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FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH IN KENTUCKY COUNTIES

John D. Conley
University of Kentucky, JDC3@insightbb.com

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John D. Conley, Student

Dr. David Freshwater, Major Professor

Dr. Michael R. Reed, Director of Graduate Studies

ABSTRACT OF DISSERTATION

John D. Conley

The Graduate School
University of Kentucky
2012

FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH IN KENTUCKY
COUNTIES

ABSTRACT OF DISSERTATION

A dissertation submitted in partial
fulfillment of the requirements for the
degree of Doctor of Philosophy in the
College of Agriculture at the University
of Kentucky

By
John D. Conley
Lexington, Kentucky

Director: Dr. David Freshwater, Professor of Agricultural Economics
Lexington, Kentucky 2012

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ABSTRACT OF DISSERTATION

FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH IN KENTUCKY COUNTIES

There is a broad literature on the finance-growth nexus in the macroeconomics literature. Is there evidence for the finance-growth nexus at the sub-national region? If so, can macroeconomic finance and growth methods be extended to sub-national regions? Joseph Schumpeter argued that banks promote economic growth by choosing which projects to fund, by mobilizing underutilized capital, by managing risk and by monitoring managers.

This dissertation proposes a modified Martin and Ottaviano (2001) model that allows for borrowing to form new firms or to expand existing firms. The model shows that if borrowing across regional lines is costly, above and beyond the normal interest rate, that new firm formation will tend to agglomerate in the more financially developed region.

With this theory in hand, the dissertation goes on to test the effects of bank deposits on earned income in Kentucky counties. Using equation-by-equation and simultaneous equations panel data methods, this dissertation shows that there is a strong correlation between the size of the bank deposits in a county and income growth. Since Kentucky counties are small and economically interconnected, spatial autocorrelation tests are applied with the result that there are pockets within Kentucky where incomes are spatially correlated. Spatial panel estimates are then conducted to correct for spatial autocorrelation. These results show a strong correlation between deposits and income growth.

This dissertation contributes to the literature in three ways. First, it proposes a model that ties endogenous growth, the New Economic Geography and the finance-growth nexus together in a Neo-Schumpeterian context. Second, it gives evidence for the finance-growth nexus in Kentucky counties under methods similar to those used in macroeconomics. Third, the dissertation suggests a way forward in performing future analysis of the finance-growth nexus in a sub-national context.

Overall, this dissertation finds evidence to support the hypothesis that the size of the banking industry in a given county positively influences earned income growth. There is also evidence that having a large banking industry in a neighboring county has a positive spillover effect on earned income. Further estimates to control for endogeneity find evidence that the effect of deposits on income growth is stronger than the effect of income growth on deposits.

KEYWORDS: Banking, Economic Growth, Regional Economics, Kentucky, Counties

Author's signature: John D. Conley

Date: March 5, 2012

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By
John D. Conley

Director of Dissertation: David Freshwater

Director of Graduate Studies: Michael R. Reed

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In Memoriam: Elizabeth Jean Yonan (1972-2000)

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Chapter 1 Introduction

Credit is a vital ingredient in economic development. Borrowing is a common technique for raising funds to start or expand a business. This, in turn, expands the local economy. In cities, there are highly developed financial markets that give entrepreneurs easy access to equity capital or a variety of debt options. In smaller communities, there are fewer options. If a sizeable amount of funding is needed, then the entrepreneur must either piece together a number of small loans or seek funding outside of his or her region. Therefore, policies designed to promote the development of rural or small urban communities need to consider local credit markets. Policies related to financial institution governance need to consider the role of those institutions in rural and smaller urban communities.

Drabenstott (2009) proposed a framework for thinking about rural credit markets. His overarching question is, “What steps should Washington take to assure effective rural financial markets in the future? (Drabenstott, 2009, p. 2)” Drabenstott then goes on to point out that rural credit markets have not been extensively studied. There is also a bias in the literature toward agricultural lending even though non-agricultural business are now the dominant rural employers. He goes on to note that rural firms have much less equity capital, from sources other than the owner, than urban businesses. So, rural businesses are getting bigger, but they rely much more on retained earnings than their urban counterparts. Does this mean that less credit is available in rural areas than in urban areas? Also, retained earnings are an easy method for financing during good economic times. In recessions, when sales are likely reduced, retained earnings are difficult to raise.

Rural communities do not exist in a vacuum. Larger cities with bigger financial markets are not too far away. With modern communications technologies, it is easier than ever for rural entrepreneurs to communicate with financiers quite far away. O’Brien subtitled his book on global financial markets, “The End of Geography (O’Brien, 1992).” Has geogra-

phy really ceased to be a barrier to credit markets? Can lenders evaluate markets hundreds of miles away?

Adding to the questions above is the wave of bank consolidations that followed the Riegle-Neal Act that legalized interstate branch banking. This meant that local banks were bought up by larger banks. The decision-taking processes were transferred from local bankers to managers in another city or state. Do these multi-state banks have the ability to monitor disparate local markets and lend efficiently in the face of costly information?

If there is to be good rural credit policy, then we need to better understand how rural firms get credit. There are some fundamental theoretical and empirical issues that need to be settled before we can formulate that policy. We need to understand the power that local banks have to influence local economic growth. We also need to understand the interaction between rural and urban credit markets. Does having a sizable banking industry improve growth in a county? How does proximity to creditors affect the borrower's ability to borrow or the lender's ability to take lending decisions? Does the information needed to take a lending decision get more costly as distance increases?

This dissertation examines how banking industry development in a Kentucky county affects its growth. When we see how the finance and growth relationship works in the existing macroeconomics literature, we see that there is no reason a similar process should not work in a smaller region if the necessary adjustments are made. For example, counties are small enough that there is considerable, low-friction commerce between them. Neighboring counties in the same state have lower friction than counties across state lines since transport costs are low and the banking laws are identical. Therefore, since Kentucky's counties are small, there can be considerable spillover from banks in neighboring counties.

This dissertation examines three questions, two are economic and one is methodological. First, how does the development of the financial industry influence the growth of Kentucky counties? Second, how does the presence of large, multi-state banks influence

the growth of Kentucky counties? Third, how do we go about bringing some recently developed tools from macroeconomics into the analysis of sub-national economies?

The size of banking markets is an important aspect of financial development, with the other major aspect being the mixture of financial firms in the market. According to Schumpeter (1934), financial institutions have several roles in growth. The first is to mobilize idle or underutilized capital. After all, there are deposits in the bank that would remain in the liability column if not mobilized. The second function is to evaluate entrepreneurial projects. In the process of approving a loan, the bank must carefully analyze the likelihood that a new venture will be profitable. Third, they monitor the managers in a project. The bank wants the new firm to be profitable and well-run so that the loan can be repaid. Fourth, banks manage the risk related to investment. The bank maintains a diversified portfolio of loans. This allows depositors to turn money over to the bank with the assurance that they will earn interest with lower risk than that they would face by seeking their own investments. Finally, but just as importantly, banks provide depository and transactional services to firms. Following Abrams, et. al (1999), we will call this the “Schumpeter hypothesis”.

The first economic question is how does financial development affect growth at the county level? There is considerable evidence that financial development influences growth in the macroeconomics literature and much anecdotal evidence at the sub-national level. How would financial development drive growth? Entrepreneurship seems to be a likely channel. Growth is accomplished by either starting new firms or expanding existing firms. These firms need funding for start up or expansion. New firms or expanding firms may need external financing. Most firms use debt financing which is usually in the form of bank loans. Big banks have limited local knowledge and rely on hard information since that is easier to collect and transmit. Local banks have extensive local knowledge and can use both hard and soft information. This allows (ideally) local banks to make better performing loans. Local banks may write loans that look risky under purely hard information but not as risky when soft information is added. The problem is that local banks are usually small

and thus write only small loans. If a firm cannot get enough financing from the small banks and the information it presents to big banks does not pass inspection, then the firm's project fails from lack of financing. This is the credit gap from local bank industry structure.

The second economic question relates to the composition of the banking market. Again, following Abrams et. al. (1999), we can call this the "Capra hypothesis" from the Frank Capra film, *It's a Wonderful Life* (Capra, 1946). Although Capra was not a professional economist, his film did pose some relevant questions. In that film, the character George Bailey runs a savings and loan institution. When he is shown how the town would be affected by his absence, one result is that Mr. Potter's bank holds a monopoly on the lending business in the town. The result is a considerably lower level of economic development in Bedford Falls. So, the hypothesis states that the composition of the banking industry is important to development.

A second and more contemporary question about the structure of the banking market has to do with interstate banking. Since the Riegle-Neal Act of 1994, banks have been able to open branches across state lines. This, in turn, led to a wave of bank consolidations as very large banks bought smaller banks. That, in addition to the direct opening of branches led to major shifts in local banking markets. Data from before 1995 are not readily available, so direct analysis of the results of the legislation is not feasible. Still with the existing data, one can examine the relationship between growth and the existence of a multi-state banking institution in the county. We can examine how the fraction of the deposits held in large, multi-state banks in the county are correlated with economic growth.

The third major question in this dissertation is methodological. In the macroeconomics literature, it is possible to treat nations as more or less isolated economic units. Each has its own markets, institutions and currency. Even in a currency union like the European Union, there are still strong distinctions that pose some restriction to cross-border economic activity. In the case of counties within a state, there is broad economic interdependence. In states with many small counties like Kentucky, there is multi-county commuting and

trade. The flaw in *It's a Wonderful Life* is that it treated Bedford Falls as an isolated community. In reality, it is quite possible to borrow across county lines, perhaps even from the other side of the state. Even though counties are the fundamental geographical units in this dissertation, they may not be the correct units. Therefore, econometric estimators using spatial autocorrelation corrections may be appropriate. In any case, counties are heterogeneous and interconnected. Therefore, it seems likely that geography would enter the picture. Therefore, any growth theory or empirical study of the relationship between financial development and economic growth would need to consider the spatial dimension of the problem.

1.1 Plan of the Dissertation

Chapter one, outlines the issues explored in this dissertation and summarizes the work to follow. Chapter two is a literature review. It explores the theoretical and the empirical literature in economic growth, banking, concepts of lending information, entrepreneurship and empirical literature on economic growth, banking, and entrepreneurship.

A theoretical model is at the center of chapter three. The model melds Neo-Schumpeterian endogenous growth and lending with the New Economic Geography. It is a modification of a model due to Martin and Ottaviano (2001), which was itself an attempt to integrate the New Economic Geography with growth theory. The model specifically alters their cost of innovation equation to allow for borrowing of the funds needed to carry out a marginal innovation, under the assumption that entrepreneurship is an important source of growth. The utility of Neo-Schumpeterian modeling is that entrepreneurship is assumed and then buried within a “black box” abstraction. This is where Kirzner’s (1973) weaker definition of entrepreneurship is useful. Since Kirzner defines entrepreneurship as simply being aware of changes in information and reacting to those changes, any expansion of the private sector can be considered entrepreneurship, regardless of the age of the firm or the size of the change.

Chapter four provides empirical testing of some of the implications of the model in chapter three. The model is a set of two simultaneous equations with panel data. There are two definitions of income growth used in this chapter. First, there is growth in the level of earned income. The second is the growth in earned income per worker. A number of estimators are used in this chapter. The model is estimated equation-by-equation with fixed effects and Blundell-Bond GMM estimators. The simultaneous equations are estimated with instrumental variables estimators. There are three reasons to check these results for spatial autocorrelation. First, counties may not be the correct geographical units. The proper units may straddle county lines or be a subset of the county. Second, there are counties bordering other states, which means that edge effects may not be correctly accounted for. Third, there is considerable commuting and cross-county trading activity that can blur distinctions among counties. Since counties are the smallest geographic units for which data are available, LISA tests are performed to determine the existence of spatial autocorrelation. The analysis concludes with spatial GMM instrumental variables estimation with the panel data. Conclusions and ideas for future research are found in chapter five.

1.2 Hypotheses to be Tested

- I. Schumpeter Hypothesis: The size of the banking industry in a region has a positive effect on economic growth. Deposits represent pools of idle liquidity that must be transformed into assets.
 - A. The sum of deposits in a region has a positive effect on earned income growth. The deposits in each branch of each bank in a county can be summed for each year. These constitute liquid liabilities that banks are eager to convert to assets through lending.
 - B. The sum of deposits in a region has a positive effect on per-worker earned income growth.

- C. The ratio of the sum of deposits to personal income has a positive effect on earned income growth. This is another measure of financial development. This is the portion of the liquid fraction of personal income that is idle in the bank.
- D. The ratio of the sum of deposits to personal income has a positive effect on per-worker earned income growth. The logic is similar to C.

II. Hypotheses on deposits.

- A. Earned income levels are positively correlated with growth in deposits. This is because income must be deposited in the bank for safe-keeping. As income rises, so should deposits.
- B. Per-worker earned income levels are positively correlated with growth in deposits. The logic is similar to A.
- C. The ratio of transfer payments to personal income is positively correlated with growth in deposits. This is because several transfer programs use direct deposit into bank accounts. In some countries, these may be a sizable fraction of all deposits and the largest source of deposits other than work earnings. Other sources of non-work deposits might include pensions or investment income, but these data were not obtainable.
- D. The ratio of transfer payments to personal income is positively correlated with growth in the ratio of deposits to personal income.
- E. The level of population is positively correlated with deposits. Population level is an instrument for economic agglomeration. If there are more agents then it seems likely they would make more deposits in banks.

- F. The level of population is positively correlated with the ratio of deposits to personal income. The logic is the same as in E.
- III. “Frank Capra” Hypothesis: the structure of the banking industry has an effect on economic growth.
- A. The share of a county’s deposits held by large multi-state banks affects total earned income growth. There is speculation that when large banks move into a region, they collect deposits and lend them in more profitable areas. While this is probably efficient globally, this may slow growth in the source region. On the other hand, a multi-state bank would have a larger pool of loanable funds which might spur growth. This makes it difficult to predict whether the relationship is positive or negative.
 - B. The share of a county’s deposits in large multi-state banks affects per-worker income growth. The logic is the same as in A.
- IV. Spatial specification is a concern in understanding county level banking markets. This is because Kentucky counties are small enough that business travel to neighboring counties is not onerous.
- A. Some counties have earned income growth that covaries with the earned income growth of other counties. Some do not. This effect probably exists to some degree in all counties. Statistically significant covariance in earned income may suggest that growth in one county has a spillover effect on its neighbor.
 - B. Some counties have per-worker earned income growth that is correlated with the earned income growth of other counties. Some do not. The logic is the same as in A.

- V. Control Hypotheses: These are other sources of economic growth. If the signs of these parameters are not as expected, then there are likely to be estimation or specification problems.
- A. Population growth is positively correlated with earned income growth. Several growth models, starting with the Solow model show that population growth is a powerful source of economic growth since it represents growth in the number of economic actors. A positive correlation with economic growth would be in line with the dominant body of growth theory.
 - B. Population growth is positively correlated with per-worker earned income growth. The logic for this is similar to that A. and this should be positively correlated to growth.
 - C. High school graduation rates are positively correlated with earned income growth. This is a measure of the ability of the county to produce human capital. Presumably, more education would translate to more human capital and that would be a contributor to growth.
 - D. High school graduation rates are positively correlated with per-worker earned income growth. Again, the logic is similar to that in C.
 - E. Unemployment rates are negatively correlated with earned income growth. This is a measure of the efficiency of labor markets. If there is high unemployment, the earned income would be reduced.
 - F. Unemployment rates are negatively correlated with per-worker earned income growth. The logic is the same as in E.

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Chapter 2 The Literature

The plan of this chapter is to first review a selection of general literature on financial development and growth. This gives a general framework that can support the specific questions of this dissertation. The second section will focus on work done so far in finance and growth at the sub-national level. The third section explains the role of small and medium-sized enterprises (SME's) and their role in economic growth. This is important since the founding and expansion of SME's is an important channel for growth. Next is a brief discussion on how SME's get their financing. The discussion then turns to the comparative natures of large and small banks. Since relationship banking is a hallmark of local banks, the discussion takes an aside on hard and soft information before discussing relationship banking itself. The chapter concludes with a review of papers on the geography of banking.

2.1 What is an Entrepreneur?

When we think of entrepreneurs, images of Jobs and Wozniak or Hewlett and Packard inventing in their garages come to mind. Entrepreneurship can be far more subtle. This dissertation uses the term in the sense of Kirzner (1973). The common usage of the word "entrepreneurship", due to Schumpeter (1934), implies starting a new business and capturing large opportunities. The Schumpeterian view holds that the entrepreneur is someone who wants to make a significant change to the economy. If the project succeeds, ideally, it would result in a positive shock to economic growth. Thus the entrepreneur is seeking out large opportunities and doing significant research and development. This is a good definition of entrepreneurship, but it is quite strict. Kirzner suggests that an entrepreneur is someone who is simply very alert. Such alertness leads to expansion or small changes to an existing business. Thus, any producer who exploits an information asymmetry is an entrepreneur. The advantage of using Kirzner's definition in this dissertation is that

even small changes in existing firms can be captured in a growth model, as will be shown in Chapter 3. In particular, it helps to motivate the monopolistically competitive markets developed in that chapter.

2.2 Financial Development and Growth in General

The primary hypothesis of this dissertation is that the size of the financial sector positively affects economic growth in a county. The first step is to look at evidence on financial development and growth in general before going to the county level. The ancestor of the finance and growth literature is Joseph Schumpeter's book, *The Theory of Economic Development* (Schumpeter, 1934). Schumpeter wrote that financial institutions have several roles in growth. The first is to mobilize idle or underutilized capital. After all, there are deposits in the bank that would remain in the liability column if not mobilized. The second function is to evaluate entrepreneurial projects. In the process of approving a loan, the bank must carefully analyze the likelihood that a new venture will be profitable. Thirdly, banks monitor the managers in a project. The bank wants the new firm to be profitable so that the loan can be repaid. Fourth, banks manage the risk related to pools of investment. The bank maintains a diversified portfolio of loans. So, depositors turn money over to the bank with the hope that they will earn interest with lower risk than they would by seeking their own investments. Finally, but just as importantly, banks provide depository and transactional services to firms.

A modern take on this idea came from King and Levine (1993). They performed growth regressions on a panel of nations. They used several sets of measurements of financial development as independent variables. The first measurement was the ratio of liquid liabilities to GDP. The next set of measurements involved relative percentages of credit issued by the central bank and by private banks. The idea here is that private banks, due to their depository operations, collect better information on the business climate than central banks do. The final set of measurements used the fraction of credit issued to non-financial private

firms and credit issued to non-financial private firms divided by GDP. Their findings show that high levels of financial development are correlated with faster growth rates, physical capital accumulation and economic efficiency improvements. They also found that the level of financial development is a predictor of future rates of capital accumulation and improvements in efficiency.

A potential problem with King and Levine (1993) that is shared by a number of papers in the field is the problem of endogeneity. Does finance drive growth, or does growth drive financial development? King and Levine, like so many subsequent papers, simply assume the former. This is especially concerning in light of Lucas's (1988) argument against the role of financial institutions in growth. He argues that financial development is a sign of growth, not a driver. As the economic agents capture the results of growth, their bank accounts enlarge.

Since King and Levine (1993), a number of papers have been published that comment on the finance and growth nexus. Rajan and Zingales(1998) found that industries that are relatively more dependent on external finance grow faster in countries with with more developed financial markets. Beck, Levine and Loyaza (2000) found that financial development has a large positive effect on total factor productivity growth. They also found that long-run links between financial intermediary development and growth in physical capital and savings growth are not strong. Beck, et. al. (2008) found that financial development boosts industries centered on small firms more than industries that center on large firms. Particularly, they found that low financial development is detrimental to firms with 20 or fewer employees.

2.3 Financial Development and Economic Growth at the Sub-National Level

The above studies are cross-country studies. Studies of smaller geographical units are less common. Guiso, Sapienza and Zingales (2004) studied financial development in Italian provinces. They computed a financial development measure from the probability that a

household will have a loan application denied. They found that stronger financial development increases the likelihood that an individual may start a business, favors entry of small firms and has an overall positive effect on economic growth and competition.

Özyildirim and Önder (2008) studied the Turkish banking sector and found that financial development had an overall positive effect on per capita local output and that this effect was greater for regions distant from the financial centers. Their first model related growth (the time difference between two periods of the logged per capita provincial GDP) to a vector of banking variables and a vector of control variables. Their second model added to the first a vector composed of the banking activity variables multiplied by the distance between branches and their headquarters. Their data were a panel of annual data from 1991-2000 and 67 to 81 provinces (14 new provinces were established during the survey period).

Özyildirim and Önder found that provincial bank credits were significant in the first model but not significant in the second. This suggests that the distribution of local loans is important in analyzing provincial per capita growth rates. The authors used three measures of distance. The first was the physical distance between Istanbul and the province. This led to the result that as distance between headquarters and branch increased, the loans contributed more to the local GDP. The second distance measure was the distance between Istanbul and the province divided by the number of branches of the bank in the province. This reflects an assumption that as the number of branches rises, there is more communication between the province and the headquarters. This did not significantly change the impact of banking activities. This led the authors to conclude that distance between provinces is critical in estimating the effect of banking on local development. The third measure was a dummy variable that was zero for a western province and one for an eastern province. The result supported the authors' hypothesis that eastern provinces are more dependent on loans than western provinces.

Another set of estimates used the ratio of bank credits to provincial GDP as the measure of banking activity. They found that a rise in this measure positively influenced local GDP. They also found that the banking activity was lower for provinces far from Istanbul. Overall, they found that banking activity has less impact as the distance from Istanbul rises. Indeed, in very distant provinces, this became a negative effect, which implies that loans were going to unproductive projects. However, they also found that when loans are adjusted for the size of the local economy, the relationship between banking activity and per capita output is negative. This suggests that as distance from the financial center increases, loans tend to fund less productive or higher risk activities. These studies will be explored in detail in the subsequent discussion.

This student has found a few papers that approach the banking and growth problem at the sub-national level in the US. The first is Abrams, et. al. (1999), that attempts a growth regression using panel data somewhat like this dissertation's empirical chapter. The authors broke the thirty year dataset into five-year periods. The cross-sectional groups consisted of the 48 contiguous US states. The authors computed a financial depth variable composed of total bank assets divided by the state's personal income level at the start of each five year period. This was further decomposed into a commercial bank depth and savings and loan depth. The authors then included a set of variables on branch banking and the presence of multi-bank holding companies. Control variables on human capital and fiscal policy rounded out the structure. They found that both general financial depth and commercial bank depth had positive and statistically significant relationships with economic growth. The branching and multi-bank holding company variables had no statistically significant effect on growth. It was also this paper that introduced the terms "Schumpeter Hypothesis" and "Frank Capra Hypothesis".

Cortes (2000) applies a modified version of the model from Abrams, et. al. (1999) to counties in Kansas. Cortes first regresses financial depth on the Herfindahl-Hirschman Index (HHI) of the banking industry, population density and other independent variables.

A second regression was done in which the residuals from the first regression were then regressed on average per capita county income growth from 1980-1987 and 1987-1997 along with financial depth, the number of bank offices, the ratio of county tax income to spending, the ratio of public capital spending to income, the share of farm employment to total employment, initial income and state dummies. Cortes found that financial depth was positively and significantly correlated with growth while the number of bank offices was negatively and significantly related to growth, which Cortes attributes to a negative relationship between the number of bank offices and the efficiency of the banking market. The fiscal policy variables were also negatively and significantly related to growth as was the farm share. This study was unique among those examined here because the two regression technique is an attack on the endogeneity problem between financial development and growth.

Two papers on growth in Italy are also useful. First is a paper by Usai and Vannini (2005). This study especially noted the effect of small and medium-sized enterprises on growth and the banking industry's effect on those enterprises. Their data were composed of Italy's NUTS-2 (multi-province) regions between the years 1970-1993. Their banking variables were numbers of public (government-owned) banks, national (private, commercial) banks, cooperative banks and "special credit institutions. They found that growth (in terms of per-capita GDP) was negatively correlated with the numbers of public and national banks. On the other hand, cooperative banks and "special credit institutions" had a positive correlation with growth. Overall, the financial variables had a weak impact on growth.

A paper by Vanona (2008) examined Italy's NUTS-3 (county-sized) provinces in the years 1986 - 2003. This study is particularly interesting because it used two different estimators. First, the author examined the endogeneity of the financial development variables by using a two-stage least squares dummy variable (2SLS DV) estimator. Then, to examine the dynamics, Vanona used the System GMM or Blundell-Bond estimator with robust standard errors. Spatial autocorrelation tests were run on all estimation results. The 2SLS DV

results showed that both short term and long term credit over value added in 1986 were positively and significantly correlated to per-capita GDP growth. Likewise for the dynamic panel results. The spatial autocorrelation tests gave small values of the test statistics that were not statistically significant.

There are several ideas developed in this section that can be carried forward into the models of Chapters Three and Four. First, a robust financial sector seems to increase the chance that a given individual will start a firm. Second, financial depth seems to positively correlated to growth. Third, there may be an inverse relationship between financial development and the distance from a given place to a financial center. Özyildirim and Önder (2008) and Vanona (2008) come to opposite conclusions on this, so this point is worth further study. Usai and Vannini found that, for Italy, small banks have a positive effect on growth while larger banks have a negative effect on growth. This suggests that a variable that measures the size or fraction of deposits held by large banks would be useful.

2.4 SME's, Entrepreneurship and Economic Growth

On Structural Change and Growth

The first question that should be asked is, “does structural change across industries promote growth?” Then we can ask if entrepreneurship causes useful structural change. Disney, Haskel and Heden (2003) examined the effect of restructuring on manufacturing productivity growth in the UK. They identify two forms of restructuring. Internal restructuring refers to the introduction of new technology or organizational change to existing firms. External restructuring consists of exit of old lower productivity firms and entry of new higher productivity firms. Their data came from the Annual Census of Production Respondents Database, which is a census of British manufacturers. Their time series ran from 1980 through 1992. All firms with 100 or more employees had to fill out a full census form while smaller firms were sampled. The authors regressed total factor productivity on real gross output, real capital, worker hours and real material use. They also ran a hazard model

that gave the probability that a firm would exist from period t through $t + 1$ given that it survived through period t . These results found that external restructuring increases overall productivity.

Disney, et. al. (2003) go on to quantify the effect of firm entry and exit on productivity. As expected, entering firms were always more productive than exiting firms. Entering firms were often more productive than surviving firms. Surviving firms were almost always more productive than exiting firms. Lastly, surviving firms saw increases in their productivity. These results were highest in the computer industry and lowest in the chemical industry. Overall, internal factors accounted for around 50% of labor productivity growth. Net entry accounted for most of the external restructuring effect. External restructuring accounted for 80 - 90% of total factor productivity growth depending on the technique used to decompose effects. Net entry also accounted for just over 50% of total factor productivity growth. Most of the labor productivity growth was driven by labor force downsizing and capital substitution for labor. They further found that market competition significantly raised both the level and the growth rate of productivity, but robustness corrections led to a smaller effect than other studies that did not correct for robustness.

Entrepreneurship and Growth

In the November, 2004 issue of *Regional Studies*, Zoltan Acs and David Storey (2004) summarized the state of research in entrepreneurship and development over the period from 1984 to 2004. More sophisticated econometrics, especially panel data, methods have improved the quality of empirical work since 1984. Theoretical work has benefited by drawing in older, more traditional ideas, such as, the neoclassical production function. These improvements in the research lead to a consensus that the entrepreneur's role in development is to shift resources from less productive uses to more productive uses.

Audretsch and Fritsch (2002) define a growth regime as a geographic region that exhibits a particular set of growth conditions. Audretsch and Fritsch define four growth

regimes. An entrepreneurial regime concentrates on starting new firms. A routinized regime focuses on the growth of large, incumbent firms in a stable environment. A revolving-door regime is a low growth state in which there are many firm births and deaths. The last is a downsizing regime which is a low growth situation characterized by layoffs, plant closings and little entrepreneurial activity. The downsizing regime can be thought of as the decline of a routinized regime.

Audretsch and Fritsch used a panel of data from 1983-98 that covered 74 West German planning regions. They classified a region as an entrepreneurial regime if both new firm starts and growth rate both exceed the median for all 74 regions. A region was labeled a revolving-door regime if the start-up rate was higher than the median but the private sector employment growth rate was below the median. If a region had a low start-up rate but an above median growth rate, it was labeled a routinized regime. A downsizing regime is a region where both the start-up and growth rates were in the bottom 50% of regions. Note that the authors refer to relative growth since overall employment growth for Germany was negative in the period 1993-1998. The years 1990 through 1993 were skipped due to German unification and the economic dislocations that resulted.

The majority of economists who look into entrepreneurship and development believe that new firm formation leads to growth, but the empirical evidence is limited. Fritsch and Mueller (2004) contribute such empirical evidence. They examined the time lag of the effect of new firm formation on regional growth in West Germany. Before going into the econometrics, they give a good summary of how new firms affect growth.

Fritsch and Mueller identify four closely related, but distinct, effects of new firm formation on growth. First, new firms spur existing firms to become more efficient. Actual entries are not necessary to force improvements. A credible threat of new entrants can force existing firms to take preemptive measures to become more efficient. If firms do not respond to these threats, then new, more efficient firms will take a large share of the market or even drive the incumbents out of business.

Acceleration of structural change is the second effect on the market. This means that existing firms fail and are replaced by new firms. This relates to the efficiency effect in the previous paragraph. Even if existing firms become more efficient this does not guarantee their survival. Schumpeter (1934) calls this “creative destruction”. This is also related to Marshall’s forest analogy in which an old tree must die to make room for a new tree.

The third effect is amplified innovation. Not only will new firms possibly be more efficient in the existing market, they may create new goods that substitute for the old ones. New firms may rise in this case because incumbent firms may be unwilling to embrace the new product. Also, setting up a new firm may appear to be the only way to fully exploit the profit potential of the innovation.

Lastly, a greater variety of products leads to a larger range of possible economic activities. This means that another firm or a consumer will have a higher probability of finding a supply that is a better match than was previously available. This allows efficiency improvements to cascade from one sector of the economy to others.

Fritsch and Mueller then go into the empirics. Their data came from a subset of the German Social Insurance Statistics and from publications from *Statistisches Bundesamt* (the German Federal Statistical Office). They assembled a panel between the years 1983 and 2002. Their spatial units were the 326 Kreise or districts of the former West Germany. Their dependent variable was the start-up rate for new firms in the current year and time lags from $t - 1$ to $t - 10$. They did test lags out to $t - 14$, but these results were not very robust. Their independent variable was the two-year regional employment change. They found that if their interpretation of the lag structure is correct (always an open question) then the indirect effects of opening a business on employment were greater than the direct effects, i. e. the number of people hired by the new business. The highest employment gains seem to come six to seven years after the firm opens. The authors also found significant spatial autocorrelation (at the 1% level in all cases), indicating that these indirect supply-side effects also benefit neighboring districts.

At this point, we should define *entrepreneurship capital* and examine its impact as an input. Audretsch and Keilbach (2004) define entrepreneurship capital as a region's endowment of factors conducive to the creation of new businesses. These include an endowment of individuals willing to take the risk of starting a business, an "innovative milieu" in the region, the existence of formal and informal networks, a general social acceptance of entrepreneurship and the presence of banks and equity investors willing to finance new firms.

Audretsch and Keilbach point out some impacts of entrepreneurship beyond those listed above. First, entrepreneurship and its capital provide mechanisms for knowledge spillovers. These have been widely acknowledged as underlying mechanisms for growth. This is because knowledge is appropriable. Other firms can observe the behavior of the entrepreneur and adapt that to their own situations. This implies a "learning by doing" mechanism in growth and that a new firm startup can have more subtle effects on growth than those identified by Fritsch and Mueller (2004). A related point is that a high endowment of entrepreneurial capital can attract workers with high levels of human capital. We see this in geographical clusters of entrepreneurship such as Silicon Valley or North Carolina's Research Triangle. Scientists, engineers and programmers are particularly attracted to living in these regions where the entrepreneurial milieu stimulates a related research and development milieu.

The authors also point out that entrepreneurship creates new firms. This is growth in and of itself since the number of economic actors increases along with the number of transactions. The firms are not only in product competition but in competition to acquire and use knowledge before other firms. As the knowledge base expands, this creates a need for more firms to open to provide goods that are complementary with the new knowledge.

The third point Audretsch and Keilbach make, related to the last, is that entrepreneurship creates product diversity. Not only are there more firms in the same industries, but new firms in other industries also open. This relates to an important point Jacobs (1969) makes. She points out that cities are sources of innovation because the diversity of firms in such

a small space leads to transmission of complementary knowledge across firms of different industries. These knowledge externalities are an important form of knowledge spillover. In short, agglomeration leads to innovation which leads to growth.

Audretsch and Keilbach then perform some empirical tests on the effect of entrepreneurship capital. First they specified a Cobb-Douglas type production function that included capital and labor stocks, a measure of knowledge capital and a measure of entrepreneurial capital. Their data came from a 1992 cross-section of 327 West German regions. Output was represented by the region's GDP in 1992. Overall, they found that entrepreneurial capital has a larger production elasticity than knowledge capital. This suggests that entrepreneurial capital stocks should be built up alongside physical capital, human capital and labor stocks.

How do small and medium firms contribute to the growth of US states? Bruce, et. al. (2009) measured their impact on Gross State Product (GSP) and State Personal Income (SPI). Their data were a panel of tax data developed and maintained by the University of Tennessee's Center for Business and Economic Research and a set of small business activity measures developed by the US Small Business Administration. The years were 1989 - 2002. Their regression's independent variables included population density, firm births and deaths, the number of firms with less than 500 employees in the state and in surrounding states, the number of firms with 500 or more employees in that state and neighboring states, percentage of residents with a college degree, tax rates, wages and a set of control variables. They found that dollar values of small business payrolls in neighboring states had small but positive effects on GSP. The number of births of small firms added much to GSP growth. They found that an increase of 5% in the number of small firms increased GSP growth by 0.465%. Deaths of small firms had a similar negative effect. They also found that the large firm activity in the preceding year had a positive effect on GSP growth. This is reasonable since there are relatively few large firms and they have very large outputs. So, contribution per firm is higher for large firms. The authors also

found that small business activity in neighboring states generally had no significant effect in a given state.

Beck and Demirgüç-Kunt (2006) examined the effect of SMEs on growth in a number of developed nations. First they point out that policies designed to promote SME growth as an engine of economic growth are based on the twin premises that SMEs are an engine of growth and that institutional and market failures prevent SME growth. They also note that recent cross-country regressions of GDP per capita growth on SMEs do not show that a large SME sector promotes growth. More specifically, they fail to reject the hypothesis that SMEs do not exert a causal impact on growth. On the other hand, there is considerable evidence that the conditions that are ripe for SME development are correlated with growth. In other words, conditions of “creative destruction” are necessary for growth rather than just having a large SME sector. SMEs are then evidence of growth rather than an engine of growth. Now, this does not mean that SMEs cannot improve growth. It may be that the constraints they face may be preventing them from exercising that role. Beck and Demirgüç-Kunt still find that finance is the major constraint on SMEs.

Constant returns to scale are a common assumption in growth models. This assumption allows for perfect competition which greatly simplifies a model. Actual markets are rarely this simple. Monopolistic competition allows a more realistic market structure with competing goods that are near substitutes. Increasing returns to scale can allow us to model competition for factors of production. How do we operationalize a growth model with increasing returns and a monopolistically competitive market? Aghion, Dewatripont & Rey (1999) developed a growth model with a Dixit-Stiglitz market. This model is not a mere novelty, but seems to settle a philosophical debate in the literature. Although this dissertation takes an unabashedly Schumpeterian view toward growth, there is a rival view due to Michael Porter. This so called Darwinian view states that domestic competition between firms forces them to innovate and be efficient. Schumpeter suggests that the possibility of future monopoly rents induces firms to innovate and be efficient. Aghion, et. al. sug-

gest this debate can be resolved by modifying the assumptions of a Schumpeterian quality ladder model. Specifically, they emphasize incentives to agent-managers within the firm.

They propose a model with a Dixit-Stiglitz intermediate goods market. They also assume that managers of intermediate goods producers face a private cost to adopting new technology. This introduces a principal-agent problem and makes the managers deviate from profit maximization. One important case is that of high levels of outside finance. In such a case, most of the monetary returns from the firm will accrue to outsiders. The authors then numerically calibrated the model to find solutions. Among the findings is that as the cost of innovation increases firms are less likely to adopt such innovations. They instead imitate other firms. This results in lower growth. Another finding is that *ceteris paribus*, higher interest rates lower growth. Aghion, et. al. then open their model to debt markets and allow the lenders to liquidate a firm if it fails to meet debt repayments. After establishing the mathematics, the authors find that the liquidation threat disciplines managers and that a certain amount of debt is optimal for a firm.

What points should be carried forward into the dissertation from this section? First, structural change across industries seems to cause growth. Entrepreneurship causes structural change. This implies that firm entry and exit improve growth since entries and exits improve productivity. This relates back to Schumpeter's concept of "creative destruction." Audretsch and Fritsch (2002) show that this effect is heterogeneous over space. Audretsch and Keilbach (2004) point out that entrepreneurship extends product diversity. This would suggest that a monopolistic competition market structure would be useful in modeling. This point is expanded by Aghion, Dewatripont & Rey (1999).

2.5 How Do SME's Get Financing?

According to Berger and Udell (1998), there is a sequencing of finance depending on business age and size. They observe that the modern information based theory of security design and a "financial pecking order" make debt financing the next best option after in-

sider financing is exhausted. These could include bank loans, loans from other financial institutions or trade credits. Yet, moral hazard is particularly high for new startups when the amount of financing needed is high relative to the amount from insider financing. In other words, if the new business will be expensive to start, and those costs are significantly above the means of the entrepreneurs, then venture capital and angel investment are needed, since banks and other conservative investors will reject the project in favor of less risky ones.

Larger firms have a number of financing options, such as, several forms of long and short term bonds, lines of credit and special loan programs from suppliers (e.g. loans from auto manufacturers to dealerships to acquire inventory.) Aggressive small firms with high growth potential can benefit from venture capital and angel financing. There are other classes of entrepreneurial projects. There are the very small “mom-and-pop” enterprises. For such entrepreneurs the best option could very well be the classic bank loan. In addition, there is a financial growth cycle that determines when a given class of finance is likely to be available (Berger and Udell, 1998).

Berger and Udell (2002) break down the categories of small firm finance in the US with a tabulation compiled from the 1993 National Survey of Small Business Finance. They define small firms as those with 20 or fewer employees and less than \$1 million in sales. The authors use their empirical methods from Berger and Udell (1998) and show that such firms get 49.63% of their financing from equity finance and 50.37% from debt. A breakdown of the equity number shows that the leading source of equity financing comes from the principal owner’s own resources at 31.33% with “angel” investors providing 3.59%, venture capital providing 1.85% and all other equity sources accounting for 12.86%. On the debt side, commercial banks provide 18.75% of all financing, Finance companies provide 4.91%, other financial institutions provide 3.00%. Trade credit accounts for 15.78%. The principal owner accounts for 4.10% of debt financing. All other sources account for 3.83%. So, next to the owner’s own resources, the most important source of small business financing is the commercial banking industry.

In short, the financing needed by new firms different from that needed by older firms. This is reflected in the fact that smaller firms have a different set of financing options from larger firms. Larger firms can access issue bonds, sell stock or access other sophisticated financial markets that smaller firms cannot access. A narrow majority of the financing for newer, smaller firms comes from debt, which makes banks important to new business formation and therefore to growth.

2.6 Hard and Soft Information

Before proceeding, we need to understand the nature of the information needed by lenders, since the lending decision by the bank is based on the information the bank collects on the borrower. Such information can be divided into hard and soft information. Hard information is a definite statement that is either quantitative, such as that found in a ledger, or is a falsifiable statement such as, “this person has filed for bankruptcy in the last seven years” Petersen (2004). Soft information consists of indefinite statements that often consist of opinion or reputation. An example might be, “Does this person have a reputation for honesty?”

Another difference is in how the two are collected. Hard information can be collected with little human assistance. Being usually numerical, it can be entered into a database electronically. This also means that hard information is often not collected by the lender. There are firms that do a good business collecting hard information into databases and selling these to lenders. Also, the subjects of hard information are often legally required to make such information public. Since hard information is easy to turn into data, the mail and Internet allow it to be collected from long distances.

Soft information is harder to collect. It requires more work and, usually, close geographic proximity or the use of social networks. Once collected, the information can usually be recorded in text. Sometimes it can be recorded as a numerical scale, but this is still a subjective measurement. If one has a scale of one to ten for honesty, then will one

lie reduce the score to 9 or to 9.5? Sometimes soft information is not even translatable to text. It can remain “just a gut feeling.”

Another advantage of hard information is its durability. Since it can be stored in databases and these can be copied, hard information can be kept indefinitely. As it accumulates, trends can be observed. Thus, as hard information ages its utility does not diminish. A related issue is information loss in transmission. Hard data can be transmitted electronically. There are various means that can assure that it has transmitted completely. Soft information can be lost in several ways. Since it is dependent on the collector’s memory, it can be forgotten. If the recipient is in a hurry, soft information can be edited for brevity which decreases the information that is transmitted. Also, the matter of what soft information should be transmitted is subjective. This sort of editing is not a scientific process and can lead to critical information being edited out because the collector does not believe it to be important. Clearly, when there are fewer people in the information chain, there is less likelihood of loss.

2.7 Relationship Banking

What is relationship banking? Boot (2000) defines it as the provision of financial intermediation services with two special characteristics. First, the bank invests in collecting customer specific information that is often proprietary in nature. Second, the bank evaluates the profitability of a lending opportunity through multiple interactions with the customer over time and/or over multiple products. In other words, relationship banking is distinguished from other forms of banking by its use of soft information. Of course, such information is very sensitive, so an additional criterion is additional discretion in handling client information above the legal and ethical minima. This additional information extends the comparative advantage that a relationship lender enjoys above those banks that do not engage in relationship lending.

Boot (2000) lists a number of ways that relationship banking adds value. First, there is the Pareto-improving transfer of information. The soft information that relationship banking depends upon allows for greater flexibility in writing contracts. This leads to implicit long-term contracting. The relationship allows for customized covenants that can reduce conflicts of interest. Relationship loans may be guaranteed by collateral which must be monitored. This means that geographical proximity to the borrower may be needed. Lastly, the relationship may allow for loans that may not be profitable in the short-run but will likely be profitable in the long-run. This means that the efficiency of intertemporal transfers can be enhanced.

So, large banks are dependent on hard information while smaller banks can do relationship lending based on both hard and soft information. Berger and Udell (2002) refer to this view as the “current paradigm.” . Why can smaller banks use soft information while large banks have difficulty with it? Stein (2002) explains this best. Stein proposes a model of firm structure that shows that decentralized firms are better at dealing with soft information while hierarchical firms perform better when information can be hardened. In a large firm, information is usually collected by one group while decisions are taken by another. Since hard information is easier to transmit, these firms tend to use more hard information than soft. Also, since large banks tend to be hierarchical, oversight of loans will likewise favor hard information. This also means that the hierarchy of the bank can divert money away from a particular branch, which decreases the incentive for a worker in a branch to collect soft information. In a small bank, information is often collected by the same people who take decisions on loans, so those individuals are able to develop and use soft information without worry about transmissibility. Also, since there is little or no hierarchy and less opportunity to divert loans outside of the community, there is more incentive to collect soft information.

Berger and Udell (2002) make particular mention of loan officers. When a firm has a relationship with a bank, this is primarily a relationship between one or more managers

of the firm and a loan officer. In a very small bank, the loan officer may be the CEO of the bank and any principal-agent problems would be minimized. If power is designated to a full-time loan officer, there is a possibility of principal-agent problems. It is possible that the loan officer's incentives may not align with the needs of the bank. This may be particularly true if the loan officer is "too friendly" with the borrowing firm. In addition, if the loan officer takes a job with another bank, he or she may carry the relationship to the new bank. Non-compete agreements may prohibit the loan officer from soliciting the firm's business, but they do not prohibit the firm from following the loan officer of their own accord. These issues, in addition to the problems of passing information through a hierarchy, cause small banks to prefer a flatter organization with trusted people in the key positions.

Another issue that Berger and Udell (2002) examine is the effect of macroeconomic and institutional shocks on relationship lending. Relationship loans are acutely sensitive to shocks. One reason is that relationship loans are difficult to securitize or sell since the buyer may have difficulty using the soft information underlying the loan. The authors also point out that regulatory changes can have a large effect on lending. There were two major legal changes in the US in the 1990's. The first was the Graham-Leach-Bliley Act which allows commercial banks to merge with other financial institutions. The second was the Riegle-Neal Act which allows multi-state banking. Both of these acts generally reduced small business lending as a wave of bank consolidation followed although mergers between small banks tended to increase lending to small firms.

2.8 Large and Small Banks

Another issue is the size of the bank. A bank with a larger deposit base is able to write more and larger loans. A bank with a larger asset base is one that will usually be profitable and will have considerable experience in lending. One way to define the size of a bank by the amount of assets it has. How the relative levels of assets are categorized is not settled.

For example, there is no agreement on the amount of assets needed to be known as a small or community bank. The Graham-Leach-Bliley Act (CFI, 12 USC 1422(13)) defines a community bank as one with an average of \$500 million or less in assets over three years. Gilbert (2000) defines a small bank as one with \$1 billion or less in assets as identified in the FDIC's Summary of Deposits. These assets are mainly the bank's loan portfolio. If the loan production technology is constant across banks, then all banks should converge to the same size. One reason there are different sizes of banks is due to different cost functions. Specifically, there is a difference in how they are able to collect and analyze information on potential borrowers. Small banks have an advantage in handling soft information. Since they are usually of local origin, they are better connected into the region's business and social networks. This allows them to do relationship lending.

Peek and Rosengren (1998) examined the wave of bank consolidations in the 1990's and its effect on small business lending. Using a panel of small business loan data from second quarter CALL reports, they regressed the ratio of small business loans to assets on on vectors of explanatory variables. These vectors combined merger related variables, regional banking market variables and bank-specific characteristics. They found that mergers result in an initial fall in small business lending. They also found that assets, leverage ratio, return on assets, loan to asset ratio and return on assets were all negatively correlated with small business lending. The authors conclude that *ceteris paribus*, acquiring banks tend to alter small-business lending to partially offset the shock to their portfolio's share of small business loans. Over the long run, the size of the acquiring bank is not the major determinant of whether or not the merged bank will lend aggressively to small firms. The major determinant is the extent to which the acquiring bank is already committed to small business lending. This suggests that when small or mid-sized banks acquired smaller banks, they retained a proclivity to loan to small firms.

Similar results were found by Strahan and Weston (1998). They again used CALL report data to examine the effects of mergers among banks of different sizes. They found

that when mergers occur, the ratio of small business lending to assets increases until banks reach about \$300 million in assets. Larger banking companies also see a rise in small business lending, but this happens slowly enough that such loans decline in importance in the portfolio. They also find that consolidation of small banks tends to increase small business lending while other sorts of mergers have little effect.

Williams and Gardener carried out an empirical study on European bank deregulation and market segmentation. Their goals were to quantify the level of X-inefficiency (the difference between efficient behavior prescribed by economic theory and observed behavior) and the importance of factors believed to explain intra-industry inefficiency. They found that cost efficiency is positively related to bank size, except in the case of the largest banks. They found that when the market became segmented, regional banks were 93% cost efficient. Overall, they found that a two-tiered banking system is efficient and that mutual banks would not benefit from becoming joint-stock banks. This reflects a need for regulators to control banks' moral hazard incentives.

Berger and Udell (1995) examined the price and non-price terms of lines of credit extended to small firms. Using data from the National Survey of Small Business Finances (NSSBF), they found that borrowers with longer banking relationships paid lower interest rates and are less likely to put up collateral. One of the particularly interesting features of the NSSBF is that interest rate information is included so that the authors could create a premium over the prime rate variable. There were also data on the relationships between firms and banks such as the number of years that the firm has been doing business with the bank and the number of years that the current owners have owned the firm. Their results were consistent with the literature as it stood in 1994.

The same authors updated their framework in Berger and Udell (2006). They point out that a framework of having large banks lend to informationally transparent borrowers and small banks carrying out relationship lending with opaque borrowers is too simple. They warn that transactions lending is not a homogeneous technology. Lending on the basis of

credit scores, financial statements, leasing, etc. encompasses different technologies. Furthermore, they integrate government policies into the framework. For example, increased government oversight of banks is widely agreed (e.g. Berger and Udell (1995) and Peek and Rosengren (1998)) to have led to the “credit crunch” of the early 1990’s when banks reduced lending to firms. Ultimately, they call on researchers to separate out lending technologies and test their effects individually.

Cole, et. al. (2004) extend this theme in a comparative study of the lending behavior of large and small banks. In their introduction they note that in the period between 1980 and 2001, the number of commercial banks declined 40% which has led to a concentration of assets in larger banks. Since larger banks lend a smaller fraction of their assets to small firms, this leads to the credit constraints that small firms experience. In studying the resulting lending and borrowing behavior, the authors use the 1993 National Survey of Small Business Finance (NSSFB) to test the hypothesis that formal financial data from a loan applicant better explain the lending decisions of large banks than of small banks. In other words, formal financial data better explain a “cookie cutter” approach to lending.

What is particularly noteworthy about Cole, et. al. (2004) is that they run into a problem that this dissertation shares: there was no theoretical or empirical literature available, at the time they wrote this paper, on why firms choose a large bank or a small bank. The authors hypothesize that a firm that is better able to supply hard information would seek a loan from a larger bank. If character and relationships are the basis of the loan, then the firm should seek a loan from a smaller bank. Although the authors include variables, such as, an index of completeness of records, firm size, firm age and other measures of the maturity of the firm and owners, the lack of literature made the authors unsure of the expected signs on these regressors.

Berger et. al. (2005) use Stein’s (2002) model as a basis for an empirical investigation of large and small bank lending practices. They have six results. First, large banks are more likely to loan to large firms or to firms that have very detailed accounting records. These

are examples of large banks relying on hard information. Second, the authors find that the distance between the branch office that issues a particular loan and the firms it lends to increases with the size of the bank. Third, firms do business with large banks in more impersonal ways than with smaller banks. Such firms are more likely to use mail, telephone or Internet means to communicate with large banks. Fourth, business relationships between a firm and a bank last longer with a smaller bank. Fifth, this business relationship tends to be more exclusive with a smaller bank. Finally, they find that small firms that borrow from large banks are more prone to repay their loans late. The authors argue, that firms that are forced to seek loans from large banks are particularly credit constrained.

How do small banks contribute to community development? Scott (2004) did an empirical study on this question. His data came from the 2001 Credit, Banks and Small Business Survey (CBSB) collected by the National Federation of Independent Business (NFIB). The survey includes a set of characteristics that are related to a business owner's relationship with the firm's bank. Respondents ranked such characteristics as, "knows you and your business," or, "is a social contact." These rankings were combined to form an instrument for soft information production. This was used as the dependent variable in a regression on independent variables such as the Herfindahl-Hirschman Index, whether or not the bank is in a Metropolitan Statistical Area and the age of the relationship. Also, financial variables such as assets, and whether or not the firm had a loan denied by the bank were included. The results suggest that Community Financial Institutions (banks with an average of \$500 million in assets or less over three years) do have a niche market for lending to small firms.

Does bank competition promote regional development? De Guevara and Maudos (2009) examined the effect of regional financial development and bank competition on the growth of firms. Although their sample was drawn from Spain, much of the work should apply in any OECD country. They ran regressions of firms' sales growth on a number of variables relating to financial development while controlling for effects from their industry sector or their province. Their measure of bank competition was a Lerner index which measured

market concentration. Their measure of financial development was the ratio of private credit to provincial GDP. Their measure of external (to the firm) financial dependence can be expressed as

$$\frac{\textit{Interest bearing debt}}{[\textit{Stockholders Equity} + \textit{Interest bearing debt}]}$$

De Guevara and Maudos' data came from the *Sistema de Análisis de Balances Ibéricos* database, the Bank of Spain and Spain's National Institute of Statistics. They found an "upside-down U" relationship between financial market power and a firm's sales growth. This means there is an optimal level of bank market power for enhancing regional economic growth. This is consistent with the relationship banking literature. If there is too much bank competition, then informationally opaque firms can be denied credit more often. Overall, it seems that intermediate monopolistic competition would be the best sort of bank market structure for enhancing growth.

This literature gives us some empirical results we may see in the modeling to come. First, according to Peek and Rosengren (1998) and Strahan and Weston (1998), we may see that when a larger bank takes over a smaller bank, we may see an initial decline in small business lending and that this decline will fade over time. We may also expect that smaller banks will have a comparative advantage in lending to SME's. We may see that the optimal banking market structure for community development is one in which a limited number of small banks exist to lend to SME's.

2.9 The Geography of Banking

Banks tend to cluster in the urban core and often agglomerate in a financial district. In other words, an agglomeration inside of an agglomeration. Even in small rural communities, this pattern often occurs as the local bank often sites itself in the business district of the town, a short distance from the city hall and other central buildings.

Also, there is a hierarchy of cities in terms of financial services. For example, New York can be considered the financial capital of the US. The financial industries of cities on the next tier, such as Chicago and Los Angeles are dependent on firms and markets based in New York. Yet this dependence is not total. Local and regional financial firms are headquartered in these cities. Cities on the next tier that are dependent on these second tier cities also demonstrate the same behavior. This repeats down the line until we get to the smallest towns.

There is evidence in the literature for these assertions. Several papers and books attempt to define a financial center. For the purposes of this dissertation, a financial center can be defined as a geographic agglomeration of financial institutions. Kindleberger (1974) points out that financial districts perform medium of exchange and store-of-value services over space rather than time. There are a number of financial centers and some are larger, both in terms of number of firms and in the volume of transactions, than others. Is there a hierarchy of financial centers?

It is possible to rank financial centers. Choi, et. al. (2000) ranked fourteen major cities as financial centers by counting the number of bank headquarters in each city plus the number of branches of banks from other cities. These numbers were put into a to-from matrix that demonstrates the interconnectedness of the financial markets of those cities. The paper goes on to theoretically justify the method with a gravity model. They found that New York is the leading financial center for the world with London and Hong Kong taking second and third place respectively. From Choi (2000), we see it is possible to organize cities into a hierarchy.

Gehrig (2000) identifies the “centripetal” and “centrifugal” forces that affect the agglomeration of banks into financial centers. The centripetal or center-seeking forces Gehrig identifies are economies of scale in the payment mechanism, information spillovers and the closely related competition in the labor market for financial experts and liquidity. Economies of scale in payments makes transactions between banks easier to settle. Even

in an age of electronic communications, there is still a considerable amount of paper that needs to be physically transferred from one bank to another.

When banks are in close physical proximity, it is easier for their agents to communicate (both formally and informally). Bankers can easily meet face to face to negotiate agreements on transactions and lending. During lunch and after work, the bankers are likely to meet in restaurants and bars and “talk shop.” Finally, there is a related centripetal force; that banks often hire away employees from other banks. By hiring employees from nearby banks, hiring banks can gain insight into the plans of their competitors. All of these situations lead to information exchange that would be less likely if banks were more widely spaced.

Liquidity might be the most important reason for banks being close together. Gehrig (2000) refers to work by Pagano that shows that risk-averse investors are more likely to invest in markets with more investors. A large number of investors diffuses the risk that a trade by any one investor would have a significant effect on the price of a given instrument.

Gehrig (2000) also identifies the centrifugal forces that push banks to separate. These are market access costs, rent seeking and local information. Market access costs consist of transportation costs as well as transaction costs that do not depend on distance such as licenses. If no other frictions are present, investors will always wish to trade in the most liquid market. If the market access costs are too high, this may not be practical. If market access costs are heterogeneous across markets, then one would think that traders would go to the lowest cost market. This is not necessarily true. Pagano (1989) found that large traders may gravitate to the higher cost markets. This is because the large traders can pay the costs while smaller traders cannot. This acts as a form of insurance against price fluctuations in the higher cost market.

Rent seeking is another important force for scattering financial institutions. Mostly, this is because rent seeking behavior can limit sovereign risk including tax policy. For example, much British banking has moved to the Cayman Islands. The Caymans are a

British protectorate and thus under British banking laws but banks receive more favorable tax treatment there than in the British Isles. Furthermore, rent seeking can be closely tied to market access costs. Existing banks can lobby for changes to taxes and banking laws to make it harder for competition to move into the market.

The third centrifugal force is local information. Since economic activity is spread across space, then information about economic activity, policies and tastes is spread across space. While such information can be collected and distributed, such information collection would be costly. In the international investment literature, such as Brennan and Cao (1997), there is evidence that investors see imperfect information as imparting higher risk to an investment. This would seem to hold to a smaller degree in interstate and inter-regional investing. Furthermore, if prices do not perfectly transmit information, then an investor may need to go to the region and observe the price setting process. Local information would seem to be part of the reason we see branching and the establishment of local banks.

Driffill (2003) reviewed the state of the finance and growth literature. Of particular interest to this dissertation are his comments on increasing returns and economic geography. He was concerned that the studies up to that time had both short time horizons and did not control for increasing returns and agglomeration. These issues imply that the empirical finance and growth literature may be picking up growth due to economies of agglomeration or falling transport costs. This, in turn, implies that a core-periphery may disentangle these issues.

Now we have evidence for the forces that disperse banking activity throughout the market, instead of letting it agglomerate in the core. We can then “collapse” the hierarchy. This lets us treat the city at the top of the tree or subtree as a core region. We can then treat the subsequent branches as the periphery. This would allow an attack on the local finance and growth problem by way of a New Economic Geography model.

2.10 Conclusions From the Literature

The literature gives us a number of stylized facts and predictions to carry forward into the dissertation. The literature suggests that financial development is correlated positively with growth. We also see that financial development improves new firm formation, which is a major channel of growth. We can expect that this effect is heterogeneous over geography. This recommends a monopolistic competition framework for modeling markets. This suggests that a Krugman-Fujita type core-periphery framework would be useful in developing a theoretical model and that tests for spatial effects would need to be included in any empirical tests.

Banks are an important source of finance for SME's. The literature also indicates that smaller, local banks have a comparative advantage in lending to SME's. The literature also suggests that having large multi-state banks move into the region may slow business growth in the short-run. In the long-run, having a larger bank move into the region may have a small effect on growth.

Chapter 3 Theoretical Model

3.1 Introduction

As seen in chapter two, a growing body of literature suggests that the level of development in the financial industry is correlated with higher rates of growth. Still, a literature search did not reveal a theoretical model to explain how this might work at the state or county level. To develop such a model, geography must be explicitly considered. This suggests that the New Economic Geography might be useful in modeling growth and financial development at the sub-national level. Even though these models do not explicitly deal with distance, they do deal with contiguity, which is a good start on the problem.

New Economic Geography (NEG), a.k.a. Krugman-Fujita, models are a flexible interpretation of the core-periphery literature. Myrdal's (1957) Spread-Backwash model is an early example. If a region is has already had some development, then new projects will gravitate to that region and will tend to bypass less developed regions. This is known as backwash. As the developed region grows and needs to import resources, it will "spread" out development to other regions. Walter Isard's book, *Location and Spatial Economy* (Isard, 1956), proposed a theory of agglomeration that also dealt with transportation costs and increasing returns much like the Krugman-Fujita model. Furthermore, input-output models, brought into Regional Science by Isard, can be configured as a multi-region core-periphery model. Since then, the core-periphery idea has passed into common usage in discussions that combine economics and geography.

The plan of the chapter is to first develop a simple model of a regional banking market using non-geographic arguments. After that, a fully developed New Economic Geography model is proposed. The appendices to the dissertation provide a review of New Economic Geography models for the non-specialist.

3.2 A Two Region Model of Banking, Growth and Agglomeration

Imagine a core-periphery structure with an urbanized core and rural periphery. Let both regions be counties or clusters of counties in the same state so that both share identical banking regulations. The lending market in region 1 (the urbanized core) has large banks that dominate the market and smaller banks that operate on the competitive fringe. Region 2, the rural periphery, has only the smaller variety. Since small banks can only make small loans, a resident of region 2 who wishes to take out a large loan must either string together loans from small banks, get a loan from a large region 1 bank or some combination of the two.

Martin and Ottaviano (2001) proposed an economic geography model that emphasizes location, agglomeration and growth. In that model, an innovator creates a new variety of the “manufactured” or monopolistically competitive good and then creates a new firm to produce that new variety. By adding a banking sector to this model, we can transform the Martin and Ottaviano model into one that reflects the finance-growth nexus in a multi-regional context.

Framework

There are two regions, called region 1 and region 2. There are two goods. There is a homogeneous good, A, and a variegated good M. In this class of model, good A is traditionally assumed to represent some agricultural good while good M is traditionally assumed to be a manufactured good. Good A has a perfectly competitive market. The market for M operates under Dixit-Stiglitz monopolistic competition (Dixit and Stiglitz, 1977) with j substitutable varieties of M. Firms that manufacture varieties of M operate under increasing returns (Krugman, 1991). For simplicity’s sake, we can assume that each firm in the M market produces only one variety. In region 1, there are n firms, each producing one variety of the M good. In region 2, there are n^* firms that again produce one variety of M each. The total number of firms in both regions is $N = n + n^*$.

In addition, we model trade frictions in the M market by making M an iceberg good (Samuelson, 1954). To supply one unit of the M good to the other region, τ units must be shipped. 1 unit arrives while $\tau - 1$ units “melt” in transit.

Consumers are infinitely lived and have the continuous time utility function

$$\int_0^{\infty} \log [M^\alpha A^{1-\alpha}] e^{-\rho t} dt \quad (3.1)$$

where α is the fraction of income spent on good M and ρ is the rate of time preference.

The demand function for all varieties of M is

$$M(t) = \left[\sum_{j=1}^{N(t)} M_j(t)^{1-\frac{1}{\sigma}} \right]^{1/(1-\frac{1}{\sigma})} \quad (3.2)$$

where $M_j(t)$ is the quantity demanded of the j th variety of good M and σ is both the own price elasticity of demand for the j th variety of M and the elasticity of substitution between varieties.

The consumer’s expenditure function in region 1 is

$$E = \sum_{j=1}^n p_j M_j + \sum_{m=n+1}^N \tau p_m M_m + p_A A \quad (3.3)$$

where m indexes all varieties but the j th variety. A similar expenditure function exists for region 2.

Under long-term equilibrium,

$$p = p^* = \frac{w\beta\sigma}{\sigma-1} \quad (3.4)$$

Note the inverse-elasticity pricing of the M good.

Solving the utility maximization problem yields the following demand functions:

$$M_j = \frac{\alpha(\sigma-1)}{w\beta\sigma} \frac{E}{N(\gamma(1-\gamma)\delta)} \quad (3.5)$$

$$M_m = \frac{\alpha(\sigma - 1)}{w\beta\sigma} \frac{\tau^{-\sigma}E}{n(\gamma(1 - \gamma)\delta)} \quad (3.6)$$

$$A = (1 - \alpha)E \quad (3.7)$$

where, M_j is the demand for region 1's output of the j th M good in region 1 and M_m is the demand for region 1's output of the m th good in region 2. The price of good A is made numeraire. $\gamma = \frac{n}{N}$ is the fraction of firms producing some variety of M in region 1. $\delta = \tau^{1-\sigma}$ is a measure of trade h. Demand functions in region 2 take identical forms.

Each firm in the M market earns a profit of

$$\pi = px - wx = \frac{w\beta x}{\sigma - 1} \quad (3.8)$$

in region 1. A similar function holds in region 2. Under long run equilibrium, $p = p^* = w = w^*$.

The growth mechanism in this model is marginal innovation. The innovation mechanism is expanded from that in Martin and Ottaviano (2001). The innovations in this case may be very small improvements or modifications to existing varieties of the M good. The candidate entrepreneur borrows the cost of innovation, F , from the bank. The inputs to the innovation process are a composite good made of all varieties of the M good and labor. Once the innovation process is complete, the innovator becomes an entrepreneur and opens a firm to produce and sell the new variety of M. Innovators get the money to cover innovation costs from their own assets, A and from one or more banks. Let there be B banks in region 1 and B^* banks in region 2. The banks sell loans off of their deposits. This makes the loan portfolio the bank's output for purposes of the profit function.

Even though the notation for interest rates is simplified. It is worth noting how the interest rates are decomposed. There are two loan markets. There is the lower risk inter-bank lending market and the more risky business lending market. The interest rate in the inter-bank market is i_f . The interest rate in business lending is constructed from several

components. First is the prime lending rate for the bank's best customers, i_p . More risky customers are charged a risk premium, i_π . i_f is subtracted to account for the opportunity cost of business lending instead of safer inter-bank lending. i_d is the fee per dollar lent due to distance from the bank. This reflects increased monitoring costs and lack of information about distant locations. In this model, i_d is charged on loans to firms in the other region. Overall, the interest rate on a loan within the bank's own region is $R_{11} = R_{22} = 1 + i_p + i_\pi - i_f$. The interest rate on a loan from region 1 to region 2 is $R_{12} = 1 + i_p + i_\pi + i_d - i_f$. Since region 2 is less agglomerated, we assume all banks in region 2 are small and they do not loan to region 1 which has bigger, more capable banks.

We can now dispense with MC_{L1} and MC_{S1} and devise a more complete cost function for the bank. The bank profit function described here borrows from Neo-Schumpeterian models such as those found in Aghion and Howitt (1997). Each bank has ψ_i employees in region 1 and ψ_j employees in region 2 who earn wages w (just like everyone else in the economy.) The number of employees, ψ , depends on the amount of deposits and on the level of necessary human capital. Small banks with limited operations need workers with less human capital, H_L . Large banks with a myriad of operations require the higher level of human capital, H_L . So, the bank's fixed costs are $w\psi_i$. If Φ is the fraction of deposits, D_i , loaned to businesses, then the i th bank in region 1 has output $\Phi_i D_i$. A bank in region 2 has output $\Phi_i^* D_i^*$. $q(B)$ is the probability that a bank in region 1 will write a loan to a borrower. $q(B^*)$ is the probability that a bank in region 2 will write a given loan. The loan will be of size $\lambda_i \Phi_i D_i$. The bank has a fraction Λ of its loan portfolio invested in its own region and $1 - \Lambda$ in the other region.

The profit function for a bank in region 1 is

$$\Pi_L = [\Lambda(1 + i_{11}) + (1 - \Lambda)(1 + i_{12})]\Phi D_i - w\psi(D_i, H_L) \quad (3.9)$$

for a large bank and

$$\Pi_S = [\Lambda^*(1 + i_{22}) + (1 - \Lambda^*)(1 + i_{21})]\Phi^*D_i^* - w\psi_i(D_i, H_S) \quad (3.10)$$

for a small bank. In region 2,

$$\Pi^* = [\Lambda^*(1 + i_{22}) + (1 - \Lambda^*)(1 + i_{21})]\Phi^*D_j^* - F_j^* - w\psi_j(D_j, H_S) \quad (3.11)$$

where Λ is the fraction of a region 1 bank's loans to region one and Λ^* is the fraction of the region 2 bank's loans written to region 2. All banks in region 2 are assumed to be small banks. In the steady state $\Pi_L = \Pi_S = \Pi^* = 0$.

So, if the borrower from region 1 seeks loans in both regions, he or she will borrow $\sum_{i=1}^B q(B)\lambda_i\Phi_iD_i + \sum_{j=1}^{B^*} q(B^*)\lambda_j\Phi_j^*D_j^*$. The steady-state cost to that borrower will be

$$C = \theta R_{11} \left(\sum_{i=1}^B q(B)\lambda_i\Phi_iD_i \right) + (1 - \theta) \left(\sum_{j=1}^{B^*} q(B^*)\lambda_j\Phi_j^*D_j^* \right). \quad (3.12)$$

where θ is the fraction of innovation costs, F , borrowed from the banks in region 1 and $(1 - \theta)$ is the fraction of F borrowed from banks in region 2. If we further stipulate that borrowers from region 1 do not seek loans in region 2 since region 1 is more financially developed, then the cost of borrowing for a region 1 borrower becomes

$$C = R_{11} \left(\sum_{i=1}^B q(B)\lambda_i\Phi_iD_i \right) \quad (3.13)$$

We will assume (3.13) to be the case for the remainder of the discussion.

The steady state cost of borrowing to the innovator in region 2 is

$$C^* = \theta R_{22} \left(\sum_{j=1}^{B^*} q(B^*)\lambda_j\Phi_j^*D_j^* \right) + (1 - \theta)R_{12} \left(\sum_{i=1}^B q(B)\lambda_i\Phi_iD_i \right), \quad (3.14)$$

where θ is the fraction of innovation costs, F^* , borrowed from the banks in region 2 and $(1 - \theta)$ is the fraction of F^* borrowed from banks in region 1.

Let A be the amount of other assets the innovator invests in the new firm which makes up a fraction, φ , of the total investment. If our innovator borrows $(1 - \varphi)$ of F from the banks, then the total steady state cost of innovation is

$$F = \varphi A + (1 - \varphi)C = \varphi A + (1 - \varphi)R_{11} \left(\sum_{i=1}^B q(B)\lambda_i \Phi_i D_i \right) \quad (3.15)$$

$$F^* = \varphi A + (1 - \varphi)C^* = \varphi A + (1 - \varphi)\theta R_{22} \left(\sum_{j=1}^{B^*} q(B^*)\lambda_j \Phi_j^* D_j^* \right) \quad (3.16)$$

$$+ (1 - \varphi)\theta R_{22}(1 - \theta)R_{12} \left(\sum_{i=1}^B q(B)\lambda_i \Phi_i D_i \right)$$

Equilibria, Agglomeration and Bank Location

Banks in both regions.

There are multiple equilibria in this model. The first equilibrium condition involves banking in both regions and innovation in region 1. Note that innovation occurs in both regions if and only if $F = F^*$. If, $F < F^*$, then all innovation occurs in region 1 since innovation is less expensive in region 1. Likewise, if $F > F^*$, then all innovation occurs in region 2 for the same reason. The equilibrium outputs are

$$x = \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left(\frac{E}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}} + \frac{E^*\delta}{N[(\delta + 1) - \gamma]} \right) \quad (3.17)$$

$$+ \frac{\sigma - 1}{2w\beta\sigma} \frac{[\varphi A + (1 - \varphi)R_{11} (\sum_{i=1}^B q(B)\lambda_i \Phi_i D_i)] \dot{N}}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}}$$

$$+ \frac{\sigma - 1}{2w\beta\sigma} \frac{[\varphi A + (1 - \varphi)R_{11} (\sum_{i=1}^B q(B)\lambda_i \Phi_i D_i)] \dot{N}\delta}{N[1 - \gamma + \gamma\delta]}$$

and

$$x^* = \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left(\frac{E\delta}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}} + \frac{E^*}{N[\delta + (1 - \gamma)]} \right) \quad (3.18)$$

$$\begin{aligned}
& + \frac{\sigma - 1}{2w\beta\sigma} \frac{\varphi A + (1 - \varphi) \left[\theta R_{22} \left(\sum_{i=1}^{B^*} q(B^*) \lambda_i \Phi_i^* D_i^* \right) \right] \dot{N}}{N \{ \gamma [\gamma + (1 - \gamma) \delta] \}} \\
& + \frac{\sigma - 1}{2w\beta\sigma} \frac{\varphi A + (1 - \varphi) \left[(1 - \theta) R_{12} \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) \right] \dot{N}}{N \{ \gamma [\gamma + (1 - \gamma) \delta] \}} \\
& + \frac{\sigma - 1}{2w\beta\sigma} \frac{\varphi A + (1 - \varphi) \left[\theta R_{22} \left(\sum_{i=1}^{B^*} q(B^*) \lambda_i \Phi_i^* D_i^* \right) \right] \dot{N} \delta}{N [1 - \gamma + \gamma \delta]} \\
& + \frac{\sigma - 1}{2w\beta\sigma} \frac{\varphi A + (1 - \varphi) \left[(1 - \theta) R_{12} \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) \right] \dot{N} \delta}{N [1 - \gamma + \gamma \delta]}
\end{aligned}$$

If operating costs are the same in both regions, then $x = x^*$. We then set (3.16) and (3.17) equal to each other and solve for γ :

$$\gamma = \frac{\alpha L (E^W [(1 + \delta) \varepsilon - \delta] + (1 - \delta) g N)}{(1 - \delta) \left\{ \alpha L E^W + 2gN \left[\varphi A + (1 - \varphi) R_{11} \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) \right] \right\}}. \quad (3.19)$$

and

ε is region 1's share of expenditures which is also the distribution of property rights on patents. $E^W = E + E^*$ is total expenditures in both regions and $g = \frac{\dot{N}}{N}$ is the growth rate of new firms and therefore the growth rate of the economy. It should also be noted that for this system to be solvable, μ must be equal to zero. In other words, there must be no externality to one region for the other region's innovations.

In either case, the equilibrium size of firms will be

$$x = \frac{\sigma - 1}{w\beta\sigma} \left\{ \alpha L \frac{E^W}{N} + \left[\varphi A + (1 - \varphi) R_{11} \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) \right] g \right\} \quad (3.20)$$

where F is defined in (3.14).

Finally, per Martin and Ottaviano (2001), the growth rate, that is the rate at which new firms are added to the economy of both regions is given by

$$g = \frac{\alpha L E^W}{(\sigma - 1) \left[\varphi A + (1 - \varphi) R_{11} \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) \right]} - \frac{\rho \sigma}{\sigma - 1}. \quad (3.21)$$

A bank in region 1 only.

This case represents a region in which banks are clustered in an urban core. The periphery has no banks, so borrowers must seek financing from the other region.

First, the equations for the cost of innovating have changed since the lending environment has changed. Now,

$$F = \varphi A + (1 - \varphi)R_{11} \left[\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i \right]. \quad (3.22)$$

and

$$F^* = \varphi A + (1 - \varphi)R_{12} \left[\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i \right]. \quad (3.23)$$

If innovation occurs in both regions, then $F = F^*$. This can only occur if $R_{11} = R_{12}$. This means that if the banks in region 1 have no competition from banks in region 2, then innovation can only occur in region 2 if the region 1 banks charge exactly the same rate of interest they would if they did have competition. If region 1 banks find it necessary to charge a higher interest rate to region 2 borrowers, then region 2 will starve for debt financing for new firm development. This is also a reason to for a region 1 bank to open a branch in region 2. With a local presence, the bank can set $R_{11} = R_{12}$ and remain profitable since extra costs involved in cross-border lending would be removed.

The equilibrium firm locations will be

$$\begin{aligned} x = & \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left(\frac{E}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}} + \frac{E^*\delta}{N[(\delta + 1) - \gamma]} \right) \\ & + \frac{\sigma - 1}{2w\beta\sigma} \frac{\{\varphi A + (1 - \varphi)R_{11} [\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i]\} \dot{N}}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}} \\ & + \frac{\sigma - 1}{2w\beta\sigma} \frac{\{\varphi A + (1 - \varphi)R_{11} [\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i]\} \dot{N}\delta}{N[1 - \gamma + \gamma\delta]} \end{aligned} \quad (3.24)$$

and

$$\begin{aligned}
x^* = & \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left(\frac{E\delta}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}} + \frac{E^*}{N[\delta + (1 - \gamma)]} \right) \\
& + \frac{\sigma - 1}{2w\beta\sigma} \frac{\{\varphi A + (1 - \varphi)R_{11} [\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i]\} \dot{N}}{N\{\gamma[\gamma + (1 - \gamma)\delta]\}} \\
& + \frac{\sigma - 1}{2w\beta\sigma} \frac{\{\varphi A + (1 - \varphi)R_{11} [\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i]\} \dot{N}\delta}{N[1 - \gamma + \gamma\delta]}
\end{aligned} \tag{3.25}$$

So, since $F = F^*$,

$$\gamma = \frac{\alpha LE^W [(1 + \delta)\varepsilon - \delta] + (1 - \delta)gN}{(1 - \delta)(\alpha LE^W + 2gNF)} \tag{3.26}$$

or

$$\gamma = \frac{\alpha LE^W [(1 + \delta)\varepsilon - \delta] + (1 - \delta)gN}{(1 - \delta) \{ \alpha LE^W + 2gN [\varphi A + (1 - \varphi)R_{11} (\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i)] \}} \tag{3.27}$$

and

$$g = \frac{\alpha LE^W}{(\sigma - 1) [\varphi A + (1 - \varphi)R_{11} (\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i)] N} - \frac{\rho\sigma}{\sigma - 1} \tag{3.28}$$

Comparative Statics

First, the fraction of firms that site themselves in region 1 depends on the cost of innovation, so

$$\frac{\partial \gamma}{\partial F} = - \frac{\partial \gamma^*}{\partial F} = - \frac{\{ \alpha LE^W [(1 + \delta)\varepsilon - \delta] + (1 - \delta)gN \} (1 - \delta)2gN}{(1 - \delta)^2 (\alpha LE^W + 2gNF)^2}. \tag{3.29}$$

As the cost of innovating in region 1 increases, then firms will not choose to operate in region 1. In turn, F depends on a number of variables such as interest rates, the number of lenders and the entrepreneur's own assets..

The relationships between the fraction of firms in each region and interest rates can be found by taking derivatives of γ with respect to interest rates. Using (3.26) and the chain rule, we can get these comparative statics relationships on γ .

$$\frac{\partial \gamma}{\partial R_{11}} = - \frac{[\alpha L(E^W[(1+\delta)\varepsilon - \delta] + (1-\delta)gN)](1-\delta)2gN}{[(1-\delta)\{\alpha LE^W + 2gN[\varphi A + (1-\varphi)R_{11}(\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i)]\}]^2} \quad (3.30)$$

$$\times (1-\varphi) \left(\sum_{i=1}^B q(B)\lambda_i\Phi_i D_i \right) < 0$$

As the interest rate rises, the cost of funds for starting a new business rises and, *ceteris paribus*, fewer new businesses will start in region 1.

Of primary interest in this paper are internally generated forces that spur growth in the periphery. Recalling that $F = F^*$, and using the symmetry between the equations for γ and γ^* then

$$\frac{\partial \gamma^*}{\partial R_{22}} = - \frac{\alpha L\{E^W[(1+\delta)\varepsilon - \delta] + (1-\delta)gN\}(1-\delta)2gN}{\{(1-\delta)[\alpha LE^W + 2gNF]\}^2} \quad (3.31)$$

$$\times (1-\varphi)\theta \left(\sum_{j=1}^{B^*} q(B^*)\lambda_j\Phi_j^* D_j^* \right) < 0$$

since a rise in region 2 interest rates will divert firms to region 1. Also,

$$\frac{\partial \gamma^*}{\partial R_{12}} = \frac{\{\alpha LE^W[(1+\delta)\varepsilon - \delta] + (1-\delta)gN\}2gN}{[\alpha LE^W + 2gNF]^2} \quad (3.32)$$

$$\times (1-\varphi)(1-\theta) \left(\sum_{j=1}^B q(B)\lambda_j\Phi_j D_j \right) < 0$$

since borrowing across the border from region 1 banks will be more expensive for region 2 borrowers. Note that,

$$= (1-\theta) \frac{\partial \gamma}{\partial R_{11}} < 0$$

This implies that firm location decisions in region 2 are less sensitive to changes in interest rates in region 1 than firms in region 1. This is because there is some banking in region 2, so there are alternatives in financing.

The change in γ due to growth in the overall economy is given by

$$\begin{aligned} \frac{\partial \gamma}{\partial g} &= \frac{\alpha N L (1 - \delta)^2 [\alpha L E^W + 2gN (\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i)]}{\{(1 - \delta) [\alpha L E^W + 2gN (\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i)]\}^2} \quad (3.33) \\ &= -\frac{2N [\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i] (1 - \delta) [\alpha L (E^W [(1 + \delta)\varepsilon - \delta] + (1 - \delta)gN)]}{\{(1 - \delta) [\alpha L E^W + 2gN (\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i)]\}^2} > 0 \end{aligned}$$

if

$$\begin{aligned} &\alpha L (1 - \delta) \left[\alpha L E^W + 2gN \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) \right] \\ &> 2N \left(\sum_{i=1}^B q(B) \lambda_i \Phi_i D_i \right) (\alpha L \{E^W [(1 + \delta)\varepsilon - \delta] + (1 - \delta)gN\}) \end{aligned}$$

3.3 How Does the Model Apply to Rural Finance?

To go from a very abstract theoretical model to an application to rural finance is not as hard as it may first seem. Both regions taken together form a simple “town and country” configuration with region 1 being a developed urban core and region 2 being a rural periphery. An example of this is the assumption above that there are no large banks in region 2. The initial conditions can be set so that region 1 has a very high fraction of manufacturing and region 2 has a very high fraction of agriculture. Furthermore we will assume that there are more and bigger banks in region 1 than in region 2.

Recall that $\gamma + \gamma^* = 1$. So, if the entrepreneur decides to locate in region 2, then that can be thought of as agglomeration “taken” from region 1. So, *ceteris paribus*, anything that reduces γ improves γ^* . Therefore, higher interest rates in region 1, *ceteris paribus*, cause more firms to locate in region 2, the rural area.

Now, say that the home market of the firm is in region 2, the rural periphery. The urban core has more banks, which would increase $q(B)$, the probability of securing a loan. Also, D_i , an individual bank's deposit base is larger. This allows the firm to borrow more money. If the firm locates in the core, then it does not have to pay the distance premium in its interest payment. This would draw the firm into the urban core, or region 1. This plays against the home market effect, which would, *ceteris paribus*, have the firm set up in region 2. So, the choice problem boils down to the trade off between financial costs and transport costs between regions.

Overall, we see that a credit gap can occur if either the possible sizes of loans are too small so that $(\Phi_i D_i) \gg (\Phi_i^* D_i^*)$ or if interest rates including distance premia are too high so that $R_{22} \gg R_{11}$ or $R_{12} \gg R_{11}$. Either case would make borrowing in the periphery unattractive.

3.4 Conclusions

This chapter proposes a modification of the Martin and Ottaviano model to account for borrowing part or all of the cost of innovation from a bank. In particular, an equation concerning the sources of funds is substituted for Martin and Ottaviano's cost of innovation equation. If funded, the borrower will develop a new product and either open a new firm or expand an existing firm. This incorporates the Schumpeter Hypothesis. Under the model, the probability of acquiring funds is dependent on the number of banks in a region, which demonstrates the "Frank Capra" hypothesis. In addition, since there are non-zero costs to borrowing from another region, in the form of a higher interest rate, it is possible that some borrowers may go unfunded. This implies that there could be a credit gap that prevents the formation of new firms or the expansion of existing firms. To further test the model, there is need for empirical analysis of its predictions, which is the subject of chapter 4.

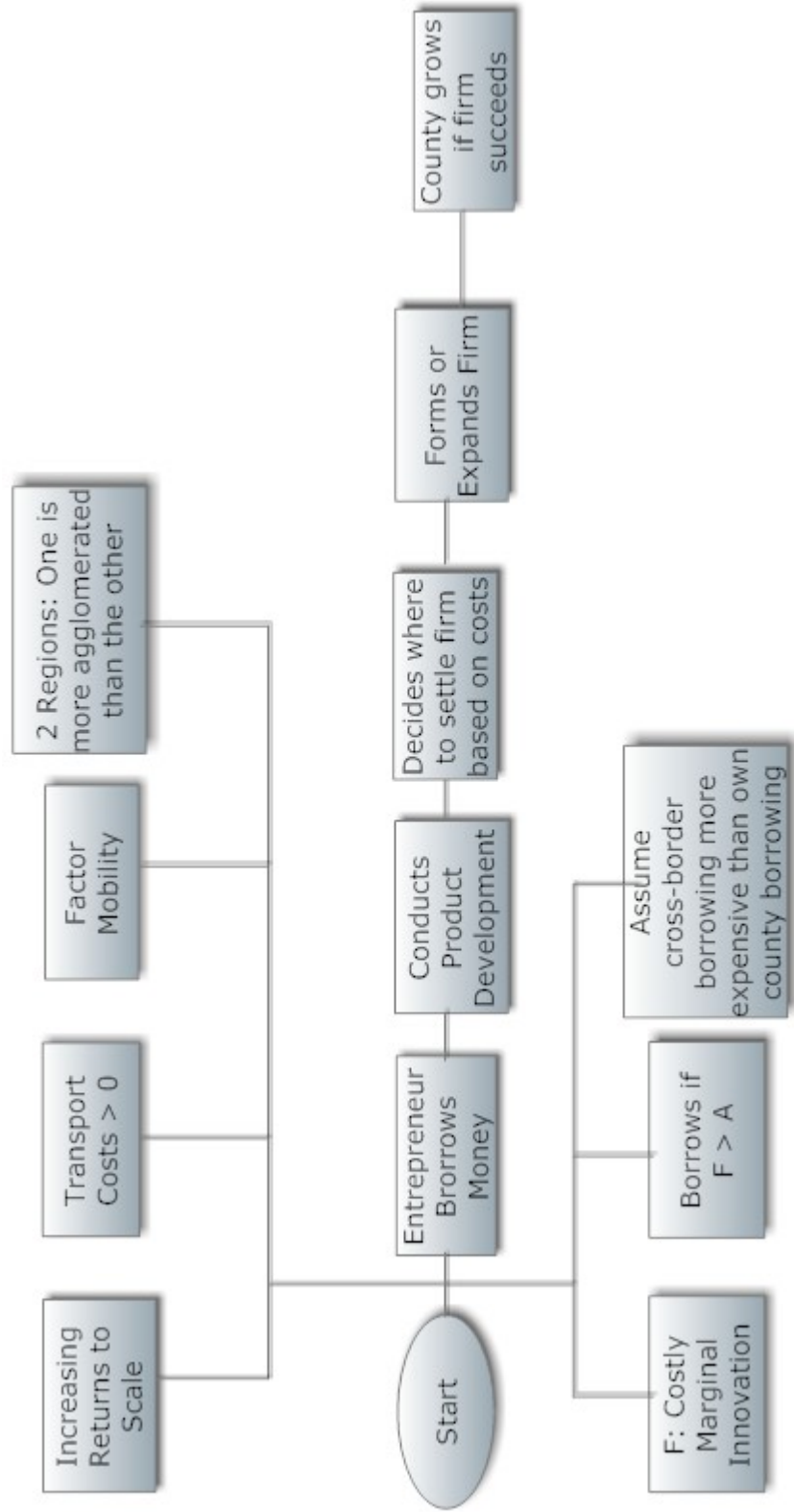


Figure 3.1: Flowchart of NEG Model

Chapter 4 Empirical Results

4.1 Introduction

This chapter reports the empirical findings of the research. The next section covers the data and variable definitions. Section 4.3 after that explains the empirical model. Section 4.4 reviews the issues of Nickel bias inherent in the model and how various Generalized Method of Moments (GMM) estimators solve those problems. Then come the estimates themselves. Section 4.5 covers simple equation-by-equation fixed effects estimates and equation-by-equation Blundell-Bond GMM estimates. Section 4.6 has results from an instrumental variables estimate that deals with the model as a system. Section 4.7 contains testing for spatial autocorrelation by Anselin's LISA test (Anselin, 1995). Section 4.8 features panel estimation with a spatial GMM estimator with instrumental variables that also accounts for the simultaneous model equations. This chapter ends with a summary of the results.

4.2 Data and Variables

The data consist of a balanced panel consisting of all 120 counties in Kentucky over 14 years. The dependent variable is a measure of income or per capita income. GDP for US counties is not easily obtained where it is calculated at all. The closest readily obtainable data are for personal income. This was not suitable since transfer payments are a sizable proportion of personal income in some counties. Furthermore, a measure of private sector growth should control for the presence of children, retirees and others not normally counted as workers. Still, we can learn about the key questions of this dissertation by working with earned income measures. These work well since earned income is a measure of the local ability to capture economic opportunity. The first variable under consideration here

is aggregate earned income which is the sum of proprietors' income and wage income in nominal dollars. The other is an earned income per worker variable which was constructed by dividing the above earned income variable by the sum of proprietor employment and wage employment. The numbers came from BEA's REIS (Regional Economic Information System). The variable was constructed for each county in each year by adding proprietors' income to workers' wages. This was divided by the sum of the number of proprietors and workers. This has the additional benefit of providing the means for computing income per proprietor and income per employee.

The usual macroeconomic measures of financial development, such as private sector investment or M2 as a fraction of GDP, are likewise not available or relevant for county level analysis. Deposits per bank branch are available. These were compiled from FDIC's Summary of Deposits dataset. Specifically, the data came from the June 30 release for the years 1995 through 2008. Then, deposits for each banking firm were summed within each county. This gives a measure of year-to-year changes in average total deposits for each county in each year. This dissertation focuses on deposits since a county's total bank deposits are an idle pool of liquidity. The bank also needs to transform its deposits from liabilities to assets. This makes the bank eager to lend from the pool of deposits. Also, the total funds banks have available for lending are a function of the total deposits. Since the banks determine who gets a loan from those deposits, a borrower's opportunity to open a new business or to expand an existing business is a function of the available deposits.

There are two possible effects from out-of-state banks. First, large, out-of-state banks can take advantage of the Riegle-Neal act to move into new communities, sweep up deposits and lend them in other regions with a higher marginal product of capital, which would be more efficient globally but may leave the home region with less financial capital for its own projects. On the other hand, if the region in question has a high marginal product of capital, then the large bank would have an incentive to bring outside financial capital to the region. How will a large bank evaluate these considerations? One function of a branch

is to collect information on local loan markets and to report that to headquarters. In an ideal system this information lead to an optimal allocation of funds. If this information is costly to collect or not perfectly transmitted, then the loanable funds may not be optimally allocated.

To test the allocation of loanable funds, a variable called BigShare was constructed. BigShare is the share of deposits in each county held by certain very large banking institutions such as JP Morgan Chase, Fifth-Third, PNC and other large international or “super-regional” banks. Since it takes some time for a bank to fully integrate itself into county after setting up a branch, BigShare is also lagged one period. BigShare doubles as a rurality measure. This is due to strong correlation with other rurality measures. In fact, in Kentucky, branches of large banks are found exclusively in counties in metropolitan areas. When explicit rurality measures such as dummy variables constructed from USDA Urban Influence Codes, were included in the dataset alongside BigShare, the regression matrices became singular, or at least computationally singular. It is an admittedly poor instrument for rurality, but the nature of the data forces it upon the estimations.

Population data came from the Kentucky State Data Center. The population variable consists of intercensal population estimates for each county except for the year 2000, in which Year 2000 Census is used. Population can explain growth in two ways. The level of population correlates with the level of agglomeration. *Ceteris paribus*, higher levels of agglomeration promote faster growth. Also, the population growth rate directly drives growth, since it measures the change in the number of economic agents and thus follows the size of county markets. GradRate is a rough estimate of high school freshman graduation rates from the US Department of Education’s Common Core of Data. This was computed by dividing the number of high school diplomas issued in a given year by the number of ninth-graders from four years earlier. This gives a measure of the county’s investment in human capital. Unemployment rates by county come from BEA’s REIS dataset, as do employment levels, wage income and proprietors income. Unemployment rates give us

some idea about how efficiently of the labor market, which is a correlate of growth. This gives us a measure of x-inefficiency in the county.

4.3 Empirical Model

The model generally follows the same growth regression pattern used in macroeconomics, such as those found in Barro and Sala-i-Martin (2003), Islam (1995) or Durlauf, Johnson & Temple(2005). Changes are made to conform the model to the smaller geography. In the case of Kentucky, this smaller geography consists of counties and clusters of counties. Kentucky, like so many states, especially in the eastern United States, has very small counties. This means that it is not uncommon to see workers commuting from several counties away. It is also common to see individuals shopping several counties away, which may not correspond to a long distance. This suggests that customers may often deal with banks outside their own county or with multiple branches of the same bank. This implies a likelihood of spatial autocorrelation.

First we need a dependent variable that measures growth. Our first candidate dependent variable are the level of earned income, which is found by adding proprietors' income and wage income. The second dependent variable to be tested is earned income level divided by the number of proprietors plus the number of wage workers. In other words, income per worker. Either way, we can begin by defining growth as the ratio of the current level of the dependent variable to its lagged value, y_{it}/y_{it-1} . Next log these to get

$$\ln \frac{y_{it}}{y_{it-1}} = \ln y_{it} - \ln y_{it-1}.$$

There are now two possible choices. This relation can go on the left hand side of the model equation for a first differences estimator or the lagged value can move to the right hand side of the model equation to form a dynamic model. This dissertation takes the second option since it makes explicit the time evolution of the dependent variable, which is a direct measure of how past growth influences current growth.

The other variables are not so straightforward. Even though there is guidance about what variables to use, there is little guidance on lags. When one considers that business growth is a result of multi-year decision processes, multi-period lags may be needed. The hypotheses give some guidance on the expected signs of the parameters. First, the growth variable is hypothesized to be positively correlated with the financial development variable. This means that the sign of the parameter for deposits should be positive in the current and lagged periods. The sign could be negative if the deposited cash could be more efficiently used (from the region's point of view, not necessarily the depositor's) in consumption. The presence of lagged values for deposits may be misleading. Banks try to put deposits to work as quickly as possible. So, levels of deposits above legal minimums may not be correlated in time, making lags moot. Population growth is positively correlated with economic growth because it is a measure of growth in the size of the economy, so its signs should be positive. The high school graduation rate should yield a positive sign since it gives us an idea about the community's investment in human capital production. The unemployment rate should yield a negative sign. There is no guidance on the sign on *bigshare*. As noted above, big banks offer additional capital and could drive growth. On the other hand, these banks may be more interested in collecting deposits to invest elsewhere. This would lead to capital leaving the region, thus slowing growth. So the regression is being asked to give us evidence in that debate.

The model is a dynamic panel structural equations model

$$\begin{aligned}
 \ln pwinc_{it} = & \alpha_0 + \alpha_1 \ln pwinc_{it-1} + \alpha_2 \ln deposits_{it} + \alpha_3 \Delta \ln population_{it} \\
 & + \alpha_4 bigshare_{it} + \alpha_5 gradrate_{it} + \alpha_6 unemprate_{it} \\
 & + \alpha_7 year dummies_t + \epsilon_{it}
 \end{aligned} \tag{4.1}$$

$$\ln deposits_{it} = \beta_0 + \beta_1 \ln deposits_{it-1} + \beta_2 \ln pwinc_{it} + \beta_3 \ln population_{it}$$

$$+\beta_4 transfrac_{it} + \beta_5 yearummies_t + \zeta_{it} \quad (4.2)$$

where $\varepsilon_{it} = \rho\varepsilon_{it-1} + \mu_{it}$, $\zeta_{it} = \rho\zeta_{it-1} + \mu_{it}$ and where $\ln pwinc_{it}$ is the logged level of earned income per worker. The lagged value of $\ln pwinc_{it-1}$ allows differencing of earned per worker and therefore introduces growth in earned income per worker. $\ln deposits_{it}$ is the level of bank deposits in county i in nominal dollars. $\Delta \ln population_{it}$ is the growth rate of population and $bigshare_{it}$ is the fraction of deposits in large, out of state banks. $gradrate_{it}$ is an index of high school completion rate computed by dividing the number of high school diplomas awarded in a particular year by the number of high school freshmen in the school year ending in period $t - 3$ for county i . $unemprate_{it}$ is the unemployment rate for county i and period t . $transfrac_{it}$ is the fraction of county i 's personal income composed of government transfers. Yearly dummy variables are also included to facilitate fixed effects and GMM estimates. Also ε_{it} is the disturbance for equation (1) and ζ_{it} is the disturbance for equation (2). μ_{it} is the purely random component of the disturbances.

An alternative model is

$$\begin{aligned} \ln wrkinc_{it} = & \gamma_0 + \gamma_1 \ln wrkinc_{it-1} + \gamma_2 \ln deposits_{it} + \gamma_3 \Delta \ln population_{it} \\ & + \gamma_4 bigshare_{it} + \gamma_5 gradrate_{it} + \gamma_6 unemprate_{it} \\ & + \gamma_7 yearummies_t + \varepsilon_{it} \end{aligned} \quad (4.3)$$

$$\begin{aligned} \ln deposits_{it} = & \delta_0 + \delta_1 \ln deposits_{it-1} + \delta_2 \ln wrkinc_{it} + \delta_3 \ln population_{it} \\ & + \delta_4 transfrac_{it} + \delta_5 yearummies_t + \zeta_{it} \end{aligned} \quad (4.4)$$

where $\varepsilon_{it} = \rho\varepsilon_{it-1} + \mu_{it}$ and $\zeta_{it} = \rho\zeta_{it-1} + \mu_{it}$.

Here, $wrkinc_{it}$ is the level of earned income and is the sum of proprietors' income and wage income.

Another measure of financial depth is the ratio of deposits to personal income. This is analogous to the M2 or M3 to GDP ratios found in the macroeconomic finance and growth literature. If $depfrac$ is the level of deposits divided by the level of personal income, then

$$\begin{aligned} \ln pwinc_{it} = & \alpha_0 + \alpha_1 \ln pwinc_{it-1} + \alpha_2 \ln depfrac_{it} + \alpha_3 \Delta \ln population_{it} \\ & + \alpha_4 bigshare_{it} + \alpha_5 gradrate_{it} + \alpha_6 unemprate_{it} \\ & + \alpha_7 yearummies_t + \varepsilon_{it} \end{aligned} \quad (4.5)$$

$$\begin{aligned} \ln depfrac_{it} = & \beta_0 + \beta_1 \ln depfrac_{it-1} + \beta_2 \ln pwinc_{it} + \beta_3 \ln population_{it} \\ & + \beta_4 transfrac_{it} + \beta_5 yearummies_t + \zeta_{it} \end{aligned} \quad (4.6)$$

where $\varepsilon_{it} = \rho \varepsilon_{it-1} + \mu_{it}$ and $\zeta_{it} = \rho \zeta_{it-1} + \mu_{it}$

$$\begin{aligned} \ln wrkinc_{it} = & \gamma_0 + \gamma_1 \ln wrkinc_{it-1} + \gamma_2 \ln depfrac_{it} + \gamma_3 \Delta \ln population_{it} \\ & + \gamma_4 bigshare_{it} + \gamma_5 gradrate_{it} + \gamma_6 unemprate_{it} \\ & + \gamma_7 yearummies_t + \varepsilon_{it} \end{aligned} \quad (4.7)$$

$$\begin{aligned} \ln depfrac = & \delta_0 + \delta_1 \ln depfrac_{it-1} + \delta_2 \ln wrkinc_{it} + \delta_3 \ln population_{it} \\ & + \delta_4 transfrac_{it} + \delta_5 yearummies_t + \zeta_{it} \end{aligned} \quad (4.8)$$

where $\varepsilon_{it} = \rho \varepsilon_{it-1} + \mu_{it}$ and $\zeta_{it} = \rho \zeta_{it-1} + \mu_{it}$.

Each set of equations has its appeal. Earned income per worker measures the ability of workers to capture economic opportunity while the level of earned income is an instrument for total county income. The level of deposits measures the size of the banking industry while the ratio of deposits to personal income is a measure of financial depth in the county

economy. The fraction of deposits in large banks measures the influence of large out-of-state banks on the local economy. By coincidence, this variable is collinear with measures of rurality since, in Kentucky, all such banks are in metropolitan areas. The only way to choose between these specifications is to estimate them all and then compare them.

4.4 Estimation Techniques

A panel with 14 years and a lagged dependent variable poses interesting estimation challenges. Generally, microeconomic panel data tend to be very short panels which require elaborate estimators that have the correct finite sample properties. Macroeconomic panels tend to have enough years that time series techniques are useful. 14 years is not particularly short or long. Fortunately, the empirical political science literature has many examples of panels of this size. Beck and Katz (2011) is a survey of methods suited to “medium-sized” panels.

The plan for the empirical analysis is designed to examine the different compromises required by both the nature of the data and the current state of the art in panel data econometrics and econometric software. Efficiency is a secondary concern since theory gives little guidance on what the parameter estimates should be. More important is to get consistent and reasonably unbiased estimates that will hopefully get the right signs on the parameter estimates. There is no perfect estimator, but rather a collection of estimators that each correct some problems, but not all. By using several different estimators, we can get a good idea of the signs on the parameters of the model. The first step is to get equation-by-equation fixed effects estimates. This is the simplest available estimator and will serve as a baseline for examining the other estimators. Equation-by-equation GMM estimates are next since these control for Nickell bias. The same consistency and efficiency problems faced by the simple fixed effects estimates are also present here, but at least the bias situation is improved. Next will be two-stage least squares (2SLS) instrumental variables estimators using the exogenous variables from the second equation in the

system as instruments in the first and vice-versa. This improves consistency, but can reintroduce Nickell-bias. Also, such an estimator is less efficient than other techniques, such as three-stage least squares, but it is reasonably robust and easily implemented. Lastly, spatial estimators will be considered. The LISA tests (below) indicate considerable clustering of counties, as intuition would suggest. This means that more consistent estimates would come from a spatial lag model. This will be a 2SLS instrumental variables model with a spatial lag term. More sophisticated and efficient estimates will have to wait for better econometric tools.

Recall that the basic model for a panel regression is

$$y_{it} = \mathbf{x}'_{it}\boldsymbol{\beta} + \mathbf{z}'_{it}\boldsymbol{\alpha} + \varepsilon_{it} \quad (4.9)$$

The Least Squares Dummy Variable (LSDV) estimator is the simplest fixed effects estimator. This is an ordinary least squares estimator on the variables of interest plus time and cross-section dummies. Assume we have a panel dataset with N cross-sectional groups, T time periods, and k independent variables. Following Greene (2003), let there be N vectors \mathbf{y}_j is the dependent variable vector with $T \times 1$ observations and $j = 1, \dots, N$. \mathbf{X}_j is a $T \times k$ matrix of independent variables and $\boldsymbol{\varepsilon}_j$ is the $T \times 1$ vector of residuals. The fixed effects model starts with

$$y_{it} = \mathbf{x}'_{it}\boldsymbol{\beta} + \alpha_i + \varepsilon_{it}, \quad (4.10)$$

In short, we run an OLS regression of y on \mathbf{x} and a matrix of dummy variables. We can also isolate time effects by adding “time-dummies,” η_t ,

$$y_{it} = \mathbf{x}'_{it}\boldsymbol{\beta} + \alpha_i + \eta_t + \varepsilon_{it}. \quad (4.11)$$

Note that in both cases, the omitted dummy variable is considered the “base” case. Cross-section and time effects are considered relative to this base case.

From here, we can move into a lagged dependent variable specification:

$$y_{it} = \gamma y_{it-1} + \mathbf{x}'_{it} \boldsymbol{\beta} + \alpha_i + \varepsilon_{it}. \quad (4.12)$$

or, more compactly,

$$y_{it} = \mathbf{w}'_{it} \boldsymbol{\delta} + \alpha_i + \varepsilon_{it} \quad (4.13)$$

where $\mathbf{w} = [\mathbf{x} \quad y_{it-1}]$

Under a lagged dependent variables specification, such as equation (4.12) and (4.13), the LSDV parameter estimates are known to be biased downward in what is known as the Nickell bias (sometimes called Hurwicz-Nickell bias) (Nickell, 1981). Kiviet (1995) proposes a bias corrected LSDV, called the corrected LSDV or LSDVC estimator. This estimator is based on an approximation of the Nickell bias. As of this writing, it is not fully implemented in any statistical package, although a user written version exists for Stata. Any practical implementation must begin with an estimate in a standard dynamic panel estimator. This gives the software a measure of the bias in the LSDV estimate. But, poor choice of initial estimator may lead to less efficient estimates. This means that while the LSDVC estimator is theoretically the most efficient estimator, it may not be available or may not work well in practice.

It is worthwhile to review the structure of dynamic panel estimators since, at this writing, they are not part of the common core curriculum in economics graduate programs. There is a host of estimators designed to overcome the various limitations of LSDV. Anderson and Hsiao (1982) proposed an instrumental variables estimator using lagged levels or lagged first differences of the dependent variable and first differences of the independent variables as instruments. First, the model is first differenced. Equation (12) becomes

$$(y_{it} - y_{it-1}) = \gamma(y_{it-1} - y_{it-2}) + (\mathbf{x}_{it} - \mathbf{x}_{it-1})' \boldsymbol{\beta} + (\varepsilon_{it} - \varepsilon_{it-1}). \quad (4.14)$$

Then, either y_{it-2} or $(y_{it-2} - y_{it-3})$ are used as instruments for $(y_{it} - y_{it-1})$.

Dynamic Generalized Method of Moments (GMM) panel estimators take this idea further. A review of the evolution of these estimators is useful in understanding the choice of methods used in this dissertation. This review is restricted to the development of the Blundell-Bond estimator through a review of its ancestors. This seems to provide the most clarity in explaining the issues that estimator addresses and the limitations of the Blundell-Bond estimator and Dynamic GMM panel estimators in general.

First, what is a Generalized Method of Moments estimator? Recall that the method of moments is based on the analogy principle: a good sample estimator of a population moment is the sample's analogue of that moment. For example, the sample mean is a useful estimator of the population mean, assuming that sample distribution is well understood. That is

$$E[y_i] = \mu$$

or

$$E[y_i - \mu] = 0.$$

The sample counterpart is the empirical first moment of the model

$$\frac{1}{N} \sum_{i=1}^N (y_i - \hat{\mu}) = 0,$$

where $\hat{\mu}$ is the value of the sample moment that satisfies the above sample moment equation. We continue to define more moment equations from the assumptions of the model to be estimated. We then attempt to estimate parameters that simultaneously satisfy the model and all of the moment conditions. In the process of defining moment equations, we try to simplify each equation as much as possible. When a precise parameter estimate cannot satisfy all of the conditions, we settle for the value that comes closest.

At a minimum we need as many variables as equations, so that the system is identified. Then there is one and only one possible value for each parameter. Of course, if there are more equations than parameters to be estimated then there may be several possible

parameter values that will solve the system of equations. One way out of this situation is to use additional instrumental variables, beyond those already specified, to estimate some of the moments. These extra instruments, such as lagged values of the variables, may be weak, but they can be effective. In the following discussion, the theme is that adding moment conditions to the estimation system and finding good instruments makes the system more identified.

The Arellano and Bond (1991) estimator uses first differences of lagged dependent variables to provide more instruments. This can be understood by looking at a simpler model, following Baltagi (2005) and Mutl (2006),

$$y_{it} = \gamma y_{it-1} + \mathbf{x}_{it} \boldsymbol{\beta} + u_{it}; \quad i = 1, \dots, N; t = 1, \dots, T \quad (4.15)$$

with $u_{it} = \mu_i + v_{it}$, $\mu_i \sim IID(0, \sigma_\mu^2)$ and $v_{it} \sim IID(0, \sigma_v^2)$. The moment conditions are

$$E[(u_{it} - u_{i,t-1})y_{i,t-k}] = 0 \quad t = 2, \dots, T, k = 2, \dots, t-1, i = 1, \dots, N \quad (4.16)$$

and for strictly exogenous variables,

$$E[x'_{is}(u_{it} - u_{i,t-1})] = 0, \quad t = 2, \dots, T, s = 1, \dots, T, i = 1, \dots, N. \quad (4.17)$$

For predetermined variables, these moment conditions work for $s = 1, \dots, t-1$.

We first difference to eliminate the individual effect, μ_i :

$$y_{it} - y_{it-1} = \gamma(y_{it-1} - y_{it-2}) + (\mathbf{x}_{it} - \mathbf{x}_{it-1})\boldsymbol{\beta} + (v_{it} - v_{it-1}).$$

In $t=3$,

$$y_{i3} - y_{i2} = \gamma(y_{i2} - y_{i1}) + (\mathbf{x}_{i3} - \mathbf{x}_{i2})\boldsymbol{\beta} + (v_{i3} - v_{i2}).$$

Note that y_{i1} is a useful instrument since it is highly correlated with $y_{i2} - y_{i1}$ and not correlated with $v_{i3} - v_{i2}$. Likewise, if the elements of \mathbf{x} are strictly exogenous, then by definition x_{i1} and x_{i2} are useful instruments.

The selection of instruments is critical as even a slight alteration in \mathbf{H} , the addition of an instrument or two, is sufficient to change the estimates, $\hat{\gamma}$ and $\hat{\beta}$ or to cause overfitting of the estimator. This is the so-called weak instruments problem and it will be a recurring theme in this chapter. Weak instruments can cause the sampling distributions of instrumental variables and nonlinear GMM estimators to be non-normal which renders the customary hypothesis tests and confidence intervals unreliable and even renders the coefficient estimates suspect. Note that there are two kinds of instruments in this chapter's section on GMM estimates. There are those found in the \mathbf{W} matrix which are necessary for the "mechanics" of the estimations. Then there are the variables themselves which are all, to some degree, instruments for the underlying economic phenomena. This means that there may be a problem of compounded errors from having both weak "mechanical" instruments as well as weak economic instruments.

Arellano and Bover (1995) explore transformations other than first differences. Of interest here is their suggestion of using the orthogonal deviations transformation, as explained by Mutl (2006),

$$\mathbf{K} = \begin{bmatrix} 1 & -\frac{1}{T-1} & -\frac{1}{T-1} & \cdots & -\frac{1}{T-1} & -\frac{1}{T-1} & -\frac{1}{T-1} \\ 0 & 1 & -\frac{1}{T-2} & \cdots & -\frac{1}{T-2} & -\frac{1}{T-2} & -\frac{1}{T-2} \\ \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & 0 & 0 & \cdots & 0 & 1 & -1 \end{bmatrix}. \quad (4.21)$$

This transforms the model equation (4.9) into,

$$(\mathbf{I}_N \otimes \mathbf{K}) y_{it} = (\mathbf{I}_N \otimes \mathbf{K}) \mathbf{w}'_{it} \delta + (\mathbf{I}_N \otimes \mathbf{K}) \varepsilon_{it}. \quad (4.22)$$

If the exogenous variables are uncorrelated with the fixed effects, then Arellano and Bover impose an additional moment condition,

$$E \left[\left(\frac{1}{T} \sum_{t=1}^T u_{it} \right) x_{is} \right] = 0. \quad (4.23)$$

The transformation matrix, \mathbf{K} is folded into another matrix,

$$\mathbf{C} = \begin{pmatrix} \mathbf{K} \\ \mathbf{e}_T/T \end{pmatrix}, \quad (4.24)$$

where \mathbf{e}_T is a vector of ones.

The instrument matrix becomes

$$\mathbf{H} = \begin{bmatrix} \begin{bmatrix} y_{i0} \\ x_{i1} \\ \vdots \\ x_{iT} \end{bmatrix} \\ \begin{bmatrix} y_{i0} \\ y_{i2} \\ x_{i1} \\ \vdots \\ x_{iT} \end{bmatrix} \\ \dots \\ \begin{bmatrix} y_{i0} \\ \vdots \\ y_{iT-2} \\ x_{i1} \\ \vdots \\ x_{iT} \end{bmatrix} \\ \begin{bmatrix} x_{i1} \\ \vdots \\ x_{iT} \end{bmatrix} \end{bmatrix}. \quad (4.25)$$

The GMM estimator is

$$\begin{pmatrix} \hat{\gamma} \\ \hat{\beta} \end{pmatrix} = ([\Delta\mathbf{y}_{-1}, \Delta\mathbf{X}]' (\mathbf{I}_N \otimes \mathbf{C}') \mathbf{H} \mathbf{A}^{-1} \mathbf{H}' (\mathbf{I}_N \otimes \mathbf{C}) [\mathbf{y}_{-1}, \mathbf{X}])^{-1} \quad (4.26)$$

$$\times [\Delta\mathbf{y}_{-1}, \Delta\mathbf{X}] (\mathbf{I}_N \otimes \mathbf{C}') \mathbf{H} \mathbf{A}^{-1} \mathbf{H}' (\mathbf{I}_N \otimes \mathbf{C}) \mathbf{y}$$

where $\mathbf{A} = \mathbf{H}' (\mathbf{I}_N \otimes \mathbf{C} \mathbf{C}') \mathbf{H}$ in the first stage and $\mathbf{A} = \mathbf{H}' (\mathbf{I}_N \otimes \mathbf{C} (\sum_{i=1}^N \mathbf{u}_{it} \mathbf{u}_{it}') \mathbf{C}') \mathbf{H}$ in the second stage.

Anh and Schmidt (1995) found additional moment conditions. First they assume that disturbances in model equation () satisfy

$$cov(\varepsilon_{it}, y_{i0}) = 0 \quad t = 1, \dots, T \quad (4.27)$$

$$cov(\varepsilon_{it}, \mu_i) = 0 \quad t = 1, \dots, T \quad (4.28)$$

$$cov(\varepsilon_{it}, \varepsilon_{is}) = 0 \quad t, s = 1, \dots, T \text{ and } t \neq s. \quad (4.29)$$

Then they impose

$$E[u_{iT}(\varepsilon_{it} - \varepsilon_{i,t-1})] = 0 \quad t = 2, \dots, T - 1. \quad (4.30)$$

This along with the other conditions listed above are the full set of moment conditions that follow from the assumption that the ε_{it} are uncorrelated among themselves and with the μ_i and y_{i0} .

Blundell and Bond, 1998 proposed using levels and lagged first differences of the dependent and independent variables to provide even more instruments. In addition to all of the restrictions listed above, they impose two more. First, they use lagged differences of the endogenous variable. This allows use of an extended linear GMM estimator. They also impose restrictions necessary to use a GLS error components estimator.

The upshot of this discussion of instruments is that an estimator that removes Nickell bias is a very complex one. It is overidentified, often to the point of overfitting the model. Indeed Roodman (2006) warns us to keep the number of overidentifying restrictions less than the number of cross-sectional groups. This is an easy rule of thumb to break. There is little guidance on picking the correct instruments matrix. We can test a particular candidate instruments matrix with a Sargan or Hansen test for overidentifying restrictions. Roodman (2006, p.44) advises us, “because of the risks, do not take comfort in a Hansen test p value somewhat above 0.1. View higher values, such as 0.25, as potential signs of trouble.” These p values are easily reached, which makes the selection of an instruments matrix a delicate process. The Hansen test is not available as an “official” Stata procedure, but it is available in the user-written `xtabond2`. The Sargan test is available in the `xtdpdsys` version written by the developers at Stata and which is used in this dissertation. Still, the quote from Roodman (2006) reminds us to be careful about making claims about the efficiency of Dynamic Panel GMM estimates.

All terms of the Nickell bias have an inverse relation to T . In fact, the dominant term in the Nickell bias is proportional to $1/T$. This implies that adding years attenuates Nickell bias. Kiviet’s study only considered cases of $T = 3$ and $T = 6$. Judson and Owen (1999) performed Monte Carlo tests and found that when $N = 100$, and T is 10 or 20, the root mean squared error of the LSDV estimator compares favorably with the more sophisticated estimators while the bias was present but small. Furthermore, the Nickell bias affects the lagged dependent variable. This is not a particularly interesting variable in this study. So, in a dataset with 14 years, the benefits of sophisticated estimation methods may be outweighed by the costs.

This paper will present both the LSDV and Blundell-Bond estimates. The LSDV serves as a baseline estimator. It is also implemented in a spatial form in R, which will be necessary for further study. Although there will be downward bias present in the coefficient estimates, the main results desired are the signs and significances of the parameters, so the

bias is tolerable. The Blundell-Bond estimator is the most sophisticated and most likely to be over-identified among the dynamic GMM estimators. It is both consistent and has a low bias.

4.5 Equation-by-Equation Estimates

Fixed Effects Estimates

Tables 4.1 and 4.2 give the results of the fixed effects regression on the eight equations with heteroskedasticity robust standard errors. These are equation-by-equation estimates, so the usual caveats about efficiency and consistency are in effect. These estimates allow a first pass at the estimation process and give us some idea of what the signs and significances will be. Non-robust standard errors were also estimated, but not presented since heteroskedasticity was found in all of the estimates.

The results for equation (4.1) are in Table 4.1, the overall R-squared is 0.9454. The F statistic for overall significance is $F_{19,1424} = 584.47$ for the non-robust estimate and $F_{19,119} = 723.19$ for the robust estimate which shows that the estimate is significant. A Wald test for heteroskedasticity (Stata command: `xttest3`) rejects the null hypothesis of homoskedasticity. With the robust standard errors, the coefficient on the lagged dependent variable is significant at the 1% level and the lagged share of deposits in large banks in the lagged period is significant at the 5% level. The unemployment rate is significant at the 10% level.

The fixed effects estimate for equation (4.2), found in Table 4.2, has an F statistic of $F_{16,1424} = 306.43$ in the non-robust case and $F_{16,119} = 148.27$ in the robust case. The “within” R-squared is 0.7749 and the overall R-squared is 0.9670. The Wald test for heteroskedasticity rejects the null hypothesis of homoskedasticity at the 5% level. The lagged dependent variable, which is the lagged level of deposits, is positive and significant. Logged earned income per worker was positive and not significant. Likewise for the share

of personal income made up of government transfers. The level of population is positive and significant.

The second column of figures in Table 4.1 shows the results of a fixed effects regression of equation (4.3). The “within” R-squared is 0.8909 and overall R-squared is 0.9967. The F statistic for overall significance is $F_{19,1424} = 610.80$. The Wald test for heteroskedasticity rejects the null hypothesis of homoskedasticity. The robust estimate had an F statistic of and $F_{19,119}^2 = 866.64$. Using the robust standard errors for significance testing, we see that the lagged dependent variable is positive and significant. The level of deposits is positive but not significant. The share of deposits in larger banks is negative and not significant in the current period and turns positive and significant at the 10% level in the lagged period. The population growth rate is positive and significant at the 1% level. The high school graduation rate is positive but not significant and the unemployment rate is negative and significant at the 1% level.

The fixed effects regression of the level of deposits on the level of earned income, equation (4.4), is given in column 2 of Table 4.2. The F statistic is $F_{16,1424} = 307.48$, the “within” R-squared is 0.7755 and the overall R-squared is 0.9587. The Wald test for heteroskedasticity rejects the null hypothesis of homoskedasticity at the 5% level. The estimate was run again with robust standard errors. This has an F statistic of $F_{16,119} = 160.08$. The lagged dependent variable, which is the lagged level of deposits, is positive and significant at the 1% level. Logged earned income per worker is positive and significant at 5%. The share of personal income made up of government transfers is positive but not significant. The level of population is positive and significant at the 5% level.

Column 3 of Table 4.1 shows the results of a fixed effects regression of equation (4.5). The “within” R-squared is 0.8878 and overall R-squared is 0.9425. The F statistic for overall significance is $F_{19,1424} = 591.65$. The Wald test for heteroskedasticity rejects the null hypothesis of homoskedasticity. The estimator was run again with robust standard errors. This had an F statistic of and $F_{19,119} = 716.39$. Using the robust standard errors for

significance testing, we see that the lagged dependent variable is positive and significant. The ratio of deposits to personal income is negative and significant. The share of deposits in larger banks is negative and not significant in the current period and turns positive and significant at the 5% level in the lagged period. The population growth rate is negative and not significant. The high school graduation rate is positive and significant at the 10% level and the unemployment rate is negative and significant at the 10% level.

The fixed effects regression of the level of deposits on the level of earned income, equation (4.6), is given in Table 4.2. The F statistic was $F_{16,1424} = 148.80$, the “within” R-squared is 0.6257 and the overall R-squared is 0.9587. The Wald test for heteroskedasticity rejects the null hypothesis of homoskedasticity at the 5% level. The estimate was run again with robust standard errors. This had an F statistic of $F_{16,119} = 114.13$. The lagged dependent variable, which is the lagged level of deposits, is positive and significant at 1%. Logged earned income per worker is negative and not significant. The share of personal income made up of government transfers is positive and significant at 1%. The level of population is positive and not significant.

Table 4.1 presents the results of a fixed effects regression of equation (4.7). The “within” R-squared is 0.8919 and overall R-squared is 0.9965. The F statistic for overall significance is $F_{19,1424} = 617.10$. The Wald test for heteroskedasticity rejected the null hypothesis of homoskedasticity. The estimator was run again with robust standard errors. This has an F statistic of and $F_{19,119} = 851.71$. Using the robust standard errors for significance testing, we see that the lagged dependent variable is positive and significant. The ratio of deposits to personal income is negative and significant at 5%. The share of deposits in larger banks is negative and not significant in the current period and turns positive and not significant in the lagged period. The population growth rate is positive and significant at 1%. The high school graduation rate is positive and not significant and the unemployment rate is negative and significant at the 1% level.

The fixed effects regression of the level of deposits on the level of earned income, equation (4.8), is given in Table 4.2. The F statistic was $F_{16,1424} = 148.37$, the “within” R-squared is 0.6251 and the overall R-squared is 0.8186. The Wald test for heteroskedasticity rejected the null hypothesis of homoskedasticity at the 5% level. The estimate was run again with robust standard errors. This had an F statistic of $F_{16,119} = 107.42$. The lagged dependent variable, which is the lagged level of deposits, is positive and significant at 1%. Logged earned income per worker is positive and not significant. The share of personal income made up of government transfers is positive and significant at 1%. The level of population is positive and not significant.

Overall, for the income equations, the lagged dependent variables are positive in all cases. On the regressions for equations (1) and (3) where logged deposits were the financial development variables, that parameter is positive. In equations (5) and (7) which featured the ratio of deposits to personal income, that variable is negative. This may be due to fraction of overall county income that is not being used in consumption. The share of deposits parameter is negative in the current period and positive in the lagged period in all four equations. Population growth is negatively correlated when earned income per worker is the dependent variable and positive when earned income is the dependent variable. This seems to indicate that population growth is positively correlated with levels of overall economic growth, but may be diluting individual returns. High school graduation rate parameters are positive in all four cases and unemployment was negative.

For the deposit equations, the lagged dependent variables are positive. The income parameters are positive except for equation (6) where the ratio of deposits to personal income and earned income per worker are variables. Population level is positively correlated with deposits, which makes sense since there are more people to deposit money in the bank. Transfer payments are positively correlated with deposits. This money must be “parked” somewhere until it is used. Also, transfer programs are increasingly relying on direct deposit.

Blundell-Bond Estimates

A Blundell-Bond dynamic Generalized Method of Moments estimator was run on the same model equation. These results are in Table 4.3. Of the several commands available in Stata for dynamic panel GMM estimates, the command `xtdpdsys` is the simplest and most straightforward to use. The trick in running these estimates is to choose enough instruments to get a good fit, but not so many that overfitting becomes a risk. There were a total of 109 instruments used to calculate the moments (the \mathbf{H} matrix) and the Sargan test for overidentifying restrictions has a value of $\chi_{89}^2 = 105.0877$ (p-value of 0.1172) which rejects the null hypothesis that the GMM system is overidentified without making us too suspicious of overfitting. For equation (4.1), The results are given in column 1 of Table 4.3. The coefficient on the lagged dependent variable is significant. The coefficient on the level of deposits is positive and significant at the 1% level. Note that the share of deposits in large banks in the lagged period is now significant at the 10% level. The unemployment rate is negative and significant at the 5% level.

The Blundell-Bond estimate for equation (4.2) is reported in table 4.4. There were 106 instruments with a Sargan test statistic of $\chi_{89}^2 = 2481.66$, which supports the null hypothesis that the restrictions are overidentified. The lagged dependent variable is positive and significant at the 1% level. Earned income per worker is positive and significant at the 5% level. The logged level of population is positive and not significant.. The ratio of transfer payments to personal income is positive and significant at the 10% level.

The Blundell-Bond estimate for equation (4.3) is given in Table 4.3. This again had 109 instruments with a Sargan statistic of $\chi_{89}^2 = 103.223$. The coefficient on the lagged dependent variable is positive and significant at the 1% level. The coefficient on the level of deposits is positive and significant at the 5% level. Again, the coefficient on the share of deposits in large banks is negative and not significant in the current period and positive and not significant in the lagged period. The population growth rate is positive and not signifi-

cant. The high school graduation rate is positive and not significant and the unemployment rate is negative and significant at the 1% level.

The Blundell-Bond estimate for equation (4.4) is reported in table 4.4. There were 106 instruments with a Sargan test statistic of $\chi_{89}^2 = 2403.74$, which supports the null hypothesis that the restrictions are overidentified. The lagged dependent variable is positive and significant at the 1% level. Earned income per worker is positive and significant at the 5% level. The logged level of population is negative and not significant.. The ratio of transfer payments to personal income is positive and significant at the 5% level.

The Blundell-Bond estimate for equation (4.5) is given in Table 4.3. This again had 109 instruments with a Sargan statistic of $\chi_{89}^2 = 103.0334$. The coefficient on the lagged dependent variable is positive and significant at the 1% level. The coefficient on the ratio of deposits to personal income is negative and not significant. The coefficient on the share of deposits in large banks is negative and not significant in the current period and positive and significant at the 10% in the lagged period. The population growth rate is positive and not significant. The high school graduation rate is positive and significant at the 5% level. The unemployment rate is positive and not significant.

The Blundell-Bond estimate for equation (4.6) is reported in table 4.4. There were 106 instruments with a Sargan test statistic of $\chi_{89}^2 = 99.51941$, which supports the null hypothesis that the restrictions are overidentified. The lagged dependent variable was positive and significant at the 1% level. Earned income per worker is negative and not significant. The logged level of population is negative and not significant.. The ratio of transfer payments to personal income is positive and not significant.

The Blundell-Bond estimate for equation (4.7) is given in Table 4.3. This again had 109 instruments with a Sargan statistic of $\chi_{89}^2 = 101.9364$. The coefficient on the lagged dependent variable is positive and significant at the 1% level. The coefficient on the ratio of deposits to personal income is negative and not significant. The coefficient on the share of deposits in large banks is negative and not significant in the current period and positive and

not significant in the lagged period. The population growth rate is positive and not significant. The high school graduation rate is positive and not significant. The unemployment rate is negative and significant at 1%.

The Blundell-Bond estimate for equation (4.8) is reported in table 4.4. There were 106 instruments with a Sargan test statistic of $\chi_{89}^2 = 98.89095$, which supports the null hypothesis that the restrictions are overidentified. The lagged dependent variable is positive and significant at the 1% level. Earned income per worker is positive and not significant. The logged level of population is negative and significant at 5%. The ratio of transfer payments to personal income is positive and significant at 5%.

To summarize the income equations, the lagged dependent variables are positive in all cases. On the regressions for equations (4.1) and (4.3) where logged deposits were the financial development variables, that parameter was positive. In equations (4.5) and (4.7) which feature the ratio of deposits to personal income, the estimate on that variable is negative. This may be due to fraction of overall county income that is not being used in consumption. The share of deposits parameter is negative in the current period and positive in the lagged period in all four equations. Population growth is negatively correlated when earned income per worker is the dependent variable and positive when earned income was the dependent variable. This seems to indicate that population growth is positively correlated with levels of overall economic growth, but may be diluting individual returns. High school graduation rate parameters are positive in all four cases. Unemployment is negative in all cases but equation (4.5) and that case is not statistically significant.

For the deposit equations, the lagged dependent variables are positive. The income parameters are positive except for equation (4.6) where the ratio of deposits to personal income and earned income per worker are variables. Population level is positively correlated with deposits and significant in equations (4.6) and (4.8) and negative and not significant in (4.2) and (4.4). Transfer payments are again positively correlated with deposits.

In comparing the fixed effects estimates to the Blundell-Bond estimates, we see that the results are similar. Financial development is positively correlated with growth. Having a large bank in the region seems to negatively influence growth in the current period but positively influence it in the lagged period. This might suggest that the big banks may have a long term beneficial impact on growth, but a negative short term impact until they get settled into their community. Still, these are equation-by-equation estimates. Simultaneous equations estimates would most likely be more consistent.

4.6 Simultaneous Equations Estimates

Now that there is some idea of the signs and significances, a more consistent estimate might come from a panel simultaneous equations estimator. The author is not aware of a panel simultaneous equations estimator implemented in any common statistical software package. Fortunately, a Two-Stage Least Squares (2SLS) estimator is easily improvised in Stata in successive instrumental variables estimators. The first equation in the system can be estimated in an instrumental variables estimator with the exogenous variables from the second equation used as instruments for the shared endogenous variables on the right hand side of the equation. The second equation can then be estimated by using the exogenous variables from the first equation as instruments.

Table 3 presents the results of the Simultaneous IV regression on equations (4.1) through (4.8). For equation (4.1), the results can be found in Table 4.5. The lagged dependent variable, logged earned income per worker is positive and significant at less than 1%. The parameter estimate for the logged level of deposits is negative and significant at less than 1%. The parameter estimate on share of deposits in large banks is negative and not significant in the current period and positive and not significant in the lagged period. The population growth parameter estimate is positive and not significant. The High School Graduation Rate parameter estimate is positive and significant at less than 1%. The Unem-

ployment Rate parameter estimate is negative and not significant. The constant is positive and significant at less than 1%.

For equation (4.2), found in Table 4.6, the lagged dependent variable, the logged level of deposits is positive and significant at less than 1%. The Logged Earned Income Per Worker is negative and not significant. Logged level of population is negative but not significant and the ratio of transfer payments to personal income is negative and not significant. The constant is positive and not significant.

Table 4.5 has results for equation (4.3). The lagged dependent variable, logged earned income per worker is positive and significant at less than 1%. The parameter estimate for the ratio of deposits to personal income is negative and significant at less than 1%. The parameter estimate on share of deposits in large banks is positive and significant at less than 10% in the current period and positive and not significant in the lagged period. The population growth parameter estimate is positive and not significant. The High School Graduation Rate parameter estimate is positive and significant at less than 5%. The Unemployment Rate parameter estimate is negative and not significant. The constant is positive and significant at less than 1%.

For equation (4.4), with results in Table 4.6, the lagged dependent variable, the ratio of deposits to personal income is positive and significant at less than 1%. The Logged Earned Income Per Worker is negative and significant at less than 5%. Logged level of population is negative but not significant and the ratio of transfer payments to personal income is negative and not significant. The constant is positive and significant at less than 5%.

Results for estimates of equation (4.5) are in Table 4.5. The lagged dependent variable, logged level of earned income per was positive and significant at less than 1%. The parameter estimate for the logged level of deposits is negative and significant at less than 1%. The parameter estimate on share of deposits in large banks is positive and not significant in the current period and positive and not significant in the lagged period. The population

growth parameter estimate is positive and not significant. The high school graduation rate parameter estimate is positive and significant at less than 5%. The unemployment rate parameter estimate is negative and significant at 1%. The constant is negative and significant at less than 1%.

For equation (4.6), with results in Table 4.6, the lagged dependent variable, the logged level of deposits is positive and significant at less than 1%. The logged level of earned income is negative and not significant. Logged level of population is positive and significant at less than 5% and the ratio of transfer payments to personal income is negative and not significant. The constant is positive and not significant.

Results for equation (4.7) are in Table 4.5. The lagged dependent variable, logged level of earned income is positive and significant at less than 1%. The parameter estimate for the ratio of deposits to personal income is negative and significant at less than 1%. The parameter estimate on share of deposits in large banks was positive and significant at less than 10% in the current period and positive and not significant in the lagged period. The population growth parameter estimate is positive and significant at less than 5%. The High School Graduation Rate parameter estimate is positive and significant at less than 1%. The Unemployment Rate parameter estimate is negative and significant at less than 1%. The constant is positive and significant at less than 1%.

Finally, the results for equation (4.8) are in Table 4.6. The lagged dependent variable, the ratio of deposits to personal income is positive and significant at less than 1%. The Logged Earned Income Per Worker is negative and significant at less than 10%. Logged level of population is positive and significant at less than 5% and the ratio of transfer payments to personal income is negative and not significant. The constant is positive and not significant.

In summary, for the income equations, the lagged dependent variables are positive in all cases. On the regressions for equations (4.1) and (4.3) where logged deposits were the financial development variables, that parameter is negative. In equations (4.5) and

(4.7) which featured the ratio of deposits to personal income, those estimates are negative. Again, this may be due to fraction of overall county income that is not being used in consumption. The share of deposits parameter is negative in the current period only in equation (4.1) and positive in the others. For the lagged period share of deposits in large banks, the parameter estimates are positive for all four equations. Population growth is positive in all cases. Again, this seems to indicate that population growth is positively correlated with levels of overall economic growth. High school graduation rate parameters are positive in all four cases and unemployment is negative.

For the deposit equations, the lagged dependent variables are positive. The income parameters are negative in all cases. Population level is negatively correlated with levels of deposits but positively correlated with the ratio of deposits to personal income, which makes sense since there are more people to deposit money in the bank. Transfer payments are negatively correlated with deposits.

4.7 Spatial Correlations

Since the counties are small and contiguous, there is a high probability that their statistics are spatially correlated. The possibility of spatial autocorrelation is increased in border counties since counties in other states are not included in the sample. There are many methods for testing for spatial autocorrelation. This dissertation uses two very common and related methods for testing for spatial autocorrelation. The first is a global Moran's I test to test for global spatial autocorrelation. The levels of local spatial correlation were examined in ArcGIS with univariate Local Indicators of Spatial Association (LISA) tests on the dependent variables, earned income per worker and the levels of earned income.

The global Moran's I statistic is a measure of spatial autocorrelation across the entire set of cross-sectional units. Let z_i be the deviation from the mean for the observation from region i of the variable of interest. If W_{ij} is a spatial weighting matrix and j is an index for a neighboring region and there are N regions, then the test statistic is computed by

$$I = \frac{N}{\sum_i \sum_j W_{ij}} \frac{\sum_i \sum_j W_{ij} z_i z_j}{\sum_i z_i^2} \quad (4.31)$$

There is no panel Moran's I test, but we can look at a sampling of years to see how spatial autocorrelation is evolving. In this case, the first year in the sample, 1995, the middle year, 2001 and the last year, 2008 are tested. The inverse distance and polygon contiguity specifications for the spatial weights matrices are used. For logged earned income, the Moran's I values for tests under inverse distance weighting were 0.006602 (p-value = 0.681827) in 1995, 2001 and 2008. Under polygon contiguity weighting, the Moran's I values for tests on logged earned income were 0.022741 (p-value = 0.319432) in all three years.

As to logged earned income per worker, under inverse distance weighting, the Moran's I values were 0.014724 (p-value = 0.124819) in 1995, 0.402969 (p-value = 0) in 2001 and 0.367375 (p-value = 0) in 2008. For logged earned income per worker, under polygon contiguity, the Moran's I values were 0.011612 (p-value = 0.102738) in 1995, 0.309483 (p-value = 0) in 2001 and 0.305966 (p-value = 0) in 2008.

The LISA test is due to Anselin (1995). Using the variable definitions from above, the LISA statistic is defined by

$$I_i = \frac{N z_i}{\sum_i z_i^2} \sum_j W_{ij} z_j. \quad (4.32)$$

Note that this statistic is related to the global Moran's I statistic by

$$I = \sum_i \frac{I_i}{N}.$$

In other terms, the global Moran's I is the mean of the LISA statistics. This means it is possible that pockets of spatial autocorrelation may exist, but their influence may be diminished in the averaging process. So it is possible that the LISA statistics may show pockets of spatial autocorrelation while the global Moran's I test does not indicate significant spatial autocorrelation.

There are four possible relationships. First is the case of a region with a high value of the variable in question being related with another region that also has a high value of the variable. This is a High-High or HH relationship. A region can have a high value center and a low value neighbor, which is a High-Low or HL relationship. There is a Low-High (LH) relationship where a low value center is correlated with a high value neighbor. Last is the Low-Low (LL) relationship in which a low value center is correlated with a low value neighbor.

ArcGIS produced choropleth maps with the centers of statistically significant clusters marked on the map. Figures 4.2, 4.3 and 4.4 show the LISA results on logged earned income per worker with inverse distance weighting for the years 1995, 2001 and 2008 respectively. In 1995, there was a high-high cluster centered on Fayette, Scott and Woodford counties. Recall that Lexington, KY, Kentucky's second largest city urban area, takes up about 95% of Fayette County. Scott County has a massive Toyota factory and all three counties have interstate highways running through them. A low-low cluster was centered on Clinton, Cumberland, Metcalfe, Green and Hart counties. Another low-low cluster was centered on Bracken, Robertson, Nicholas, Fleming, Bath and Menifee counties. A fourth low-low cluster centers on Elliott county and a fifth centers on Jackson county. The 2001 map was identical. By 2008, Woodford county dropped out of the previous high-high cluster, the Elliot County cluster disappeared, The Bracken, Robertson, etc. cluster picked up Lewis County and new high-high clusters appeared centered on Knott and Perry county and Henderson, McLean and Webster counties, which are essentially suburbs of Evansville, IN.

Logged earned income per worker under polygon contiguity looks similar. These choropleths are found in figures 4.5, 4.6 and 4.7 for 1995, 2001 and 2008 respectively. The Fayette, Scott and Woodford high-high cluster was still there along with the Elliot and Bracken, Robertson, et. al. low-low clusters. There was a low-low cluster centered on Clinton, Cumberland, Metcalfe, Adair and Green Counties. Martin and Pike counties form the center of a high-high cluster. Another high-high cluster centered on Leslie County.

Owen county appeared as the center of a Low-High Cluster contiguous with the Fayette, Scott and Woodford cluster. The 2001 results were identical. In 2008 we see that Lewis County drops out of the Bracken, Robertson, et. al. cluster. The Martin County drops out of its cluster and Pike County clusters with Knott and Letcher Counties in a new high-high cluster. Another high-high cluster appears that includes Henderson, McLean, Hopkins and Christian counties. Scott and Woodford counties drop out and leave Fayette by itself.

The logged level of earned income was given similar treatment. In 1995, in figure 4.8, for inverse distances, there is a high-high cluster centered in the three counties that border Cincinnati, OH. These are Kenton, Boone and Campbell counties. Fayette and Scott counties also form the center of a high-high relationship. Spencer County is the center of a low-high cluster (it is next to Louisville-Jefferson County). Bracken and Robertson counties center a low-low cluster as do Menifee, Wolfe, Lee and Owsley counties. McCracken county is the center of a high-low cluster. Again, 2001, in figure 4.9, was identical. 2008 (figure 4.10) was almost identical, but the Bracken and Robertson cluster extended into Nicholas and Bullitt County appeared as a high-high center.

Under polygon contiguity in 1995 (figure 4.11), the high-high cluster next to Cincinnati centers only on Kenton County. Robertson county forms the center of a low-low cluster as do Menifee, Wolfe and Lee. The Central Kentucky cluster centers on Fayette, Scott and Woodford counties. Jefferson County (Louisville) is the center of a high-high cluster as does Hardin county (Elizabethtown and Ft. Knox). Spencer County again is the center of a low-high cluster. The 2001 map, figure 4.12, is identical again. The 2008 map, figure 4.13, is also close but Jefferson and Hardin County high-high clusters are joined by Bullitt County into a single strip. Robertson County is joined by its neighbor Nicholas County. The Central Kentucky cluster loses Woodford county.

So while there is little evidence for spatial autocorrelation in the global tests, the local tests do find some. In particular, the vertices of the “Golden Triangle”, Boone, Fayette and

Jefferson counties are all parts of high-high clusters. This is to be expected since these are the most agglomerated regions and actually form cores and peripheries.

4.8 Spatial Fixed Effects Estimates

Finally, spatial fixed effects estimates were attempted. As a rule of thumb, most commuters tend to limit their commutes to no more than one hour. In Kentucky, this works out to roughly one county's width in distance. This implies that a weighting matrix with polygon contiguity, "queen" contiguity to be exact, is sufficient for spatial econometrics estimates. Since an important question is how proximity to neighboring counties, and their banks, affects economic growth, this suggests that a spatial lag model should be used. The general form of a spatially lagged panel data model is,

$$y_{it} = \lambda \mathbf{W}y_{it} + \mathbf{X}\beta + \mathbf{u}_{it} \quad (4.33)$$

where λ is the coefficient on the spatial lag term and \mathbf{W} is the spatial weighting matrix. The model was estimated in the R language using the package "splm". Even though this package is considered beta code, it is stable enough for moderately complex estimates. Also, the instrumental variables estimator provided is a spatial generalized method of moments estimator due to Kapoor, Kelejian and Prucha (2007).

Attempts to estimate the model with logged earned income per worker failed since the dependent variable is highly collinear with its lagged values. This made the estimation matrix close enough to singular that R was unable to invert it. This problem did not arise with the logged level of earned income. Table 4.7 gives estimates for spatial versions of equations (4.5) and (4.7). The estimates for equations (4.6) and (4.8) are given in table 4.8.

For equation (4.5), the coefficient on the spatial lag term was negative and not significant. The parameter estimate on the lagged dependent variable was positive and significant and less than 1%. The logged level of deposits was positive and not significant. The parameter estimate on share of deposits in large banks was negative and not significant in both

the current period and the lagged period. The parameter estimate on the population growth rate was positive and not significant. The parameter estimate on the high school graduation rate was positive and significant at less than 1%. Likewise for the unemployment rate. The constant was negative and not significant.

The equation (4.6) results show that the estimate on the lagged dependent variable was positive and significant at less than 1%. The estimate on the logged level of population was positive and not significant. The share of transfer payments in personal income was negative and significant at 10%. The constant was positive and not significant. The coefficient on the spatial lag was negative and not significant.

As to equation (4.7), the coefficient on the spatial lag term was negative and significant at less than 10%. The parameter estimate on the lagged dependent variable was positive and significant and less than 1%. The ratio of deposits to personal income was positive and significant at less than 1%. The parameter estimate on share of deposits in large banks was negative and not significant in both the current period and the lagged period. The parameter estimate on the population growth rate was positive and not significant. The parameter estimate on the high school graduation rate was positive and significant at less than 1%. Likewise for the unemployment rate. The constant was negative and significant at less than 1%.

In the estimates for equation (4.8), the lagged dependent variable's estimate was positive and significant at less than 1%. The logged level of earned income was positive and not significant. The logged population was negative and significant at less than 1%. The share of transfer payments to personal income was positive and not significant. The constant was negative and not significant. The estimate for the spatial lag is negative and significant at less than 10%.

When we compare the standard 2SLS estimates to the spatial 2SLS estimates, we see that the estimates disagree on the effect of deposits and the ratio of deposits to personal income. The spatial 2SLS estimates have positive signs which match theory. There is also

disagreement on the share of deposits in large banks in both the current and lagged periods. In the spatial estimates these are strictly negative while the standard 2SLS estimates are mostly positive.

4.9 Conclusion

In the equation-by-equation fixed effects and GMM estimators, deposits were significantly correlated with growth in both levels of earned income and per-worker earned income. Levels of earned income and per-worker earned income were significantly correlated with growth in deposits. Similar results are found with the ratio of deposits to personal income. Those are the expected results, but endogeneity issues are not untangled. This is to be expected since growth in income would lead to an increase in deposits. The banks would then have a larger pool of loanable funds and a desire to transform them from liabilities into assets. The lending would cause economic growth that would lead to income growth and the cycle repeats *ad infinitum*.

The simultaneous instrumental variables estimators are far from perfect, but they are broadly used in the literature, recommended in top econometrics texts (such as Baltagi (2005)), and easy to implement with existing tools such as Stata or R. In the non-spatial estimates, the level of deposits was positively correlated with growth in levels of earned income and in per-worker earned income. The ratio of deposits to personal income likewise was positively correlated with levels of earned income and per-worker earned income. LISA tests with queen contiguous spatial weights matrices indicated clusters of spatially correlated incomes with the high income areas on the vertices of the “golden triangle” and the low income areas in Eastern Kentucky some distance from the coal mining areas. Spatial IV estimates show that the ratio of deposits to personal income was significantly correlated with growth in levels of earned income but the converse relation of income on deposit growth was not significant.

As to the fraction of deposits in large, multi-state banks, the results were not clear. There was some evidence that this variable, lagged one year, was significant to varying degrees in the equation-by-equation fixed effects estimates. This variable was either not significant or significant at less than 10% in the other estimates. The share of deposits in large, multi-state banks in the current period was significant at less than 10% in the non-spatial simultaneous IV estimate and not significant in the other estimates. In the current period, the signs of the parameter estimates had a tendency to be negative while they tended to be positive in the lagged period. This might suggest that large banks have a disruptive effect as they move into a region, but that effect turns positive as the bank becomes integrated into the economy. Since large banks frequently move into a market by purchasing an existing smaller bank which might disrupt existing banking relationships. As the large bank gets integrated into the county economy its effect might turn positive. This is a possible explanation, but without stronger evidence, it remains conjectural.

Overall, the level of deposits and the ratio of deposits to personal income are correlated with income growth and per-worker income growth. Due to clusters of economic activity in space, spatial estimators seem to perform better than non-spatial estimators. This is to be expected in light of commuting patterns and wide-open trade as well as possible spatial specification issues.

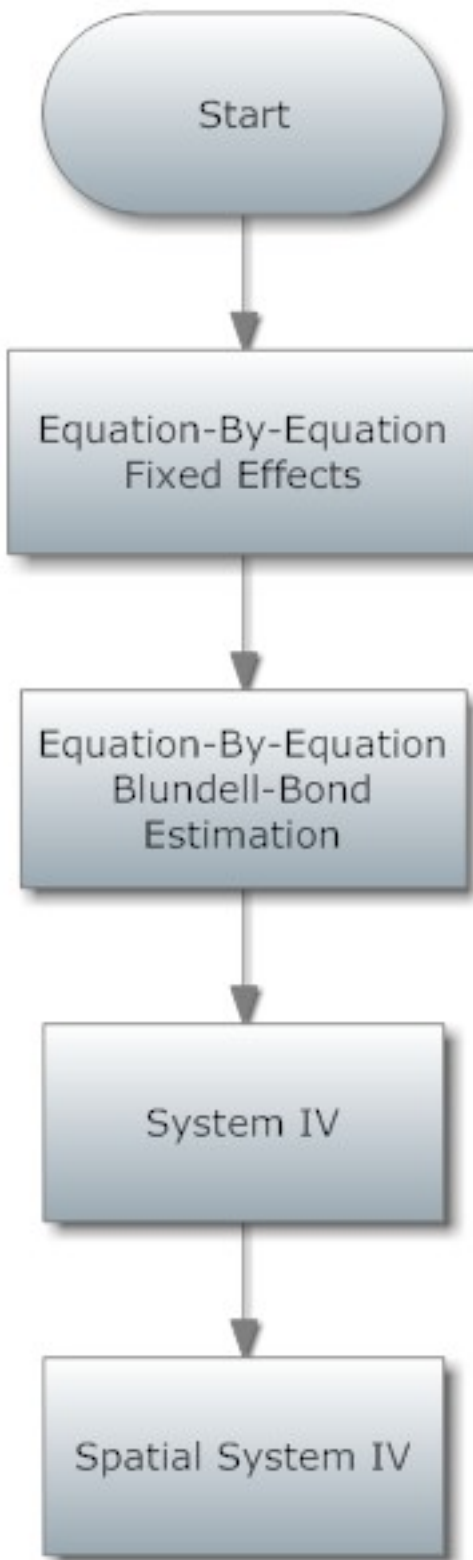


Figure 4.1: Flowchart of Empirical Modelling Process

Table 4.1: Equation-by-Equation Fixed Effects Estimates of Equations 1,3,5 and 7 with Robust Standard Errors

Variable	Log Earned Income Per Worker.	Log Level of Earned Income	Log Earned Income Per Worker	Log Level of Earned Income
Log Earned Inc. Per Wrkr. (t-1)	.6783 (.0286)***		.6680 (.0315)***	
Log Level of Earned Income (t-1)		.7788 (.0343)***		.7754 (.0360)***
Log Level of Deposits	.0023 (.0096)	.0085 (.0105)		
Ratio of Deposits to Pers. Inc.			-.1053 (.0578)*	-.1162 (.0557)**
Share of Deposits. in Lg. Banks	-.0472 (.0287)	-.0452 (.0276)	-.0404 (.0306)	-.0370 (.0297)
Share of Deposits in Lg. Banks (t-1)	.0394	.0323	.0384	.0313
Population Growth Rate	.0189**	(.0197)*	(.0184)*	(.0108)***
	-.0041	.0461	-.0030	.0484
	.0046	(.0098)***	(.0044)	(.0108)
HS Graduation Rate	.0273	.0286	.0296	.0323
	.0167	(.0197)	(.0165)*	(.0196)
Unemployment Rate	-.0020	-.0076	-.0020	-.0076
	.0011*	(.0014)***	(.0011)*	(.0014)***
Constant	3.2223	2.6393	3.3896	2.8606
	.3438***	(.4420)***	(.3194)***	(.4382)***
R^2 within	0.8866	0.8909	.8878	.8919
$F_{19,119}$	723.19***	866.64***	716.39***	851.71

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Table 4.2: Fixed Effects Estimates of Equations 2,4,6 and 8 with Robust Standard Errors

	Log Level of Deposits	Log Level of Deposits	Ratio of Deposits to Personal Income.	Ratio of Deposits to Personal Income.
Log Earned Income Per Wrkr.	.0614 (.0478)		-.0246 (.021)	
Log Level of Earned Income		.0878 (.0379)**		.0065 (.0119)***
Log Level of Deposits (t-1)	.7569 (.0504)***	.7558 (.0510)***		
Ratio of Deposits to Pers. Inc. (t-1)			.7588 (.0663)***	.7671 (.0651)***
Log Population	.1828 (.0746)**	.1481 (.0748)**	.0261 (.0168)	.0314 (.0191)
Ratio of Transfers to Pers. Inc.	.3410 (.3335)	.6288 (.3959)	.3232 (.1198)***	.4256 (.1487)***
Constant	2.021 (.9962)**	1.8435 (.7592)**	-.0410 (.2852)	-.4535 (.2216)**
<i>R</i> ² within	.7749	.7755	.6257	.6251
<i>F</i> _{16,119}	148.27***	160.08***	114.13	107.42

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Table 4.3: Blundell-Bond GMM Estimates on Income Equations with Windmeijer Corrected Standard Errors

	Log Earned Income Per Worker.	Log Level of Earned Income.	Log Earned Income Per Worker	Log Level of Earned Income
Log Earned Inc. Per Wrkr. (t-1)	.7233 (.0514)***		.8091 (.0674)***	
Log Lvl. of Earned Inc. (t-1)		.9570 (.0025)***		.9919 (.0245)***
Log Lvl. of Deposits	.0661 (.0192)***	.0784 (.0323)**		
Ratio of Deposits to Pers. Inc.			-.0785 (.0688)	-.1280 (.0796)
Share of Deposits in Lg. Banks	-.0562 (.0427)	-.0564 (.0504)	-.0535 (.0509)	-.0487 (.0549)
Share of Deposits in Lg. Banks (t-1)	.0471 (.0247)*	.0433 (.0278)	.0450 (.0262)*	.0444 (.0287)
Population Growth Rate	.0025 (.0243)	.0317 (.0231)	.0055 (.0190)	.0262 (.0210)
HS Graduation Rate	.0416 (.0273)	.0450 (.0346)	.0510 (.0248)**	.0494 (.0310)
Unemployment Rate	-.0002 (.0020)	-.0115 (.0020)***	.0001 (.0018)	-.0100 (.0019)***
Constant	1.5761 (.6370)*	-.7879 (.4391)*	1.9060 (.6372)***	.2174 (.3076)
Instruments	109	109	109	109
Sargan Test Statistic χ^2_{89}	105.877	103.223	103.0344	101.9364

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Table 4.4: Blundell-Bond GMM Estimates on Deposit Equations with Windmeijer Corrected Standard Errors

	Log Deposits	Log Deposits	Ratio of Deposits to Personal Income	Ratio of Deposits to Personal Income
Log Earned Income Per Wrkr.	.1869 (.0914)**		-.0126 (.0306)	
Log Level of Earned Income		.1706 (.0818)**		.0260 (.0216)
Log Level of Deposits (t-1)	.1869 (.0914)**	.8829 (.0814)***		
Ratio of Deposits to Pers. Inc. (t-1)			.8668 (.0446)***	.8613 (.0505)***
Log Population	.0700 (.0681)	-.1000 (.0867)	-.0296 (.0182)	-.0554 (.0281)**
Ratio of Transfers to Pers. Inc.	.6649 (.3994)*	.9861 (.4529)**	.3484 (.2481)	.5221 (.2166)**
Constant	-.9435 (1.1304)	.8310 (.9952)	.3589 (.3782)	.1182 (.1921)
Instruments	106	106	106	106
Sargan Test Statistic χ^2_{89}	101.1232	99.9005	99.5194	98.8910

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Table 4.5: Simultaneous IV Estimates on Income Equations

	Log Earned Inc. Per Wrkr.	Log Lvl. of Earned Inc.	Log Earned Inc. Per Wrkr.	Log Lvl. of Earned Inc.
Log Earned Income Per Wrkr. (t-1)	.6690 (.0252)***		.5050 (.4674)***	
Log Level of Earned Income (t-1)		.8042 (.0205)***		.6996 (.0339)***
Log Level of Deposits	-.2166 (.0453)***	-.1659 (.0504)***		
Ratio of Deposits to Pers. Inc.			-1.7921 (.2514)***	-2.0444 (.2682)***
Share of Deposits in Lg. Banks	-.0159 (.0214)	-.0210 (.0228)	.0636 (.0359)*	.0796 (.0408)*
Share of Deposits in Lg. Banks (t-1)	.0280 (.0202)	.0251 (.0215)	.0249 (.0320)	.0200 (.0369)
Population Growth Rate	.0053 (.2959)	.0517 (.0315)	.0137 (.0469)	.0821 (.0544)
HS Graduation Rate	.0522 (.0188)***	.0493 (.0202)**	.0629 (.0292)**	.0776 (.0338)**
Unemployment Rate	-.0015 (.0011)	-.0074 (.0012)***	-.0021 (.0017)	-.0077 (.0020)***
Constant	7.3970 (.8961)***	-.0074 (.0193)***	5.4468 (.5063)***	4.2478 (.4408)***
R^2 within	0.8303	0.8662	0.5724	0.6021
Wald χ^2_{19}	4.67e+07	6.14e+07	1.85e+07	2.06e+07

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Table 4.6: Simultaneous IV Estimates on Deposit Equations

	Log Lvl. of Deposits	Ratio of Deposits to Pers. Inc	Log Lvl. of Deposits	Ratio of Deposits to Pers. Inc.
Log Earned Income Per Wrkr.	-0.7372 (.5042)	-0.4220 (.1935)**		
Log Level of Earned Income			-0.2773 (.3421)	-0.2239 (.1195)*
Log Level of Deposits (t-1)	.7584 (.1888)***		.7610 (.0012)***	
Ratio of Deposits to Pers. Inc. (t-1)		.7302 (.0255)***		.7550 (.0197)***
Log Population	-0.0418 (.1598)	-0.0827 (.0586)	.2205 (.0967)**	.0805 (.0343)**
Ratio of Transfers to Pers. Inc.	-1.932 (1.4633)	-0.7283 (.5481)	-1.2942 (1.8216)	-0.7814 (.6327)
Constant	12.9860 (6.9644)	5.3993 (2.6614)**	6.0867 (4.0381)	2.2415 (1.4219)
R^2 within	0.7270	0.4224	0.7603	0.5208
Wald χ^2_{16}	4.67e+07	76351.74	5.32e+07	92036.52

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Table 4.7: Spatial IV Estimates on Income Equations

	Log Earned Income	Log Earned Income
Log Level of Earned Income (t-1)	0.9921 (0.0020)***	0.9997 (0.0012)***
Log Level of Deposits	0.0216 (0.0139)	
Ratio of Deposits to Pers. Inc.		0.3010 (0.0759)***
Share of Deposits in Lg. Banks	-0.0189 (0.0192)	-0.0215 (0.0193)
Share of Deposits in Lg. Banks (t-1)	-0.0094 (0.0204)	-0.0076 (0.0205)
Population Growth Rate	0.0459 (0.0295)	0.03988 (0.0296)
HS Graduation Rate	-0.0356 (0.0121)***	-0.0275 (0.0122)**
Unemployment Rate	-0.0048 (0.0006)***	-0.0049 (0.0006)***
Constant	-0.0083 (0.0137)	-0.2928 (0.0761)***
Spatial Lag	-0.0061 (0.0038)	-0.0068 (0.0039)*

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

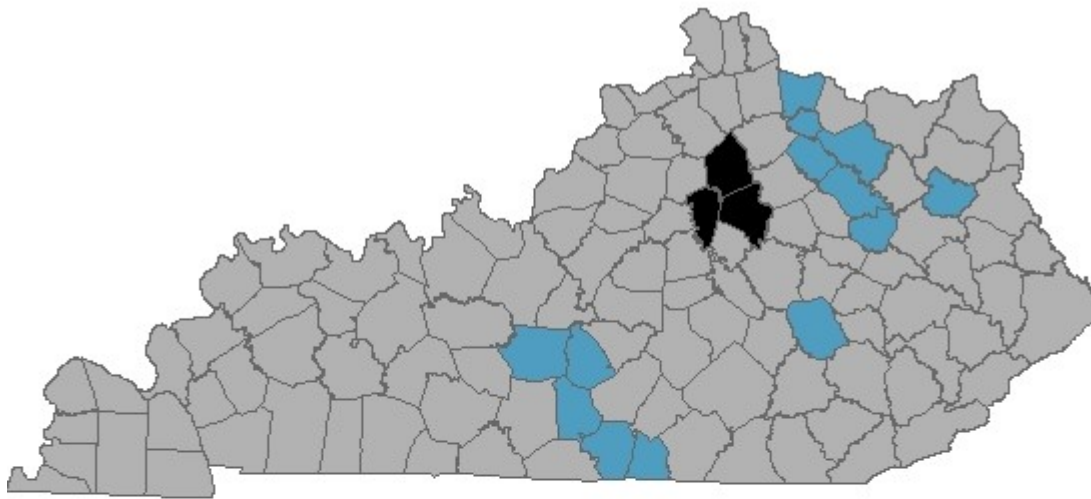
Table 4.8: Spatial IV Estimates on Deposit Equations

Variable	Log Deposits	Ratio of Deposits to Personal Income
Log Deposits (t-1)	0.9641 (0.0055)***	
Ratio of Deposits to Pers. Inc. (t-1)		0.9616 (0.0060)***
Log Level of Earned Income	-0.0515 (0.1175)	0.0137 (0.0130)
Log Population	0.0057 (0.0074)	-0.0082 (0.0024)***
Share of Transfer Payments in Pers. Inc.	-0.0484 (0.0283)*	0.0092 (0.0078)
Constant	0.0674 (0.1173)	-0.0088 (0.0129)
Spatial Lag	-0.0084 (0.0110)	-0.0338437 (0.0190)*

***, ** and * refer to p-value < 1%, p-value < 5% and p-value < 10%, respectively.

Figure 4.2: LISA map for Earned Income Per Worker with Inverse Distance Weighting for 1995

Figure 1



Legend

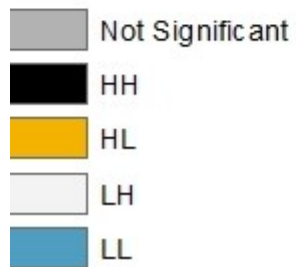
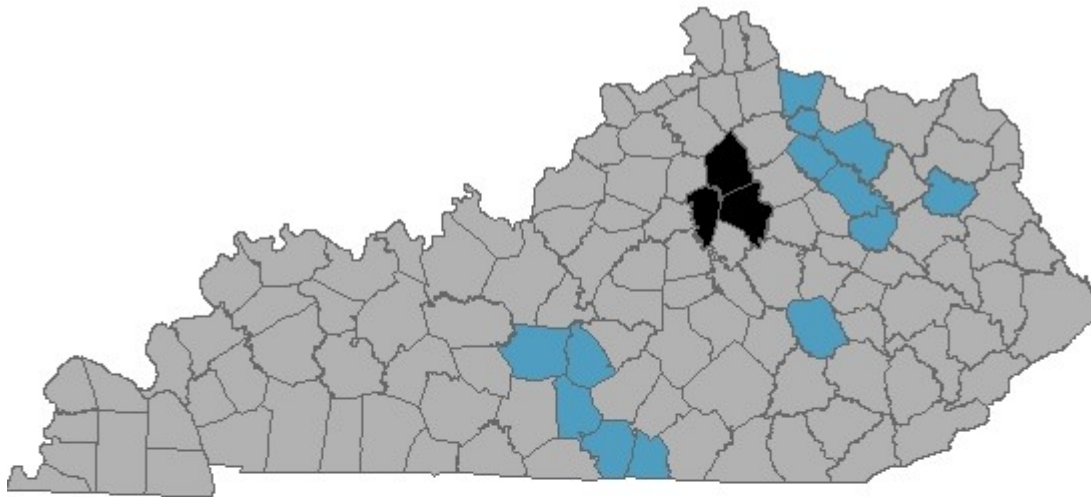


Figure 4.3: LISA map for Earned Income Per Worker with Inverse Distance Weighting for 2001

Figure 2



Legend

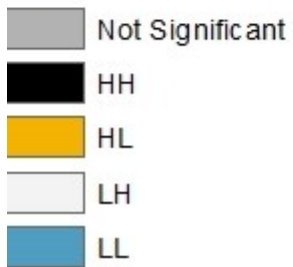
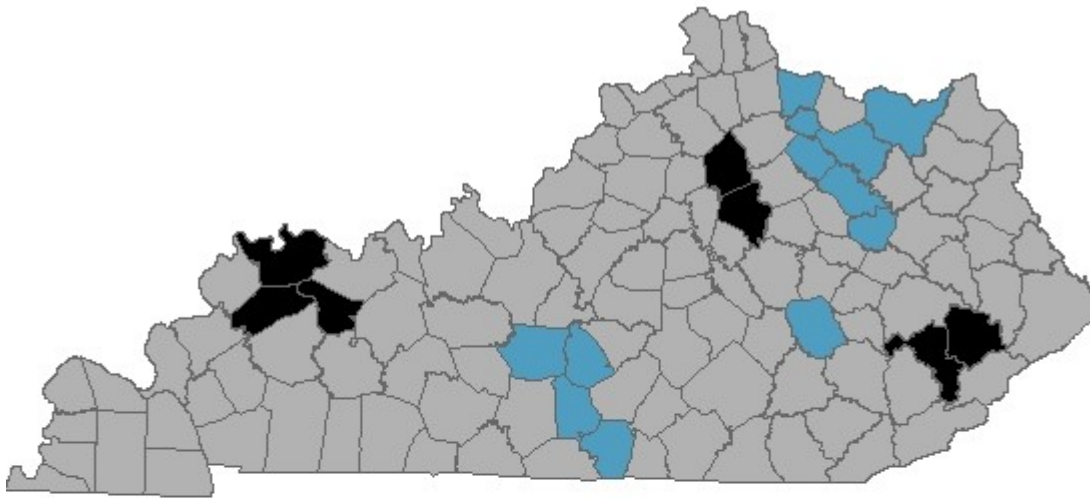


Figure 4.4: LISA map for Earned Income Per Worker with Inverse Distance Weighting for 2008

Figure 3



Legend

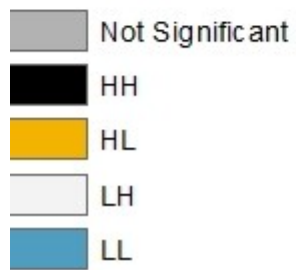
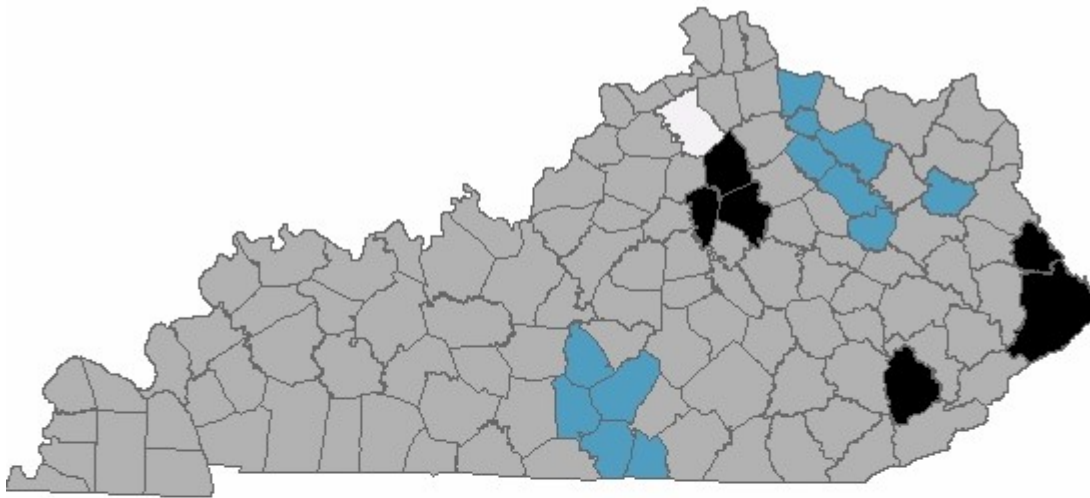


Figure 4.5: LISA map for Earned Income Per Worker with Polygon Contiguity Weighting for 1995

Figure 4



Legend

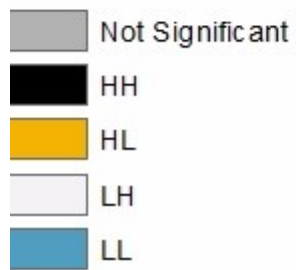
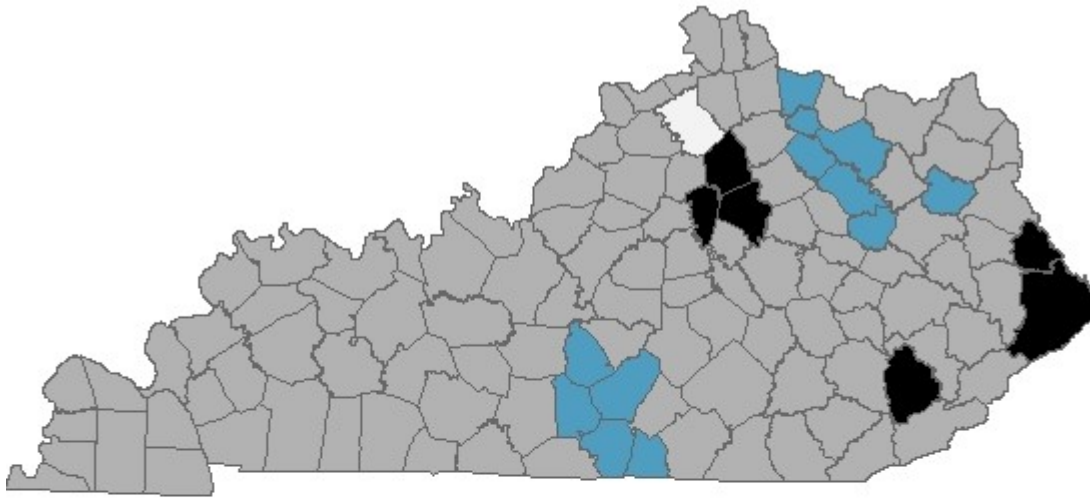


Figure 4.6: LISA map for Earned Income Per Worker with Polygon Contiguity Weighting for 2001

Figure 5



Legend

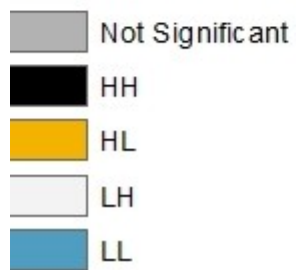
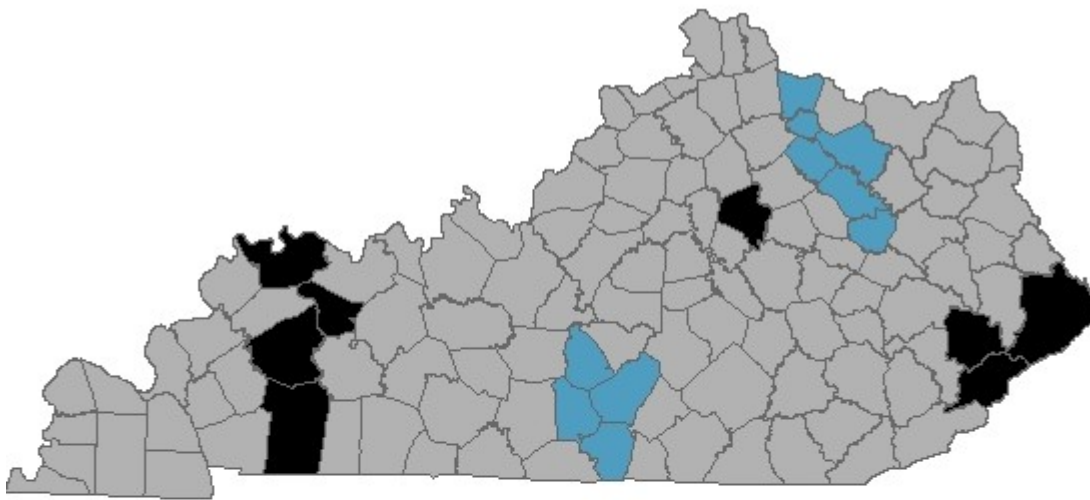


Figure 4.7: LISA map for Logged Earned Income Per Worker with Polygon Contiguity Weighting for 2008

Figure 6



Legend

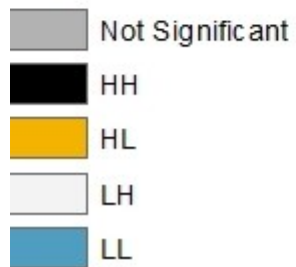
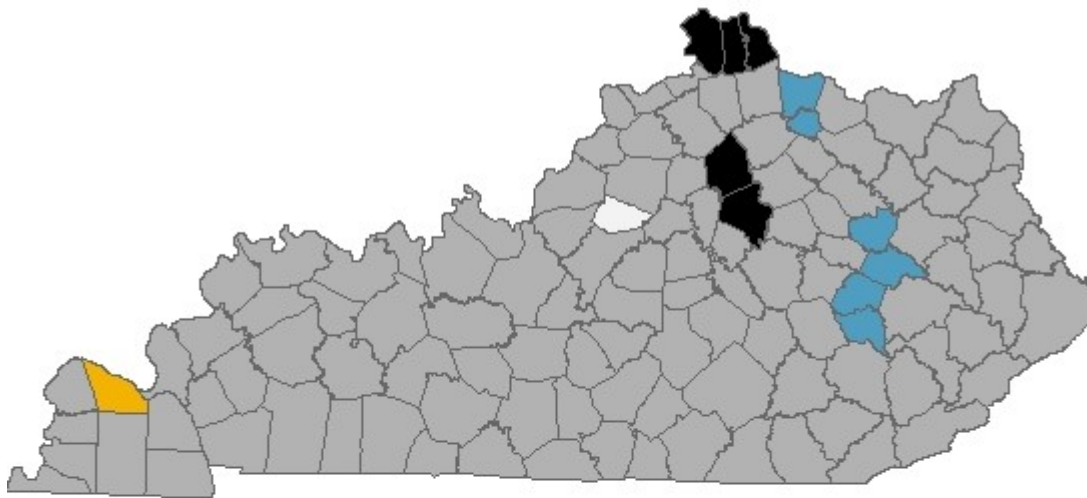


Figure 4.8: LISA map for Logged Earned Income with Inverse Distance Weighting for 1995

Figure 7



Legend

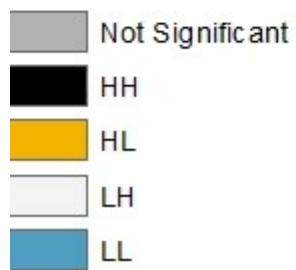
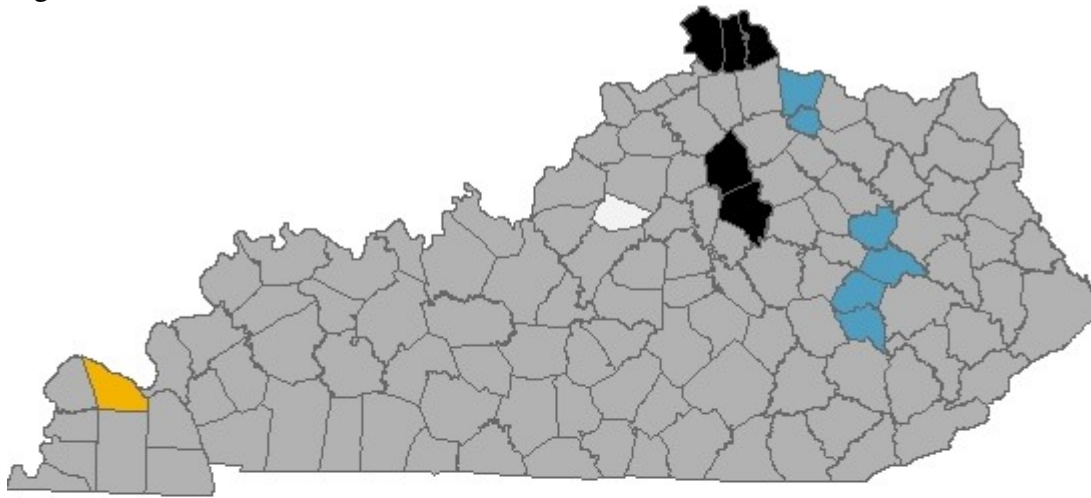


Figure 4.9: LISA map for Logged Earned Income with Inverse Distance Weighting for 2001

Figure 8



Legend

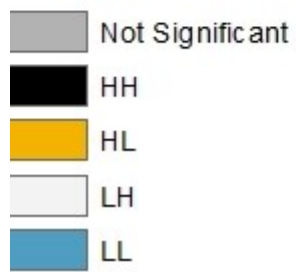
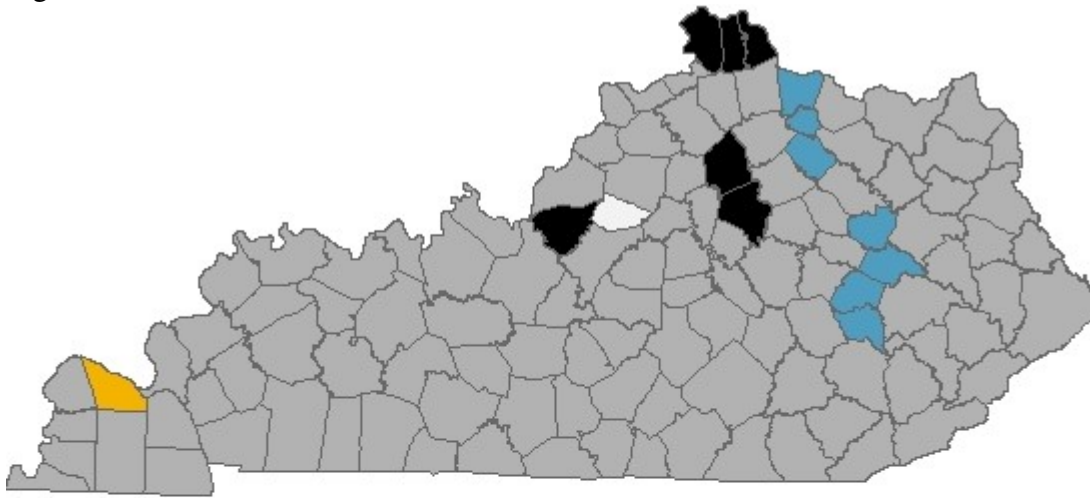


Figure 4.10: LISA map for Logged Earned Income with Inverse Distance Weighting for 2008

Figure 9



Legend

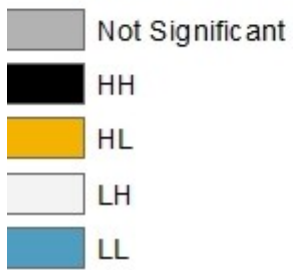
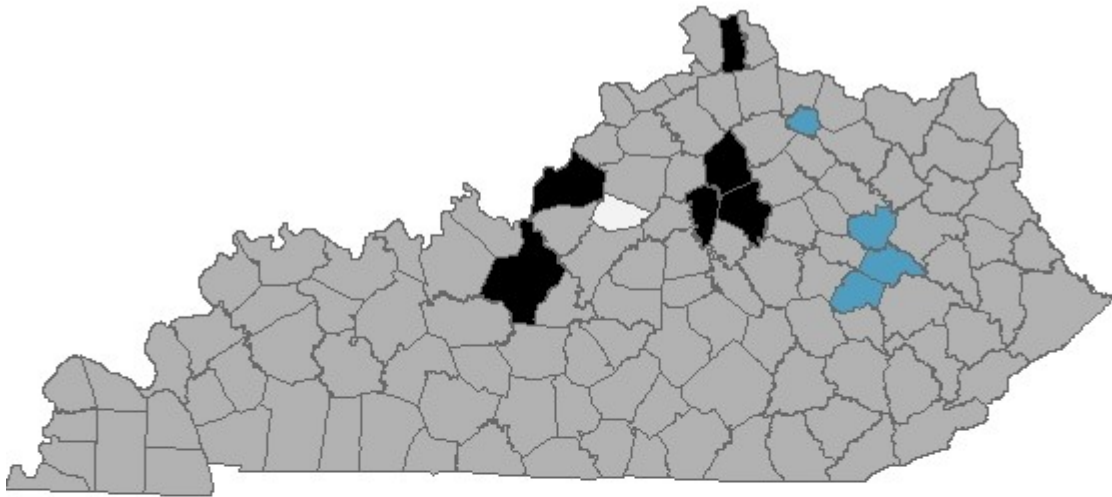


Figure 4.11: LISA map for Logged Earned Income with Polygon Contiguity Weighting for 1995

Figure 10



Legend


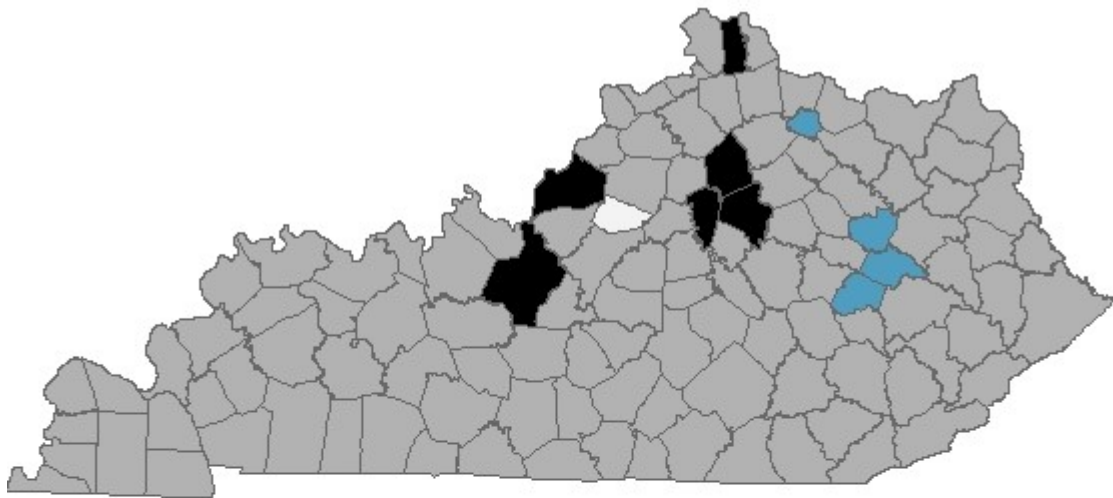
-  Not Significant
-  HH
-  HL
-  LH
-  LL
-  County_Poly_1z

Figure 4.12: LISA map for Logged Earned Income with Polygon Contiguity Weighting for 2001

Figure 11



Legend

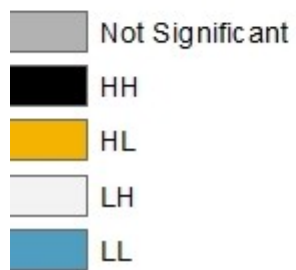
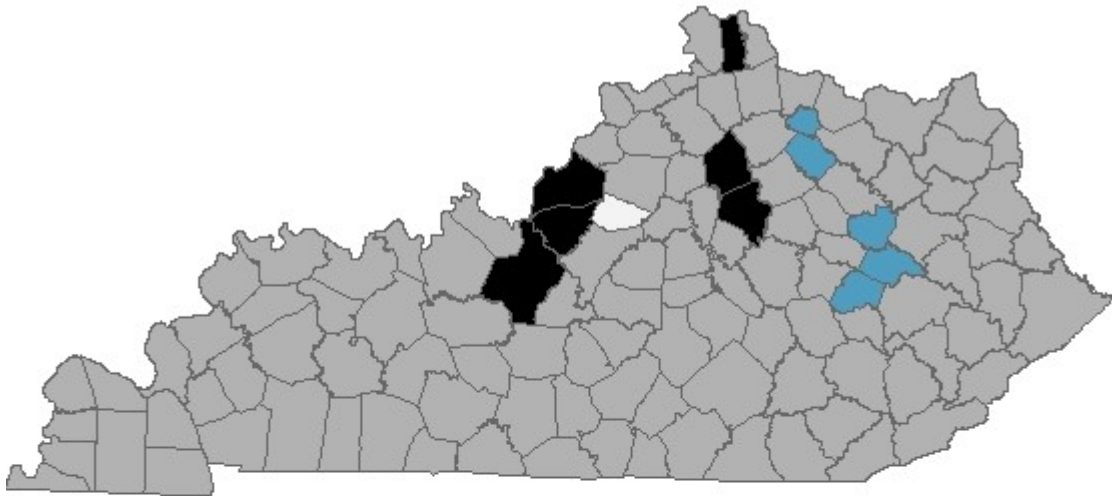
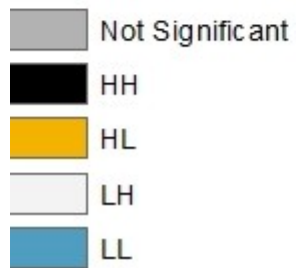


Figure 4.13: LISA map for Logged Earned Income with Polygon Contiguity Weighting for 2008

Figure 12



Legend



Chapter 5 Conclusions

5.1 Review of Results

The literature review in chapter 2 provides reasons to suspect that financial development is a driver of growth. First, there is the macroeconomics literature which finds that the relationship holds at a large scale. The few studies on smaller regions find support for the hypothesis that financial development drives growth. The rest of the chapter explores possible explanations. The short summary is that entrepreneurs and existing firms need to borrow to partially fund new businesses or expansions. Banks have pools of liquid liabilities that they want to turn into assets. Thus they lend from their deposits. The firms then take the borrowed funds to either get started or expand. This grows the local economy. Smaller, local banks may have an advantage with their understanding of the local economy and established social networks that allow them to develop superior lending information. Larger banks have an advantage by having large sums to lend, but may lack local information. This makes the likely effect of having a large bank move into a county difficult to predict.

Chapter 3 presents a model that marries endogenous growth with the New Economic Geography to address financial development and economic growth. In particular it modifies the Martin and Ottaviano (2001) model by allowing borrowing of the costs of marginal innovation and firm formation. If one region starts out more agglomerated than the other, investment will tend to concentrate in the more agglomerated area anyway, but a high concentration of financial development can reinforce this process. This is because larger banks can write larger loans, because there are more banks so that a borrower can string together a set of loans and because monitoring and due diligence costs are higher when lending out of one's home region.

Chapter 4 is a set of empirical studies on the effects of financial development on growth. The financial development variables focused on deposits since they are the most liquid of bank assets. Equation-by-equation fixed effects and GMM estimators were first used to establish baseline estimates. Then instrumental variables estimators were used to control for endogeneity. One of these was a standard IV estimator while the other was a spatial GMM estimator that admits instrumental variables was used for spatially corrected estimates. This was necessary as pockets of spatial autocorrelation were detected with LISA tests. In general, deposits and deposits as a fraction of personal income were found to be highly correlated with income growth, both in terms of levels and per-worker incomes. In general, the converse equations with deposits as endogenous variables and incomes as independent variables had somewhat less significant estimates. The evidence presented suggests that the size of the banking industry in a county is a driver of economic growth. Income growth also increases the size of the bank. These forces form a virtuous circle of growth.

The results of tests of the hypotheses outlined in the introduction follow:

- I. Schumpeter Hypothesis: The size of the banking industry in a region has a positive effect on economic growth.
 - A. The sum of deposits in a region has a positive effect on earned income growth. The majority of the regression results support this hypothesis with support generally strengthening as econometric techniques better suited to the data were applied.
 - B. The sum of deposits in a region has a positive effect on per-worker earned income growth. Again, the majority of the empirical results support this hypothesis. Spatial results were not possible as the regression matrices were not invertible by R.

- C. The ratio of the sum of deposits to personal income has a positive effect on earned income growth. The majority of these results were supported by the econometrics. These results were somewhat more significant, which suggests that this may be the better of the two bank size variables. In particular, this result was significant at less than 1% in the spatial estimate, while its counterpart in A., above, was not significant.
- D. The ratio of the sum of deposits to personal income has a positive effect on per-worker earned income growth. Again, these results generally supported this hypothesis. Again, these results were mostly significant at better than 5%. As in B., spatial estimates were not possible since R could not invert the regression matrix.

II. Hypotheses on deposits.

- A. Earned income levels are positively correlated with growth in deposits. There was support for this hypothesis, but when simultaneous equations techniques were used, the significance disappeared.
- B. Per-worker earned income levels are positively correlated with growth in deposits. This hypothesis was generally supported and this hypothesis had the strongest support with simultaneous equations techniques. The simultaneous spatial case was not tested since it's companion equation on the growth of per-worker earned income was not estimable in R.
- C. The ratio of transfer payments to personal income is positively correlated with growth in deposits. The majority of estimates did not find a statistically significant relationship here.

- D. The ratio of transfer payments to personal income is positively correlated with growth in the ratio of deposits to personal income. There was stronger support for this hypothesis than for C. The support disappeared under the simultaneous and spatial specification.
 - E. The level of population is positively correlated with deposits. There was general support for this hypothesis but this variable was not significant under the spatial IV estimator.
 - F. The level of population is positively correlated with the ratio of deposits to personal income. This was significant including the spatial estimate.
- III. “Frank Capra” Hypothesis: the structure of the banking industry has an effect on economic growth.
- A. The share of a county’s deposits in large multi-state banks negatively affects total earned income growth. There was little support for this hypothesis.
 - B. The share of a county’s deposits in large multi-state banks negatively affects per-worker income growth. There was little support for this hypothesis.
- IV. Spatial specification is a concern in understanding county level banking markets.
- A. Some counties have earned income growth that covaries with the earned income growth of other counties. This was not a uniform result. The LISA tests indicated pockets of both high income counties neighboring other high income counties and low income

counties that neighbor other low income counties. These results suggest that in these pockets, this hypothesis is true.

B. Some counties have per-worker earned income growth that is correlated with the earned income growth of other counties. These results were just like those in A. This was not a uniform result. The LISA tests indicated pockets of both high income counties neighboring other high income counties and low income counties that neighbor other low income counties. Again, there is evidence to support the hypothesis in isolated groups of counties.

V. Control Hypotheses: These are other sources of economic growth. If the signs of these parameters are not as expected, then there are likely estimator problems or specification problems.

A. Population growth is positively correlated with earned income growth. This was generally not significant in the estimates.

B. Population growth is positively correlated with per-worker earned income growth. Again this was generally not significant in the estimates.

C. High school graduation rates are positively correlated with earned income growth. This was significant in the simultaneous equations estimates but turned negative in the spatial estimates. This could be due to the delicate nature of GMM estimators.

D. High school graduation rates are positively correlated with per-worker earned income growth. Again this was mainly significant in the simultaneous equations estimates and turned negative in the spatial estimate. This is again likely due to the delicate nature of GMM estimators.

- E. Unemployment rates are negatively correlated with earned income growth. This was generally quite significant with the expected negative signs.
- F. Unemployment rates are negatively correlated with per-worker earned income growth. Again this was generally quite significant with the negative signs one would expect.

5.2 Unexplored Questions

Some questions posed by this research do not lend themselves to satisfying answers. Two particular issues are entrepreneurship and social capital. They are hard to define much less explore in a rigorous and quantitative fashion.

First, entrepreneurship is a word that appears occasionally in the dissertation but does not really get explored. Since the precise growth mechanism is treated as a “black box”, we know that entrepreneurship is in there, but a detailed exploration is not needed to get results. One reason is that entrepreneurship is hard to define and harder to quantify. The debate over Schumpeterian versus Kirznerian entrepreneurship was covered in the introduction. Schumpeter reserved the word “entrepreneurship” for the starting of whole new industries that replace old ones. This led to his embracing of “creative destruction”, that is the replacement of old industries by new ones, as the principle source of economic growth. This is indeed a powerful source of positive growth shocks as witnessed by the 1990’s Internet boom. Kirzner’s definition of entrepreneurship is weak enough to encompass almost any form of business activity as a form of entrepreneurship. Any time a firm reacts to a new piece of information, that is entrepreneurship in Kirzner’s thinking, especially if the firm is either first to react or is the sole possessor of the information. Thus, most measures of economic growth due to business activity are functions of entrepreneurship, to some degree. Either case gives us an epistemological problem. We can see the results of entrepreneur-

ship but not the sources. Until better measures become available this will remain a gap in the literature.

The second unexplored question is about how social capital plays into the finance and growth nexus. This does not appear to be a major concern in macroeconomics. Perhaps it should be since the world of high international finance is a small community. It does become a very serious issue in local economic development. The literature review makes much of soft information. Social capital networks are the mechanisms for obtaining soft information. Soft information is acquired datum by datum in club meetings, discussions with neighbors, long-term casual observation and, yes, even on the golf course. If a banker knows a potential borrower through shared religious affiliation, through school ties or by reputation through mutual friends and family members, then that banker has a comparative information advantage over a banker working strictly with credit scores and financial reports. Still, how do we generate a measure of social capital that is rich enough to generate data useful to an economist?

Why are these issues so important to sub-national growth? Putnam (2000) showed that regions with lower social capital experience lower economic growth. One likely explanation from an economic standpoint is that without strong social ties an agent will face a smaller flow of economic information. Even an off-hand comment about the lack or overabundance of a good can lead, respectively, to starting a new firm or abandoning a plan to start a firm. Also, since soft lending information is often developed through social networks, a borrower with insufficient social capital may have greater difficulty borrowing from a small bank than a borrower with more social capital.

5.3 Policy Implications

There are several predictions from this research that have policy implications. First, local lending seems useful in the economic development of counties. Secondly, the arrival of

large, multi-state banks may have a neutral or mildly negative impact on economic growth, at least for the first year or so.

A bank's *raison d'être* is to be an intermediary between individual depositors with cash available for lending and borrowers who need those funds. In other words they are agents who intermediate the local capital markets. Yet, banks are in a difficult position as regards local lending. If a bank does not lend aggressively enough, it may be criticized for not contributing to the community's development. In other words, it is not risking enough. If loans go bad, then the bank is criticized for taking bad risks. Banks are the biggest local lenders, but they may not be the correct institutions for lending in local development. Yet, where else would a community find such a large pool of locally generated funds? Might there be a new sort of institution that could be designed to address these market failures?

Secondly, banking authorities may need to be more cautious in approving mergers between large banks and small banks. Even though this dissertation did not provide clear cut evidence that large banks negatively influence growth, it does raise the question and extend the debate. If the presence of large banks does turn out to be a negative influence, then mergers may need to be scrutinized more carefully and perhaps denied more frequently. The sign change in the econometric results between the current and lagged periods suggest that the issue may be one of an adjustment period while the new bank weaves itself into the economy. This would be in is consistent with some other research, such as Peek and Rosengren (1998) or Strahan and Weston (1998). One solution might be to slow the pace of a merger. A slowing of the merger might allow the new bank to develop business relationships before it begins to manage local funds. This may smooth the merger process and reduce possible negative effects from the adjustment.

Another result is that lending information seems to be costly. This implies that interest rates are higher than the perfectly competitive equilibrium rate. Therefore, borrowers in regions where lending information is costly to lenders, such as very rural areas, will pay higher interest rates than borrowers in less costly regions. This implies, *ceteris paribus*,

unequal access to credit in very rural regions. Unequal access to credit would then imply, *ceteris paribus*, that rural regions will lag behind urban or less rural regions in growth. If rural areas are to enjoy equal access to credit, then subsidies to lenders for information collection might be a solution. For example, further research and data collection by Federal and state agencies would make information that might aid in lending decisions publicly available.

Finally, this dissertation has focused exclusively on debt financing since equity institutions are not as well developed in rural areas. In an era when government is facing high deficits and banks are recovering from a credit bubble, debt financing may not be the correct answer for financing rural entrepreneurship. Perhaps there is a market for equity investment provided that knowledgeable people can be found to administer those funds. Even though such a firm would also face high information costs, the hope would be that equity stakes would be sufficiently lucrative to cover those costs.

5.4 Future Research

The first need for future empirical research is more data. With only fourteen years worth of data, the panel estimation techniques used in chapter 5 are barely adequate. Thirty years worth would be ideal as that would allow the time series elements to be more robust. With more years of data, the Nickell bias issue would be further suppressed. Also, more sophisticated analysis of time lags would be possible.

In general, there is a need for more efficient estimators. There are estimators like the Feasible Generalized Spatial Three Stage Least Squares (FGS3SLS) estimator that would be more efficient, but, as of this writing, such an estimator would require considerable computer programming in a language like Matlab as it is not implemented as a fully supported feature in any econometric software. A good estimator would be one that combines dynamics, simultaneous equations and spatial effects all into one. There is active research on this question but, so far, a workable estimator has not been forthcoming.

Another approach might be to try Geographically Weighted Regression (GWR). This is a kernel regression that uses a distance-decay function as the kernel. One issue is the panel nature of the data. The author is not aware of any literature that extends GWR into the panel realm. One possibility might be to use a LSDV scheme under GWR. Before trusting such results, a Monte Carlo study of such an estimator would have to be done to see if the results would be reasonable.

A second extension would be to try the model on other states. There is nothing in the model that is specific to Kentucky. The main concern is that in the western states tend to have fewer and larger counties than eastern states. This means that counties may no longer be the best geographical units. Since counties are the smallest geographical units for which the full dataset can be obtained this is a serious issue.

Another reason to examine other states is due to variations in state banking laws. Since each state has considerable power to regulate lending, the effects of business lending on economic growth might have some variation from state to state. Of particular interest would be Utah since that state has a particularly stringent set of usury laws. This may reduce the availability of loans to the riskiest borrowers and place Utah at a competitive disadvantage to states with looser standards.

Appendix A. Standard Assumptions in the New Economic Geography

New Economic Geography models start with three rather strong assumptions. These are increasing returns to scale, transportation costs and factor mobility. These set up the choice problems and make the model tractable.

Increasing Returns to Scale, the Home Market Effect and Monopolistic Competition

The first assumption in NEG models is that of increasing returns. This is imposed on each region and provides an attraction for factors of production. This sets up competition between regions for factors of production and creates a the choice problem for producers at the heart of the model. If one region has increasing returns to scale and the other does not, then all the activity goes to the region with increasing returns. The region without is abandoned by producers. This is known as *catastrophic agglomeration* or the “black hole” effect.

Increasing returns also imply that comparative advantage may not tell the whole story. Under increasing returns, there is a tendency to produce a good where it is under the greatest demand, not where relative costs of production are lowest. This is known as the “home market effect.”

How do we operationalize increasing returns? We need to use a consumer demand system that features inverse elasticity pricing. It is also useful to have a variety of goods to trade between regions. Dixit and Stiglitz (1977) described a monopolistic competition model that is suitable for general equilibrium modeling. It is not overly complicated, but it does have enough detail to provide a rich trade environment.

Let there be $N + 1$ goods. Good x_0 is a numeraire good. Goods $x_1 \dots x_N$ are varieties of the monopolistically competitive good. The overall utility function is a Cobb-Douglas

type. Furthermore, let the demand system for the manufactured good be of the constant elasticity of substitution (CES) type. In general, the utility function would have a form of

$$u = U \left(x_0, \left[\sum_{i=1}^N x_i^\rho \right]^{\frac{1}{\rho}} \right). \quad (1)$$

where, ρ is the “love of variety” parameter with $0 < \rho < 1$. Furthermore, $U(\cdot)$ is homothetic.

The particular form of the utility function that is used in most of the NEG literature is something like

$$U = C_M^\mu C_A^{1-\mu} \quad (2)$$

where M is the variegated good, A is the numeraire good, μ is the share of income given to C_M , C_A is the consumption of the numeraire good and C_M is the consumption of a composite good made of varieties of good M . This is colloquially known as the “Dixit-Stiglitz lite” (Foltyn, 2009) form. C_M is given by

$$C_M = \left[\sum_{i=1}^N c_i^\rho \right]^{1/\rho} \quad (3)$$

where c_i is the demand for the i th variety of the manufactured good and ρ is the “love of variety” parameter.

We can derive the demand functions through a two-stage constrained optimization process. The first stage is the following optimization problem (Foltyn, 2009):

$$\max_{C_A, C_M} U = C_M^\mu C_A^{1-\mu} \quad (4)$$

$$\text{subject to : } C_A + \sum_{i=1}^N p_i c_i = I$$

We can solve this with the usual Lagrange Multiplier technique (Foltyn, 2009).

$$\mathcal{L} = C_A^{1-\mu} \left[\sum_{i=1}^N c_i^\rho \right]^{\mu/\rho} + \lambda \left[I - C_A - \sum_{i=1}^N p_i c_i \right] \quad (5)$$

The first order condition with respect to c_i is

$$\frac{\partial \mathcal{L}}{\partial c_i} = C_A^{1-\mu} \frac{\mu}{\rho} \left[\sum_{i=1}^N c_i^\rho \right]^{(\mu-\rho)/\rho} \rho c_i^{\rho-1} - \lambda p_i = 0 \quad (6)$$

Now, dividing the first order conditions for the i th and j th variety of the manufactured good gives:

$$\frac{c_i}{c_j} = \left[\frac{p_i}{p_j} \right]^{\frac{1}{\rho-1}}. \quad (7)$$

Multiply both sides by p_i :

$$p_i c_i = p_i^{\frac{\rho}{\rho-1}} p_j^{-\frac{1}{\rho-1}} c_j \quad (8)$$

and sum over i :

$$I - C_A = \sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}} p_j^{-\frac{1}{\rho-1}} c_j. \quad (9)$$

Then,

$$c_j = \frac{(I - C_A) p_j^{-\frac{1}{\rho-1}}}{\sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}}}. \quad (10)$$

Now, the solution for C_A is the well-known solution for a demand function under Cobb-Douglas utility

$$C_A = (1 - \mu)I. \quad (11)$$

If we let I be numeraire, then,

$$C_A = (1 - \mu). \quad (12)$$

So, c_j simplifies to

$$c_j = \frac{\mu I p_j^{-\frac{1}{\rho-1}}}{\sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}}}. \quad (13)$$

Now, since the varieties of the manufactured good are close substitutes, we should check the elasticity of substitution, σ . The easiest thing is to do this from equation (8):

$$\begin{aligned} \sigma &= \frac{\partial(c_i/c_j)}{\partial(p_i/p_j)} \frac{(p_i/p_j)}{(c_i/c_j)} = \frac{\partial}{\partial(p_i/p_j)} \left(\left[\frac{p_i}{p_j} \right]^{\frac{1}{\rho-1}} \right) \left(\frac{p_i}{p_j} \left[\frac{p_i}{p_j} \right]^{-\frac{1}{\rho-1}} \right) \\ &= \frac{1}{\rho-1} \left(\frac{p_i}{p_j} \right)^{\frac{1}{\rho-1}-1} \frac{p_i}{p_j} \left(\frac{p_i}{p_j} \right)^{-\frac{1}{\rho-1}} = \frac{1}{\rho-1} \end{aligned} \quad (14)$$

It will also be useful to check the own-price elasticity of a variety:

$$\begin{aligned} \epsilon_d &= \frac{\partial c_j}{\partial p_j} \frac{p_j}{c_j} = \frac{\partial}{\partial p_j} \left[\frac{\mu I p_j^{-\frac{1}{\rho-1}}}{\sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}}} \right] p_j \frac{\sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}}}{\mu I p_j^{-\frac{1}{\rho-1}}} \\ &= -\frac{1}{\rho-1} \frac{\mu I p_j^{-\frac{1}{\rho-1}-1}}{\sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}}} p_j \frac{\sum_{i=1}^N p_i^{\frac{\rho}{\rho-1}}}{\mu I p_j^{-\frac{1}{\rho-1}}} = -\frac{1}{\rho-1} = -\sigma \end{aligned} \quad (15)$$

The profit maximization problem in the manufacturing market takes the form

$$\max_{c_j} \Pi = p(c_j)c_j - MCc_j - F, \quad (16)$$

where MC is the marginal cost of the j th variety and F is the fixed cost of production.

So, the price of c_j follows the well-known inverse elasticity rule. Thus,

$$p_j = \frac{MC}{\left[1 - \frac{1}{\sigma}\right]} = \left(\frac{\sigma}{\sigma-1}\right) MC. \quad (17)$$

These basics are sufficient to provide a description of a market for goods in the NEG environment.

Iceberg Goods, Trade Friction and Trade Freedom

The next assumption is that of trade frictions. Without this assumption, given that the goods may not be perfect substitutes, consumers would have no reason to substitute one variety of the manufactured good or another. They could instead costlessly shop for the good in the other region.

The typical NEG model uses iceberg goods to model transportation costs (Samuelson, 1954). An iceberg good “melts” in transit as if it were a giant block of ice on the back of a truck on a hot summer day. Only part of the shipment will arrive at the destination. More formally, for one unit of the good to arrive at its destination, the shipper must send out τ units of the good, where $\tau \geq 1$. One unit arrives and $\tau - 1$ units disappear in transit.

The iceberg assumption can also be used to create an index of trade freedom, $\delta = \tau^{1-\sigma}$. This function takes values between zero and one. A value of one implies autarky, or no trade whatsoever. $\delta = 0$ means frictionless trade between regions.

Factor Mobility

The third ingredient in NEG models is one or more mobile factors of production. The factors move between regions based on the endogenous economic pressures generated in the model. For example, in the Krugman (1991) model below, differences in real wages cause manufacturing workers to migrate between regions. In fact, the level of agglomeration is a function of the region’s level of mobile factors. In some models, this is a simple identity. In other cases, the process is more involved as factors and firms chase each other between regions.

Appendix B. Krugman (1991): the First NEG Model

Paul Krugman was the first to pull together all of these assumptions into a complete model in his paper, “Increasing Returns and Economic Geography” (1991). His model of labor mobility between a core and a periphery paints a complete picture of location decisions even if it does not easily yield an analytic solution.

Krugman begins with the Cobb-Douglas utility function as specified above,

$$U = C_M^\mu C_A^{1-\mu}, \quad (18)$$

where C_M is the consumption of the “manufactured” good and C_A is consumption of the “agricultural good. μ is the share of income used to buy the manufactured good which makes $1 - \mu$ the share of income used on the agricultural good.

The market for the agricultural good operates under constant returns to scale and perfect competition. The market for the manufactured good operates under increasing returns to scale. This rules out perfect competition. This is why we assume Dixit-Stiglitz (1977) monopolistic competition. Let there be N firms in the manufactured good market. Each firm produces one variety of the M good, so the number of firms equals the number of varieties. This gives us an aggregate demand for the manufactured good of

$$C_M = \left[\sum_{i=1}^N C_i^{(1-\sigma)/\sigma} \right]^{\sigma/(1-\sigma)} \quad (19)$$

where C_M is the consumption of M, N is the number of firms in the market, C_i is the consumption of one particular variety of the manufactured good and σ is the elasticity of substitution between varieties of the the manufactured good. Note that N is the number of firms in both regions. That means

$$N = n_1 + n_2, \quad (20)$$

where n_1 is the number of firms in region 1 and n_2 is the number of firms in region 2.

There are two regions in this model that we shall call region 1 and region 2. The factors of production are two classes of labor, peasants and workers. Peasants are agricultural workers and are immobile. So, both regions have equal endowments of peasants of $(1 - \mu)/2$ each. Workers perform manufacturing labor and are able to move between the regions. Let L_1 and L_2 be the number of manufacturing workers in region 1 and region 2 respectively. If the total worker population is μ then

$$L_1 + L_2 = \mu. \quad (21)$$

$$L_{Mi} = \alpha + \beta x_i, \quad (22)$$

where L_{Mi} is the total labor used in a manufacturing firm, α is the labor not directly involved in production of the manufactured good (security guards, maintenance staff, accountants, etc.), and βx_i is the labor needed to produce x_i units of the manufactured good.

The price of the manufactured good follows inverse elasticity pricing, so the profit maximizing price charged by a manufacturing firm in region 1 is

$$p_1 = \left(\frac{\sigma}{\sigma - 1} \right) w_1 \beta, \quad (23)$$

where σ is the elasticity of substitution between varieties of the manufactured good, w_1 is the manufacturing wage in region 1 and β is the labor needed to make one unit of the manufactured good. A similar equation holds for region 2. So the relative wages and prices between regions one and two are

$$\frac{p_1}{p_2} = \frac{w_1}{w_2} \quad (24)$$

Free entry into the manufacturing market drives profits to zero. So, each firm has revenue $p_1 x_i$ and costs $w_1 L_{Mi}$. This means,

$$(p_1 - \beta w_1)x_1 = \alpha w_1, \quad (25)$$

where αw_1 is the fixed labor cost of operating the firm. Likewise

$$(p_2 - \beta w_2)x_2 = \alpha w_2. \quad (26)$$

Solving simultaneously yields

$$x_1 = x_2 = \frac{\alpha(\sigma - 1)}{\beta}. \quad (27)$$

Since output is the same in both regions, then the number of firms is proportionate to the number of manufacturing workers and

$$\frac{n_1}{n_2} = \frac{L_1}{L_2}. \quad (28)$$

The structure is now complete and we can turn to the equilibrium. First, we get the ratio of region 1's consumption of its own manufacturing production to its consumption of region 2 manufacturing product.

$$\frac{c_{11}}{c_{12}} = \left(\frac{p_1 \tau}{p_2} \right)^{-\sigma} = \left(\frac{w_1 \tau}{w_2} \right)^{-\sigma} \quad (29)$$

where, c_{11} is the consumption of region 1 manufactured goods in region 1 and c_{12} is the consumption of the region 2 manufactured good in region 1. p_1 is the price of region 1 manufactured goods. The region 2 price for a region 1 manufactured good is p_1/τ . The price of a manufactured good from region 2 is p_2 in region 2 and p_2/τ in region 1. w_1 and w_2 are the manufacturing wages in regions 1 and 2.

Let z_{11} be the ratio of expenditures by region 1 consumers on manufactured goods from region 1 to expenditures by region 1 consumers on region 2 manufactured goods. Then

$$z_{11} = \left(\frac{n_1}{n_2} \right) \left(\frac{p_1 \tau}{p_2} \right) \left(\frac{c_{11}}{c_{12}} \right) = \left(\frac{L_1}{L_2} \right) \left(\frac{w_1 \tau}{w_2} \right)^{-(\sigma-1)} \quad (30)$$

Likewise, the ratio of region 2 spending on region 1 manufactured goods to spending on region 2 manufactured goods is

$$z_{12} = \left(\frac{L_1}{L_2}\right) \left(\frac{w_1}{w_2\tau}\right)^{-(\sigma-1)}. \quad (31)$$

Now, define Y_1 and Y_2 as the regional incomes of regions 1 and 2 respectively including peasants. Then the income of a region 1 worker is

$$w_1L_1 = \mu \left[\left(\frac{z_{11}}{1+z_{11}}\right) Y_1 + \left(\frac{z_{12}}{1+z_{12}}\right) Y_2 \right]. \quad (32)$$

Similarly, the income of a region 2 worker is

$$w_2L_2 = \mu \left[\left(\frac{1}{1+z_{11}}\right) Y_1 + \left(\frac{1}{1+z_{12}}\right) Y_2 \right]. \quad (33)$$

We can define the regional incomes, Y_1 and Y_2 as:

$$Y_1 = \frac{1-\mu}{2} + w_1L_1 \quad (34)$$

and

$$Y_2 = \frac{1-\mu}{2} + w_2L_2 \quad (35)$$

where, Y_1 is the regional income in region 1 and Y_2 is the regional income in region 2. As stated above, there are $\frac{1-\mu}{2}$ peasants who earn numeraire wages. These equations, (28)-(34) are sufficient to find equilibrium values of w_1 , w_2 , z_{11} , z_{12} , Y_1 , and Y_2 given L_1 and L_2 . Note that if $L_1 = L_2$ then $w_1 = w_2$. If labor migrates to region 1, w_1/w_2 can either increase or decrease. Why? Because there is a tension between the Home Market Effect and the extent of competition for labor. The Home Market Effect makes wages higher in the larger region, *ceteris paribus*. In the smaller region, however, there is less competition for labor, so wages would tend to be higher, *ceteris paribus*. There is a trade-off between proximity to the larger market and lack of competition for the smaller market. Relative wages are set

So far, so good, but workers are not interested in nominal wages. They are interested in real wages. To calculate real wages, price indices are necessary. Define

$$f \equiv \frac{L_1}{\mu} \quad (36)$$

which is the share of manufacturing labor in region 1. This makes $1 - f$ the share of manufacturing labor in region 2. The price indices are

$$P_1 = \left[f w_1^{-(\sigma-1)} + (1-f) \left(\frac{w_2}{\tau} \right)^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \quad (37)$$

in region 1 and

$$P_2 = \left[f \left(\frac{w_1}{\tau} \right)^{-(\sigma-1)} + (1-f) w_2^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \quad (38)$$

in region 2. This makes real wages

$$\omega_1 = w_1 P_1^{-\mu} \quad (39)$$

in region 1 and

$$\omega_2 = w_2 P_2^{-\mu} \quad (40)$$

in region 2. Now, workers will make location decisions by comparing real wages. That is they will migrate based on the ratio of real wages, ω_1/ω_2 and f , region 1's share of labor. If the ratio is equal to one, workers will be indifferent to location and will not migrate. $f = \frac{1}{2}$ in this case. If ω_1/ω_2 decreases with f then if there are more workers in one region than the other, workers will migrate to the region with fewer workers. If ω_1/ω_2 increases with f , then workers will migrate into the region with more workers. In other words, the degree of agglomeration increases. and the regions will converge. Here we see the essence of the NEG models. Agglomeration is endogenously determined. In this model, the location of

workers is determined by ratio of real wages. This ratio is endogenously determined by the countervailing pressures of the Home Market Effect and the effects of price indices.

There is one last critical question: under a situation where all manufacturing is concentrated in one region, is it profitable for a new firm to locate in the other region? Is the “black hole” truly inescapable?

Recall that μ is the share of expenditures that goes to manufactured goods. All of this goes to region 1. The ratio of regional incomes is

$$\frac{Y_1}{Y_2} = \frac{1 - \mu}{1 + \mu}. \quad (41)$$

If n is the number of manufacturing firms, then the value of sales to each firm is

$$V_1 = \left(\frac{\mu}{n}\right) (Y_1 + Y_2) \quad (42)$$

which provides enough revenue to make profits zero.

In order to attract workers to region 2, wages must be high enough to compensate workers for the higher prices for their purchases of manufactured goods (recall the transportation costs.) The ratio of wages must be at least

$$\frac{w_2}{w_1} = \left(\frac{1}{\tau}\right)^\mu. \quad (43)$$

This means that the new firm’s profit maximizing price will be higher than the profit maximizing price in region 1. So, the value of the new firm’s sales is

$$V_2 = \left(\frac{\mu}{n}\right) \left[\left(\frac{w_2}{w_1 \tau}\right)^{-(\sigma-1)} Y_1 + \left(\frac{w_2 \tau}{w_1}\right)^{-(\sigma-1)} Y_2 \right]. \quad (44)$$

From the above equations, we see that the ratio of the values of sales between regions 1 and 2 is

$$\frac{V_2}{V_1} = \frac{1}{2} \tau^{\mu(\sigma-1)} \left[(1 + \mu) \tau^{\sigma-1} + (1 - \mu) \tau^{-(\sigma-1)} \right]. \quad (45)$$

So, it will be profitable for a firm to defect from region 1 if $V_2/V_1 > w_2/w_1 = \tau^{-\mu}$. Now we can define a new variable from the above that shows us when it is profitable for a firm to open in region 2 instead of region 1:

$$v = \frac{1}{2} \tau^{\mu\sigma} \left[(1 + \mu) \tau^{\sigma-1} + (1 - \mu) \tau^{-(\sigma-1)} \right]. \quad (46)$$

We see that it is profitable to defect from region 1 if $v > 1$. It is more profitable to stay in region 1 if $v < 1$. Either case is equally profitable if $v = 1$.

Finally, it is worth briefly reviewing the comparative statics of the

$$\frac{\partial v}{\partial \mu} = v \sigma \ln(\tau) + \frac{1}{2} \tau^{\mu\sigma} \left[\tau^{\sigma-1} - \tau^{-(\sigma-1)} \right] < 0. \quad (47)$$

This means that as the share of expenditures on manufactured goods increases, it is more profitable to open the firm in region 1. The relative sales of the defecting firm decrease as μ grows larger. There are two reasons for this. First, workers require higher relative wages to move to region 2. Also, the market for manufactured goods will be larger in region 1 and the home market effect will be stronger.

As to transportation costs,

$$\frac{\partial v}{\partial \tau} = \frac{\mu \sigma v}{\tau} + \frac{\tau^{\mu\sigma} (\sigma - 1) \left[(1 + \mu) \tau^{\sigma-1} + (1 - \mu) \tau^{-(\sigma-1)} \right]}{2\tau}. \quad (48)$$

If τ is small, it is profitable to defect to region 2. Eventually, τ rises up to a critical point. Above this, v becomes less than 1 and it is no longer profitable to defect. So, higher transportation costs make agglomeration more likely.

Finally, we calculate

$$\frac{\partial v}{\partial \sigma} = \ln(\tau) \left(\frac{\tau}{\sigma} \right) \left(\frac{\partial v}{\partial \tau} \right). \quad (49)$$

This shows us that as the elasticity of substitution rises, agglomeration is more likely.

Appendix C. Ottaviano and Martin (2001)

There are two regions, called region 1 and region 2. There are two goods. There is a homogeneous good, Y , and a variegated good D . Good Y has a perfectly competitive market. The market for D operates under Dixit-Stiglitz monopolistic competition (Dixit and Stiglitz, 1977) with j substitutable varieties of D . Firms that manufacture varieties of D operate under increasing returns (Krugman, 1991). For simplicity's sake, we can assume that each firm in the D market produces only one variety. In region 1, there are n firms, each producing one variety of the D good. In region 2, there are n^* firms that again produce one variety each. The total number of firms in both regions is $N = n + n^*$. Note that the “unstarred” variables refer to region 1 and the “starred” variables refer to region 2. This has become a convention of the New Economic Geography literature.

In addition, we model trade frictions in the D market by making D an iceberg good. To supply one unit of the D good to the other region, τ units must be shipped. 1 unit arrives while $\tau - 1$ units “melt” in transit.

Consumers are infinitely lived and have the continuous time utility function

$$\int_0^{\infty} \log [D^\alpha Y^{1-\alpha}] e^{-\rho t} dt \quad (50)$$

where α is the fraction of income spent on good D and ρ is the rate of time preference.

The demand function for all varieties of D is

$$D(t) = \left[\sum_{j=1}^{N(t)} D_j(t)^{1-\frac{1}{\sigma}} \right]^{1-\frac{1}{\sigma}} \quad (51)$$

where $D_j(t)$ is the quantity demanded of the j th variety of good D and σ is both the own price elasticity of demand for the j th variety of D and the elasticity of substitution between varieties.

The consumer's expenditure function in region 1 is

$$E = \sum_{j=1}^n p_j D_j + \sum_{m=n+1}^N p_m D_m + p_Y Y(t) \quad (52)$$

A similar expenditure function exists for region 2.

Under long-term equilibrium,

$$p = p^* = \frac{w\beta\sigma}{\sigma - 1} \quad (53)$$

where, p is the price of some variety of good D in region 1 and p^* is the price in region 2. The star over any region 2 variable is a convention in the literature. Note the inverse-elasticity pricing of the D good.

Solving the utility maximization problem yields the following demand functions:

$$D_j = \frac{\alpha(\sigma - 1)}{w\beta\sigma} \frac{E}{N(\gamma(1 - \gamma)\delta)} \quad (54)$$

$$D_m = \frac{\alpha(\sigma - 1)}{w\beta\sigma} \frac{\tau^{-\sigma} E}{n(\gamma(1 - \gamma)\delta)} \quad (55)$$

$$Y = (1 - \alpha)E \quad (56)$$

where, D_j is the demand for region 1's output of the j th D good in region 1 and D_m is the demand for region 1's output of the m -th good in region 2. The price of good Y is made numeraire. $\gamma = \frac{n}{N}$ is the fraction of D producing firms in region 1. $\delta = \tau^{1-\sigma}$ is a measure of trade freedom. Demand functions in region 2 take identical forms.

Each firm in the D market earns a profit of

$$\pi = px - w\beta x = \frac{w\beta\sigma x}{\sigma - 1} - w\beta x = \frac{w\beta x}{\sigma - 1} \quad (57)$$

in region 1 where, x is the output of the firm. A similar function holds in region 2.

Individuals can become entrepreneurs by innovating. The candidate entrepreneur borrows wages from the bank and thus funds the innovation process. The input to the innovation process is a composite good made of all varieties of the D good. Let z_1 be a region 1 entrepreneur's demand for D goods from region 1. Let z_2 be a region 1 entrepreneur's demand for D goods from region 2. Let η be the price of one innovation and let the innovator's production function be N^μ . The composite good consists of n units of z_1 and n^* units of z_2 . If we denote the innovator's cost function as F , then the innovator's cost minimization problem is

$$\min_{z_1, z_2} F = w \left(\frac{\beta \sigma}{\sigma - 1} \right) [nz_1 + n^*z_2] \quad (58)$$

$$\text{subject to: } \eta N^\mu = \left[nz_1^{1-\frac{1}{\sigma}} + n^* \tau z_2^{1-\frac{1}{\sigma}} \right]^{1-\frac{1}{\sigma}}$$

The solutions are

$$z_1 = \eta N^\mu (n + n^* \delta)^{\frac{\sigma}{1-\sigma}} \quad (59)$$

and

$$z_2 = \eta N^\mu \tau^{-\sigma} (n + n^* \delta)^{\frac{\sigma}{1-\sigma}}. \quad (60)$$

Similar functions hold for an entrepreneur in region 2. The solutions for the cost of innovation are

$$F = \frac{w\beta\sigma}{\sigma-1} \eta N^\mu N^{\frac{1}{1-\sigma}} [\gamma + (1-\gamma)\delta]^{1-\frac{1}{\sigma}}. \quad (61)$$

and

$$F^* = \frac{w\beta\sigma}{\sigma-1} \eta N^\mu N^{\frac{1}{1-\sigma}} [1-\gamma + \gamma\delta]^{1-\frac{1}{\sigma}} \quad (62)$$

where F is the cost of innovation in region 1 and F^* is the cost of innovation in region 2. $w\beta$ is the marginal cost of a variety of D , σ is the elasticity of substitution between varieties of D which makes $[\sigma/(\sigma - 1)]$ the inverse of the elasticity of demand for a variety of the manufactured good. η is the marginal cost of the innovation, N is the number of firms in both regions and γ is region 1's share of firms in the manufacturing market. δ is our measurement of trade freedom and μ is a measurement of knowledge spillovers from past innovations. Note that the presence of N , implies that current innovation is a function of past innovation. This means learning by doing in innovation is part of the model.

Finally, we can solve for the total output of each firm. If all innovation occurs in region 1,

$$x = \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left[\frac{E}{N[\gamma + (1 - \gamma)\delta]} + \frac{E^*\delta}{N[\delta\gamma + 1 - \gamma]} \right] \quad (63)$$

$$+ \frac{\sigma - 1}{w\beta\sigma} \left[\frac{F\dot{N}}{N[\gamma + (1 - \gamma)\delta]} \right]$$

and

$$x^* = \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left[\frac{E\delta}{N[\gamma + (1 - \gamma)\delta]} + \frac{E^*}{N[\delta\gamma + 1 - \gamma]} \right] \quad (64)$$

$$+ \frac{\sigma - 1}{w\beta\sigma} \left[\frac{F\dot{N}\delta}{N[\gamma + (1 - \gamma)\delta]} \right]$$

where x is the output of a firm in region 1 and x^* is the output of a firm in region 2. If innovation is symmetric,

$$x = \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left[\frac{E}{N[\gamma[\gamma(1 - \gamma)\delta]]} + \frac{E^*\delta}{N[(\delta + 1) - \gamma]} \right] \quad (65)$$

$$+ \frac{\sigma - 1}{2w\beta\sigma} \left[\frac{F\dot{N}}{N[\gamma[\gamma(1 - \gamma)\delta]]} + \frac{F\dot{N}\delta}{N[1 - \gamma + \gamma\delta]} \right]$$

and

$$x^* = \frac{\alpha L(\sigma - 1)}{w\beta\sigma} \left[\frac{E\delta}{N[\gamma[\gamma(1 - \gamma)\delta]]} + \frac{E^*}{N[\delta + 1 - \gamma]} \right] \quad (66)$$

$$+ \frac{\sigma - 1}{2w\beta\sigma} \left[\frac{F\dot{N}\delta}{N[\gamma[\gamma(1 - \gamma)\delta]]} + \frac{F\dot{N}}{N[1 - \gamma + \gamma\delta]} \right]$$

where E and E^* are the expenditures in region 1 and region 2 respectively. This means that if innovation is concentrated in region 1,

$$\gamma = \frac{\alpha LE^W[(1 + \delta)\varepsilon - \delta] + gNF}{(1 - \delta)[\alpha LE^W + gNF]} \text{ if } \frac{\alpha LE^W}{2gNF} > \frac{\delta}{1 - \delta} \quad (67)$$

and $\gamma = 1$ otherwise. If innovation is split between the regions, then

$$\gamma = \frac{\alpha LE^W[(1 + \delta)\varepsilon - \delta] + (1 - \delta)gN}{(1 - \delta)[\alpha LE^W + 2gNF]} \quad (68)$$

where ε is the distribution of patents between regions. In either case, the size of each firm is

$$x = \frac{\sigma - 1}{w\beta\sigma} \left[\alpha L \frac{E^W}{N} + Fg \right]. \quad (69)$$

One more condition needs to be set for intertemporal equilibrium. Let v be the value of an innovation (a patent.) If r is the rate of return on a safe asset, then our no arbitrage condition between innovations and the safe asset is

$$r = \frac{\dot{v}}{v} + \frac{\pi}{v}, \quad (70)$$

where \dot{v} is the time-derivative of v and π is the discounted future profit on of a firm that buys the innovation and holds a monopoly on it forever. Finally, we need to impose one more condition for tractability: $\mu \equiv (\sigma - 2)/(1 - \sigma) = 0$ or there will be no analytic solution for the equilibrium.

With all of the preliminaries in place, we can now find the equilibrium solutions. First, we apply our $\mu = 0$ on equation (61) to get

$$F = w \frac{\beta \sigma}{\sigma - 1} \eta N^{-1} [\gamma + (1 - \gamma) \delta]^{1/(1-\sigma)}. \quad (71)$$

Now, γ and w are constant in the steady state and this ensures that FN is constant. Also, under the steady state, $\dot{v}/v = \dot{F}/F = -\dot{N}/N = -g$. In other words, the growth rate is the rate of change in agglomeration. Consumer expenditures are constant and $r = \rho$; that is the interest rate is equal to the rate of time preference. Using these results with equations (56), (68) and (69) gives us

$$g = \frac{\alpha}{\sigma - 1} \frac{LE^W}{FN} - \rho \frac{\sigma}{\sigma - 1}. \quad (72)$$

Now we need to look at the market clearing condition in the labor market, which is

$$2L = \frac{(1 - \alpha)LE^W}{w} + \beta Nx. \quad (73)$$

where $p_Y = w$.

Substituting equation (68) into (72) yields

$$E^W = 2 \frac{w\sigma}{\sigma - \alpha} - \frac{\sigma - 1}{\sigma - \alpha} \frac{gNF}{L}. \quad (74)$$

Now we can solve for g . We combine equations (70), (71) and (73) and get

$$g = \frac{2\alpha L}{\eta \beta \sigma} [\gamma + \delta(1 - \gamma)]^{1/(\sigma-1)} - \rho \frac{\sigma - \alpha}{\sigma - 1}. \quad (75)$$

Finally, we can solve for consumer expenditures. Combining equations (71) and (73) gives us

$$E^W = 2w + \rho \frac{FN}{L} \quad (76)$$

The model features multiple steady states. Two can be accounted for with very high (close to 1) or very low values of δ (close to 0). The middle values of δ take more work. By using equations (70) and (75), we can rewrite (66) as

$$g = \frac{(1-\delta)(2\gamma-1)\alpha}{1-(1-\delta)\gamma} \left\{ \frac{\sigma-1}{\eta\beta\sigma} [\gamma + (1-\gamma)\delta]^{1/(\sigma-1)} + \frac{\rho}{2L} \right\} \quad (77)$$

The third steady state lies at the intersection of (74) and (76).

Martin and Ottaviano conclude with an extensive discussion of the stability of the steady states. The steady state where $\gamma = \frac{1}{2}$ is unstable when the equilibrium growth rate is positive unless the economy starts with $\gamma = \frac{1}{2}$, that is with the same number of firms, and stays there forever. This means that one region will dominate as the center of innovation.

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Vita

John D. Conley
Born March 4, 1969, Ashland, KY USA

EDUCATION

University of Kentucky
M.S., Economics, 1995
B. A., Economics and Physics, 1992

Northeastern Illinois University
B.S., Computer Science, 2002

PAST EMPLOYMENT

Graduate Research Assistant, Department of Agricultural Economics, University of Kentucky, 2007-2011.
Adjunct Instructor, Division of Business and Economics, Transylvania University, 2005-2006.
Adjunct Instructor, Mt. Sterling Center, Morehead State University, 2004-2005.
Sr. Business Support Analyst, The Northern Trust Co., 1997-2002.
Technical Services Analyst, KeyCorp Auto Finance Group, 1996-1997.

PUBLICATIONS AND CONFERENCE PAPERS

Leigh J. Maynard, Ellen Goddard and John Conley (2008), "Impact of BSE on Beef Purchases in Alberta and Ontario Quick-Serve Restaurants" *Canadian Journal of Agricultural Economics/Revue Canadienne D'Agroeconomie*, 56(3) PAGES 337-351
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