0.0960 (0.090)	-0.5644** (0.233)	-0.1742 (0.098)
Dekle Diversity (-1)	-13.192** (5.503)	7.8492*** (2.599)	4.2004 (3.391)	-11.216*** (2.761)

Structure	-0.0179*** (0.006)	-0.0018 (0.001)	-0.0070*** (0.002)	-0.0083*** (0.002)
	AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference

IV: Lag level variables

Combes' Methodology (Recursive VAR) with Dekle Diversity

	Information	Finance	Health	Professional
Employment Regression				
Constant	-0.0933** (0.041)	-0.0078 (0.021)	-0.0313*** (0.001)	-0.0430*** (0.007)
Establishment	-0.1543*** (0.009)	-0.0314*** (0.001)	-0.0398*** (0.005)	-0.0067*** (0.001)
Log(Emp)	92.911*** (2.748)	49.567*** (1.330)	72.562*** (5.854)	26.918*** (0.308)
Specialization	0.3429 (3.858)	0.2606 (0.967)	-3.0698 (2.301)	-0.1488 (0.487)
Competition	-27.655*** (7.978)	-2.6963** (1.245)	2.3389 (8.534)	-1.2244** (0.6184)
Dekle Diversity	-474.049*** (140.18)	-61.125 (64.23)	72.512 (103.07)	-4.1210 (13.089)
Average Emp (-1)	-0.0520** (0.020)	-0.0541*** (0.020)	0.0068 (0.066)	0.0125 (0.013)
Establishment (-1)	0.0132** (0.001)	-0.0010 (0.001)	0.0019 (0.001)	0.0003** (0.000)
Specialization (-1)	7.3204 (4.490)	0.9376 (0.943)	-1.8796 (2.488)	-0.7329** (0.352)
Competition (-1)	-7.3594 (7.872)	1.6051 (1.646)	-0.1206 (5.423)	-0.1313 (0.432)
Dekle Diversity (-1)	-179.73* (108.55)	-92.764*** (30.66)	-38.939 (124.48)	-26.793*** (7.556)
Structure				0.0689*** (0.005)
	AR(1)	AR(1)		AR(1)
Establishment Regression				
Constant	0.0126*** (0.004)	0.0086*** (0.002)	0.0005 (0.001)	0.0179*** (0.000)
Average Emp (-1)	0.0271*** (0.003)	0.0159* (0.008)	-0.0400*** (0.011)	-0.1382*** (0.014)
Log(Emp)	0.3454*** (0.056)	-0.1740*** (0.048)	0.3726*** (0.041)	0.0142 (0.041)
Specialization	0.3000*** (0.088)	0.6396*** (0.035)	0.0278 (0.061)	0.1958*** (0.067)
Competition	0.9281*** (0.102)	0.9503*** (0.060)	0.6018*** (0.059)	0.1084* (0.058)
Dekle Diversity	5.1624 (3.297)	-9.1561*** (1.780)	7.6239*** (1.367)	6.9248*** (1.869)
Log (Estab (-1))	3.1492*** (0.445)	0.8824* (0.478)	-2.1167** (0.828)	-4.4753*** (0.396)
Average Emp (-2))	0.0005* (0.000)	0.0022** (0.001)	0.0010*** (0.000)	0.0104*** (0.001)
Log(Emp (-1))	-2.9460*** (0.383)	-0.9060** (0.414)	2.6223*** (0.797)	4.2182*** (0.378)
Specialization (-1)	-0.3213*** (0.105)	-0.0365 (0.092)	-0.3568*** (0.052)	0.1714*** (0.059)
Competition (-1)	-0.6027*** (0.141)	0.2809 (0.188)	-0.1857* (0.096)	0.4234*** (0.075)
Dekle Diversity (-1)	0.7930	-3.1635	-4.7236***	-0.8953

	(2.144)	(2.323)	(1.845)	(1.591)
Structure	-0.0164*** (0.004)			
	AR(1),AR(2)	AR(1),AR(2)	AR(1),AR(2)	AR(1), AR(2), AR(3)

All variables are first difference

IV: Lag level variables

Structure Model – 3SLS with Dekle

	Construction	**Manufacture**	**Wholesale**	**Retail**
Demand Equation				
Constant	198.278*** (45.687)	144.614*** (38.661)	2.7487 (17.737)	40.8141* (24.321)
Wage	-1.7793*** (0.650)	-0.5001 (0.509)	-1.0015*** (0.384)	-0.8777** (0.452)
Output	1.2105*** (0.396)	-0.0443 (0.051)	0.9436** (0.389)	
Output (-1)	-0.0439 (0.063)			-0.0456 (0.039)
Material Cost	-3.5835*** (1.174)	0.1800 (0.332)	-1.4900** (0.567)	0.2306* (0.127)
Material Cost (-1)				0.5040** (0.241)
Interest Rate				-0.2688 (0.196)
Establishment		-0.0302** (0.016)	-0.0107*** (0.003)	
Establishment (-1)				0.0101*** (0.005)
Franchise	-0.8691 (0.579)			-0.0467 (0.313)
Structure	-3.4214*** (0.640)			
Season 1	-4.2192*** (1.085)	-1.4004** (0.720)	-0.2337 (0.159)	-2.2142*** (0.508)
Season 2	-3.377*** (1.179)	-1.3582** (0.686)	-0.4247* (0.229)	-1.3803*** (0.292)
Season 3	-2.3597** (1.189)	-0.9437* (0.551)	-0.5382** (0.204)	-1.0721*** (0.258)
Total Emp	0.0001*** (0.000)	0.0004*** (0.000)	0.0001*** (0.000)	
Trend				-0.4414*** (0.141)
Housing		0.0183 (0.018)		0.1711*** (0.047)
Specialization	-0.1940 (16.363)	-14.963 (20.901)	20.5905*** (2.416)	-16.701 (20.910)
Competition	-77.576*** (18.574)	-11.898 (19.036)	29.577*** (7.770)	-10.736 (10.772)
Dekle Diveristy	-1028.66*** (345.5)	-694.54*** (287.05)	-177.88 (129.61)	-103.61 (138.45)
Supply Equation				
Constant	117.67*** (24.715)	220.277*** (64.712)	79.970** (38.547)	83.895*** (14.811)
Wage	0.0645 (0.1030)	0.7234** (0.315)	0.1310** (0.066)	0.1850* (0.111)
Wage(-1)	-0.5029*** (0.125)			
Income	-0.4087 (0.256)	-0.5404 (0.580)	0.1135 (0.176)	

Race	-0.6051 (0.482)	0.8778 (0.587)	0.4249 (0.392)	0.0958 (0.159)
Gender		5.7778 (4.883)	2.833* (1.520)	1.2340 (0.923)
Age	-0.1021 (0.075)	0.2351 (0.184)	0.1023** (0.051)	-0.0991*** (0.020)
Housing			-0.1101*** (0.026)	
Establishment		0.1101*** (0..011)		-0.0035** (0.002)
Establishment (-1)	-0.012*** (0.005)			
Trend		0.2822*** (0.058)	0.1545** (0.062)	
Total Emp 1	0.0001*** (0.000)			0.0001*** (0.000)
Specialization	5.6888 (10.815)	-116.903*** (26.568)	-6.2807 (7.175)	-19.2086 (12.146)
Competition	-42.137*** (11.386)	-108.668*** (20.497)	-9.6301 (20.257)	-41.889*** (4.246)
Dekle Diversity	-569.519*** (237.87)	-1063.81** (405.543)	-354.67* (213.24)	19.642 (101.92)
Avg Emp (-1)	0.4559*** (0.073)			

Structure Model – 3SLS with Dekle

	Information	**Finance**	**Health**	**Professional**
Demand Equation				
Constant	453.787*** (106.04)	97.955*** (28.563)	127.053*** (33.309)	137.263*** (25.210)
Wage	-1.7892*** (0.567)	-0.2340*** (0.090)	-1.2209 (0.836)	-0.5703** (0.225)
Wage (-1)		0.0295 (0.024)	0.0017 (0.193)	
Output	0.8977*** (0.231)	0.0058* (0.031)	0.8563 (0.551)	0.4636*** (0.167)
Output (-1)				
Material Cost	-3.7152*** (0.548)	0.1632 (0.147)	-1.1066 (0.929)	-1.7023*** (0.552)
Material Cost (-1)				
Interest Rate		-0.3804*** (0.111)		
Establishment			-0.0535*** (0.011)	
Establishment (-1)				-0.0069*** (0.000)
Franchise		-2.0101*** (0.604)		
Structure				-0.8363 (0.516)
Season 1	-0.2157 (1.561)		-0.6807 (0.966)	-0.6550 (0.465)
Season 2	-4.4353*** (1.506)		-0.9396 (0.945)	-1.1209** (0.548)
Season 3	-4.9551*** (1.477)		-0.5336 (0.833)	-1.1068** (0.498)
Total Emp	0.0001** (0.000)	-0.0011*** (0.000)		
CO_emp		0.0006*** (0.000)	0.0002*** (0.000)	0.0001*** (0.000)
Trend				
Housing				
Specialization	31.006 (30.52)	-35.764*** (7.442)	29.4130*** (8.573)	-19.523*** (7.909)
Competition	-106.42** (48.230)	-72.578*** (10.488)	24.4176 (15.0124)	-37.128*** (11.529)
Dekle Diveristy	-3232.2*** (915.51)	492.82** (238.91)	-831.39*** (307.04)	-364.71*** (156.48)
Supply Equation				
Constant	537.334*** (85.125)	130.840*** (19.585)	91.975*** (28.856)	107.537*** (12.410)
Wage	0.2199** (0.090)	-0.0146 (0.024)	0.0827 (0.128)	0.0313 (0.022)
Wage(-1)				
Income	1.3610* (0.810)	-0.3903*** (0.143)	-0.1382 (0.519)	0.0095 (0.054)

Race	1.1652 (3.377)	0.0275 (0.369)	-0.8117 (0.689)	0.0349 (0.221)
Gender	10.656* (6.084)	-1.8108 (1.152)	-2.0934 (3.422)	-1.2160*** (0.406)
Age	-0.5555** (0.268)	-0.0525 (0.050)	-0.0596 (0.115)	-0.0109 (0.014)
Housing		-0.0425*** (0.016)	0.2146*** (0.039)	
Establishment			-0.0184 (0.012)	0.0040*** (0.001)
Establishment (-1)		-0.0174*** (0.003)		
Trend	-0.5201*** (0.066)		-0.1798 (0.116)	-0.3703*** (0.046)
Total Emp 1		-0.0007*** (0.000)		
CO Emp		0.0005*** (0.000)		
Specialization	10.7901 (28.474)	-33.292*** (4.553)	50.349*** (11.969)	-22.471*** (4.722)
Competition	-143.081*** (34.532)	-45.511*** (8.210)	-3.7492 (15.913)	-46.702*** (8.346)
Dekle Diversity	-3922.7*** (478.29)	70.818 (167.26)	-834.07*** (180.863)	-233.79 (169.15)
Avg Emp (-1)				

Glaeser's Diversity

OLS with Glaeser

	Construction	**Manufacture**	**Wholesale**	**Retail**
Constant	33.1925 (33.161)	40.1922 (40.975)	14.1427 (17.810)	44.1354** (18.286)
Wage (-1)	-0.4383*** (0.123)	-0.3757*** (0.133)	-0.0092 (0.043)	0.0006 (0.131)
Establishment	-0.0078 (0.008)	-0.0064 (0.014)	-0.0063** (0.003)	-0.0112*** (0.003)
Specialization(-1)	50.5181 (38.386)	24.8037 (22.007)	6.4121 (4.009)	11.2006 (13.468)
Competition(-1)	0.8193 (0.723)	31.9233 (17.628)	29.3580*** (8.780)	17.2338** (8.657)
GLAESER(-1)	49.5921 (63.521)	5.4242 (45.494)	13.3274 (21.428)	-14.5741 (16.190)
Season 1				-1.4738*** (0.117)
Season 2				-1.2996*** (0.127)
Season 3				-1.1449*** (0.117)
	AR(1)	AR(1)	AR(1)	AR(1) MA(1)

OLS with Glaeser

	Information	Finance	Health	Professional	Pool
Constant	100.0149 (118.423)	-2497.073 (17,756)	118.3259* (71.953)	13.2130 (15.259)	128.8979*** (37.681)
Wage	-0.0101 (0.173)		0.0751 (0.208)		-0.1160 (0.126)
Wage (-1)	0.6278*** (0.178)	-0.0330 (0.025)	0.3134* (0.178)	-0.0206** (0.009)	
Establishment	-0.0532** (0.024)	-0.0143** (0.007)	0.0488*** (0.015)	-0.0056*** (0.001)	-0.0066*** (0.001)
Specialization(-1)	-9.8310*** (2.729)	-8.6517 (8.264)	-20.2376 (20.484)	4.5113 (4.930)	45.1554*** (8.462)
Competition(-1)	209.3789*** (46.017)	-19.7982 (16.898)	-13.8547 (30.082)	8.1491 (6.532)	-28.8104*** (5.326)
Glaeser (-1)	-647.0323*** (162.143)	48.5000 (51.464)	-224.2251*** (66.937)	38.8770** (18.541)	-162.3971** (69.082)
Season 1					
Season 2					
Season 3					
		AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)	Fixed Effect Time/Sector

GMM Methodology with Glaeser Diversity

		Construction	Manufacture	Wholesale	Retail
Constant		0.5086** (0.198)	-0.4691*** (0.017)	-0.3908*** (0.112)	0.0400** (0.020)
Log(emp)	t-1	-0.3924* (0.218)	-0.7645*** (0.054)	-0.3672* (0.206)	0.6134** (0.241)
Wage	t	1.5433*** (0.268)	0.2089*** (0.012)	0.2374*** (0.090)	-0.0623 (0.065)
	t-1	0.9879** (0.384)	0.2787*** (0.020)	0.1392*** (0.049)	-0.0264 (0.062)
Sector	t	0.0001** (0.000)	0.0001** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	-0.0001 (0.000)	0.0001*** (0.000)	-0.0001*** (0.000)	-0.0001*** (0.000)
Size	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001 (0.001)	-0.0001** (0.000)
	t-1	-0.0001 (0.001)	0.0001*** (0.000)	0.0001 (0.001)	0.0001*** (0.000)
Specialization	t	-4.9418*** (0.364)	-0.0301 (0.072)	0.1685 (0.233)	-1.3298*** (0.211)
	t-1	-0.1397 (1.076)	-0.1388*** (0.041)	-0.2298 (0.265)	0.4605** (0.209)
Competition	t	-0.0327 (0.028)	-0.2268*** (0.071)	-0.5387 (0.469)	-1.5104*** (0.118)
	t-1	-0.0307* (0.018)	-0.1293 (0.081)	0.3091 (0.656)	1.3943*** (0.435)
Glaeser	t	-1.4478* (0.839)	-0.5389*** (0.165)	1.8022*** (0.548)	0.1466 (0.362)
	t-1	-0.0987 (1.463)	0.6084*** (0.100)	1.2558*** (0.602)	0.6450*** (0.211)
Education	t	-0.0713*** (0.020)	0.0216*** (0.001)	0.0313*** (0.125)	-0.0071*** (0.002)
	t-1	0.0279 (0.018)	0.0123*** (0.000)	-0.0038 (0.008)	0.0041** (0.002)
			AR(1) AR(2)		

All variables are first difference, except education

GMM Methodology with Glaeser Diversity

		Information	Finance	Health	Professional
Constant		-0.1711*** (0.037)	-0.0248** (0.010)	0.0453 (0.028)	-0.0041 (0.005)
Log(emp)	t-1	0.2344*** (0.055)	-0.3644*** (0.073)	-0.2158*** (0.073)	0.0355 (0.105)
Wage	t	-0.0151 (0.011)	0.0070 (0.005)	-0.0031 (0.012)	-0.0067 (0.007)
	t-1	0.0866*** (0.008)	0.0048 (0.004)	0.0305* (0.017)	-0.0601*** (0.001)
Sector	t	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)
	t-1	-0.0001** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	0.0001* (0.000)
Size	t	-0.0001*** (0.000)	0.0001*** (0.000)	0.0001*** (0.000)	-0.0001 (0.001)
	t-1	-0.0001 (0.001)	0.0001*** (0.000)	0.0001 (0.001)	0.0001** (0.000)
Specialization	t	0.9354*** (0.052)	0.1710*** (0.042)	-0.0464 (0.075)	-0.1294* (0.068)
	t-1	-0.0893 (0.082)	0.0505* (0.030)	0.0674 (0.044)	0.3917*** (0.099)
Competition	t	-0.6741*** (0.064)	-1.8651*** (0.062)	-1.5897*** (0.109)	-0.7770*** (0.067)
	t-1	0.0585 (0.160)	-0.6819*** (0.110)	-0.1736 (0.131)	0.2826* (0.146)
Glaeser	t	-2.6879*** (0.317)	1.0213*** (0.171)	0.1582 (0.117)	-1.3997*** (0.241)
	t-1	0.6039 (0.419)	0.4816*** (0.150)	0.8731*** (0.157)	0.1083 (0.201)
Education	t	0.0229*** (0.003)	0.0032*** (0.001)	0.0032** (0.001)	-0.0020*** (0.000)
	t-1	-0.0114*** (0.002)	-0.0031** (0.001)	-0.0074*** (0.002)	0.0014** (0.000)
		AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference, except education

Combes' Methodology (Recursive VAR) with Glaeser Diversity

	Construction	**Manufacture**	**Wholesale**	**Retail**
Employment Regression				
Constant	-0.0233** (0.011)	-0.0186*** (0.003)	-0.0012*** (0.000)	0.0000 (0.001)
Establishment	-0.0234*** (0.001)	-0.0747*** (0.001)	-0.0016*** (0.000)	-0.0167*** (0.0001)
Log(Emp)	35.9859*** (0.207)	81.030*** (0.413)	36.8242*** (0.0475)	36.8860*** (0.083)
Specialization	-3.0208** (1.431)	4.6865*** (0.750)	0.2501*** (0.043)	0.1765 (0.590)
Competition	-0.0602*** (0.014)	4.7583*** (0.614)	-0.4027*** (0.110)	0.0574 (0.288)
Glaeser	-1.4857 (2.049)	11.4261*** (1.159)	-0.3471** (0.131)	0.2957 (0.687)
Average Emp (-1)	-0.0082** (0.004)	0.0071** (0.004)	-0.0054** (0.002)	-0.0029 (0.003)
Establishment (-1)	0.0001 (0.001)	-0.0033*** (0.001)	-0.0002*** (0.000)	0.0002 (0.001)
Specialization (-1)	10.0216*** (1.160)	2.3148*** (0.525)	-0.0046 (0.042)	-0.9830* (0.548)
Competition (-1)	0.0585*** (0.020)	2.0952*** (0.458)	-0.3959*** (0.086)	-0.2483 (0.474)
Glaeser (-1)	-0.5393 (1.312)	1.7041 (1.261)	-1.4304*** (0.217)	1.4490 (0.699)
	AR(1) AR(2) AR(3)	AR(1) AR(2) AR(3)	AR(1) AR(2) AR(3)	AR(1) AR(2)
Establishment Regression				
Constant	0.0075** (0.003)	-0.0024*** (0.000)	0.0016 (0.001)	-0.0019 (0.001)
Average Emp (-1)	-0.1573*** (0.042)	-0.0634*** (0.014)	0.2243*** (0.072)	0.2148** (0.085)
Log(Emp)	0.4365*** (0.069)	0.4815*** (0.048)	0.8867*** (0.128)	0.3480*** (0.053)
Specialization	0.4808 (0.367)	0.3489** (0.107)	-0.1642** (0.0.85)	1.5371*** (0.191)
Competition	-0.0020 (0.007)	0.2636*** (0.080)	0.0074 (0.153)	0.6007*** (0.115)
Glaeser	-1.5246** (0.645)	-0.0854 (0.219)	0.2877 (0.276)	-1.1993*** (0.252)
Log (Estab (-1))	-5.3537*** (1.546)	-4.9889*** (1.154)	7.9794*** (2.547)	8.1452** (3.153)
Average Emp (-2))	0.0003 (0.002)	0.0014** (0.001)	0.0089*** (0.002)	0.0028** (0.001)
Log(Emp (-1))	5.3053*** (1.477)	4.8931*** (1.106)	-8.5548*** (2.579)	-7.9793** (3.177)
Specialization (-1)	0.5603 (0.348)	-0.4477*** (0.101)	0.0756 (0.086)	-0.8778*** (0.233)
Competition (-1)	-0.0102* (0.006)	-0.3113*** (0.062)	-0.3731** (0.166)	-0.7793*** (0.122)
Glaeser (-1)	3.5240*** (0.977)	0.0765 (0.252)	0.4323 (0.305)	-0.1328 (0.214)

Structure	-0.3506*** (0.123)	-0.0001 (0.001)	-0.0061*** (0.002)	0.0049** (0.002)
	AR(1)	AR(1)	AR(1)	AR(1)

All variables are first difference

IV: Lag level variables

Combes' Methodology (Recursive VAR) with Glaeser Diversity

	Information	**Finance**	**Health**	**Professional**
Employment Regression				
Constant	-0.0763* (0.045)	-0.0032 (0.022)	-0.0096 (0.024)	-0.0724*** (0.009)
Establishment	-0.1689** (0.013)	-0.0310*** (0.000)	-0.0311*** (0.008)	-0.0063*** (0.001)
Log(Emp)	99.4019*** (3.258)	49.6241*** (1.453)	59.9398*** (8.799)	25.8508*** (0.435)
Specialization	12.4003*** (4.180)	1.4115 (1.461)	-6.2281 (4.619)	0.5405 (0.490)
Competition	-5.7873 (7.310)	-2.5608* (1.508)	-17.7219 (18.120)	-0.9884 (0.760)
Glaeser	-31.7879** (15.944)	-4.5966 (5.917)	7.3906 (8.454)	-9.3526*** (1.552)
Average Emp (-1)	-0.0043 (0.015)	-0.0614** (0.026)	0.1152 (0.091)	0.0042 (0.014)
Establishment (-1)	0.0183** (0.007)	-0.0007 (0.001)	-0.0012 (0.004)	0.0005*** (0.000)
Specialization (-1)	-1.4415 (4.971)	2.5832** (0.919)	4.7573 (5.492)	-1.5186*** (0.453)
Competition (-1)	-17.2625 (8.206)	4.0418*** (1.314)	17.8998 (15.745)	-2.5401*** (0.559)
Glaeser (-1)	6.3404 (15.948)	-5.4706 (6.918)	-2.3087 (7.010)	5.3317*** (1.573)
Structure				0.0776*** (0.007)
	AR(1)	AR(1)		AR(1)
Establishment Regression				
Constant	0.0010 (0.002)	0.0030*** (0.000)	0.0010*** (0.000)	0.0131*** (0.000)
Average Emp (-1)	0.0335*** (0.004)	0.0440*** (0.006)	-0.0168 (0.003)	-0.0914*** (0.012)
Log(Emp)	0.2910*** (0.066)	-0.3801*** (0.067)	0.2559*** (0.010)	0.1925*** (0.039)
Specialization	0.2967 (0.139)	0.6006*** (0.059)	0.2968*** (0.030)	-0.0140 (0.047)
Competition	0.9518*** (0.146)	0.5498*** (0.056)	0.8075*** (0.049)	0.4890*** (0.082)
Glaeser	0.5576* (0.340)	-1.1586*** (0.267)	-0.7916*** (0.076)	-1.3222*** (0.265)
Log (Estab (-1))	4.0620*** (0.500)	3.2274*** (0.429)	-0.8319*** (0.200)	-2.8839*** (0.312)
Average Emp (-2))	0.0012*** (0.000)	0.0057*** (0.001)	0.0001 (0.001)	0.0004 (0.002)
Log(Emp (-1))	-3.5316*** (0.436)	-2.3229*** (0.329)	1.0485*** (0.198)	2.8387*** (0.316)
Specialization (-1)	-0.4686*** (0.134)	-0.4867*** (0.093)	-0.1560*** (0.034)	0.1090*** (0.038)
Competition (-1)	-0.5283* (0.197)	-0.5906*** (0.119)	-0.4671*** (0.070)	0.3087*** (0.086)
Glaeser (-1)	0.6954**	0.3177	1.4863***	0.0795

	(0.383)	(0.270)	(0.109)	(0.215)
Structure	-0.0097 (0.006)			
	AR(1)	AR(1) AR(2)	AR(1) AR(2)	AR(1) AR(2)

All variables are first difference

IV: Lag level variables