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Rust Belt City Revitalization: Estimating the Effects of Input Stock on Post-Recession Economic Recovery of 51 Rust Belt Cities

Cheng Chen

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by

Cheng Chen

Accepted for Honors

Thomas P. LaSalvia, PhD, Director

Donald Campbell, PhD

Jungping Shi, PhD

Williamsburg, VA
December 4, 2019

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Abstract

Rust Belt cities, after suffering from the economic downturn during the recession in 2008, were striking to revive during the post-recession period. The Rust Belt was gradually transferring into a new economy whose dominant industry is no longer manufacturing. This research examines variation in post-recession job growth as it relates to city level characteristics regarding fundamental clustering theory. Twelve location factors are included in a cross-section regression model to estimate the post-recession economic recovery, which is indicated by job creation of 51 Rust Belt cities in 11 States. The results inform public decisionmakers of how to take action on Rust Belt cities' revitalization.

1 Introduction

Rust Belt cities experienced population decline, high rates of poverty, urban decay, and overall economic downturn since the 1970s due to deindustrialization (World Population Review 2019). The population dropped by over 29% after the recession in 2008 in Detroit, Michigan, which is the largest recorded change of population decline during the recession. Flint, Cleveland, Dayton, and Buffalo also experienced significant losses in their populations. Poverty rate, on the other hand, grew at an average of 8% after the Great Recession. There are many reasons for this economic downturn, and three main reasons are discussed in this research – lack of competition in labor and output market, diminishing agglomeration, and increased foreign competition. However, this economic downturn of the Rust Belt was not persistent. During the post-recession period (2009-2015), large cities (cities with a population above 100,000) were bouncing back from persistent economic decline, while smaller cities were not as fortunate.

Researchers and relative institutions have developed systematic strategies that help to revive the economies of the Rust Belt, and the general idea is to help Rust Belt cities differentiate into new economies, whose dominant industry is no longer manufacturing but education services, health care, and other industries related to professional jobs. The pie chart below shows the average sector distribution of jobs in smaller cities in 2014, which supports the statements above.

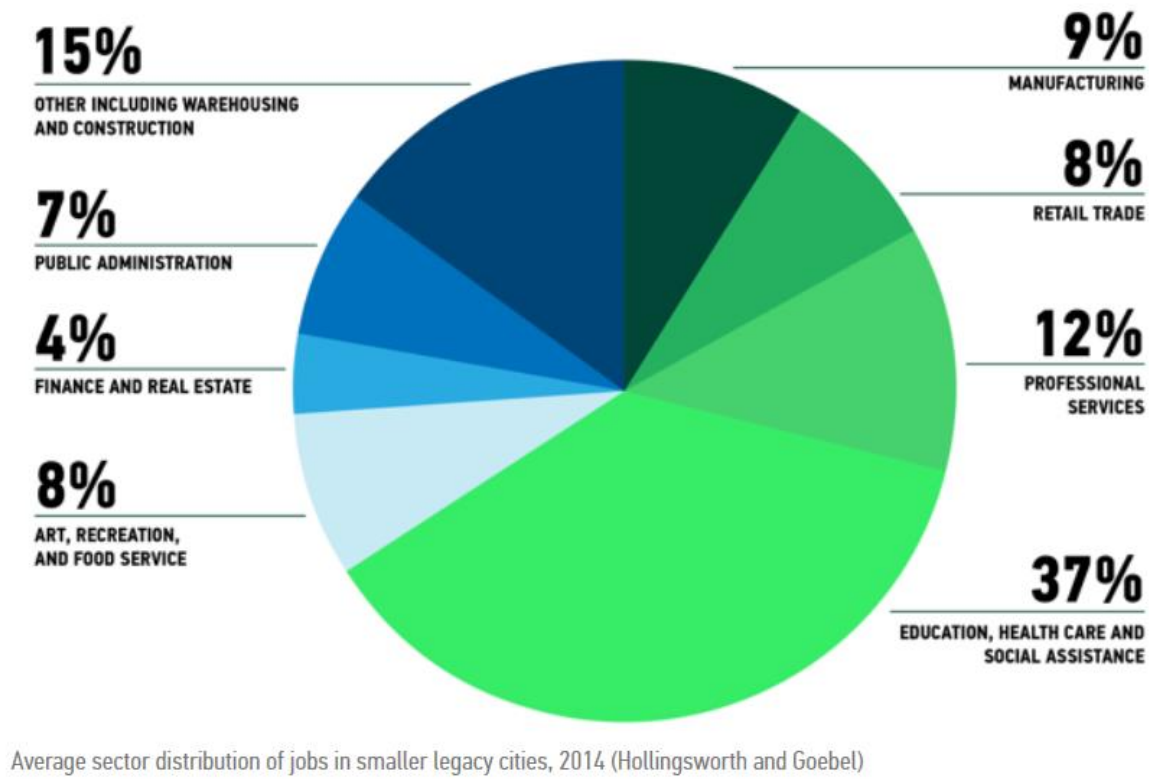


Figure 1

We also observe that larger cities have better economic recovery outcomes, and they, in general, have higher quantity and quality of stock of production inputs for information firms. Some smaller cities in our sample that have more post-recession economic vitality have more developed resources for producers of knowledge as well. Thus, we assume that Rust Belt cities with larger and higher quality stock of production inputs for information firms had better economic performance during the post-recession period, which further implicates that smaller cities generally needed to work harder in developing their stock of production inputs for information firms because they had relatively low stock for knowledge producers and smaller agglomerations for information firms. Agglomeration and stock of production inputs for manufacturing firms in

Rust Belt cities seemed unrelated to post-recession economic recovery at this point given all the literature reviews (World Population Review 2019, Eide 2017, Alder et.al 2012, Kotkin et.al 2012, EPA 2015). Therefore, we made the general hypothesis that it was the development of stock of production inputs for information firms not those for manufacturing firms that contributed to the post-recession economic recovery, and cities that were relatively not diversified in their stock of production inputs would have a harder time during the post-recession period.

The revitalization strategies helped the formation of clusters of information firms, with gradually developing the self-reinforcing process of agglomeration for information firms. An increasing number of jobs in the Rust Belt indicates post-recession economic recovery. To test the general hypothesis above, we use a cross-section model that estimates the post-recession job growth of 51[1] Rust Belt cities based on 12 variables that are extracted from the production functions to represent the stock of production inputs for information and manufacturing firms.

The regression results show that stock of production inputs for information firms in 2009 are positively associated with the job creation from 2009 to 2015 of the 51 Rust Belt cities, whereas stock of inputs for manufacturing firms are not statistically significant in estimating post-recession job growth. The result of the model is consistent with the general hypothesis above that shows most of the Rust Belt cities were transforming into new economies that no longer depend heavily on the manufacturing industry. Thus, we conclude that if firms recognize agglomeration of information firms and the stock of inputs for knowledge producers are more developed in a city, the more firms will enter the current cluster, and the city will experience more economic recovery. The product of this research provides insights for local government and the public sector that Rust

[1] We initially have 78 cities that satisfy the criterion of being Rust Belt cities but Among the 78 observations, there are 27 cities that do not have the data of job growth. We then finalized the sample with 51 observations.

Belt cities should shift gears from stock of inputs for manufacturing firms to stock of inputs of information firms, such as improving air travel and education services. Specifically, for cities with smaller scales of diversified stock of production inputs, they need to put more efforts on diversification to revive.

The paper reads as follows: the following parts of section 1 discuss the Rust Belt cities' definitions and economic downturns, and the central idea of current revitalization strategies. Section 2 discusses the fundamental clustering and agglomeration theory, the production function of information firms and manufacturing firms, and the cross-section model that estimates post-recession economic recovery. Section 3 presents and analyzes the regression results and suggests potential adjustments that could be made in future studies. The appendix includes the robustness test of the cross-section model in Section 2 and other potential variables that could be added to the model and their problems regarding the variable-selection process. Section 4 concludes with the implications of the cross-section model and suggests potential works that could be done to help with Rust Belt cities' revitalizations.

1.1 Definitions of Rust Belt Cities

Rust Belt, in general, are places that once were prosperous because of their thriving manufacturing industries in the 1920s, but then have been suffering economic decline and struggling to redevelop in the last decades (Boone 2017). Because there is no official definition of the Rust Belt, definitions on Rust Belt of related research (Eide; Harrison, J.A; Wilson, Wouters;) vary by specific topic, but they are all consistent with the concept that Rust Belt cities are places that experienced population decline, high poverty and unemployment, and overall declines in economic activity. The observation units in this research are cities, because it has been proved by empirical studies that observation units at county or township levels only exhibit agglomerations of knowledge spillovers, and observation units at a state or a metropolitan area level are too broad to account for the effects of agglomerations (Rosenthal, Strange 2001). We define Rust Belt cities in this research based on Eide's 2017 report of *Rust Belt cities and their Burden of Legacy Costs* which focuses on poor major cities in 11 Rust Belt states: Connecticut, Illinois, Indiana, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Wisconsin. "Poor" is defined as that the city has a higher poverty rate than the state average, and "major" is defined as that the city has a population of at least 60,000 residents (Eide 2017). We choose 2009 data of the two metrics to be consistent with the cross-section model, and the model will be introduced in Section 2. There are 78 cities that satisfy these criteria and the cities are listed in the Appendix. We eliminate New York City and Philadelphia because they both have a population above one million that generates a variance that is too high for us to rely on the average poverty rate. The graphs[2] below show the location of the Rust Belt and the observations of this research.

Figure 2: The Rust Belt Area

[2] Source: DepositPhotos, www.depositphotos.com

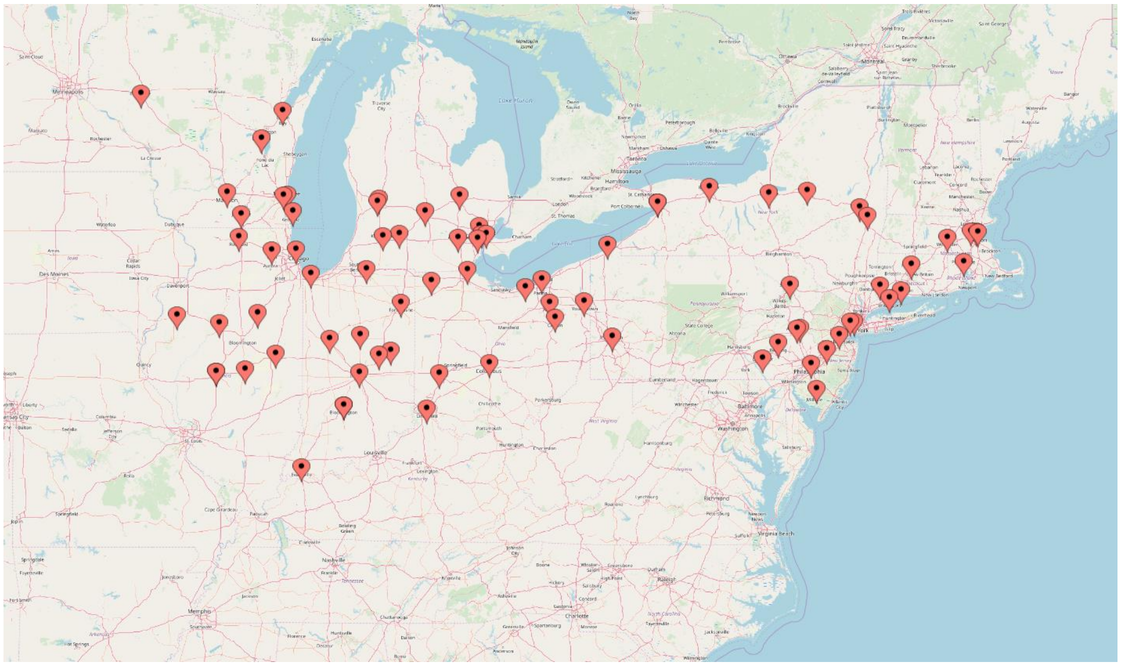


Figure 3: 78 Observations[3]

1.2 Reasons for Rust Belt Downturns

Since the end of World War II, the Rust Belt's share of aggregate economic activity declined dramatically (Alder et.al 2012), and this decline was due to three main reasons – lack of competition of labor and output markets, diminishing agglomeration, and increasing foreign competition.

Firstly, some scholars (Alder, Simeon, Lagakos, Ohanian) contribute the Rust Belt regions' decline to lack of competition in labor and output markets. The labor market of the Rust Belt was no longer competitive because of the powerful labor unions in the Rust Belt's manufacturing

[3] Source: MapCustomizer, www.mapcustomizer.com

industry. Fewer competitions mean less incentive to work productively, and so firms had to pay more to generate the same level of labor productivity with the past. Furthermore, many of the industries (steel, automobile, and rubber manufacturing) of the output markets were oligopoly markets that hindered competition for years after the end of WWII. The lack of competition in output markets depressed new firms to enter the markets and so stifled productivity growth (Alder et.al 2012).

Other studies (Beeson, Patricia; Carlino, Moonaw) empirically prove the existence of a positive correlation between productivity growth and city size and conclude that agglomeration potential decline contributes to the reduction of productivity growth advantage of metropolitan areas in Rust Belt. To some extent, the reduction of agglomeration potential was caused by the large urban population decline in the 70s. Cities that were greatly affected by this population decrease had left-over populations that were less than their critical mass. Having a population that is less than the critical mass means that it is highly probable to fail to generate sufficient vibrancy or incentives for an urban area to develop, because collective behaviors often spread via the self-reinforcing dynamics of critical mass, and the self-reinforcing dynamics is unstable when population is small or critical mass does not exist (Centola 2012). Therefore, a large reduction of population led to decreases in both demands to purchase and incentives to produce. Firms left the clusters and as the size of the clusters shrank, positive externalities of agglomeration disappeared, and resulted in a further urban decline. Finally, increased foreign competition and decreased demand for steel and other products led to drastic declines in manufacturing in the Rust Belt (Kahn, Matthew E 1999).

Lack of competition in both the labor market and the output market, decreased agglomeration potential, and increased foreign competition and decreased demand are the three main reasons why Rust Belt cities experienced population decline, high unemployment and overall economic decline after its thriving time.

1.3 Revitalization Strategies and the General Hypothesis

Although Rust Belt cities have been battered by decades of declining economic health, they still have valuable fundamental resources such as top-ranked universities, sophisticated companies in global trade, and emerging centers of clean energy research, to revive (Austin et.al 2010). Besides, lower housing prices, recovering business climate and a nascent industrial rebound also serve as "real lures" that attract businesses and firms to come back (Kotkin et.al 2012).

Given the fundamental advantages of Rust Belt cities, researchers and relative institutions have developed systematic approaches that facilitated clustering and agglomerations for information firms to recover the economies of the Rust Belt. Larger Rust Belt cities that used to depend heavily on manufacturing should both innovate to transfer its current manufacturing plants to meet the global demand and strive to develop a new economy and differentiate into other sectors and industries, such as health care, information technology, and so on (EPA 2015). Smaller cities, on the other hand, would choose to merge in new economies since it is relatively easier for them to differentiate into new economies due to smaller manufacturing shares in their local economies (Austin et.al 2010). Low-carbon energy strategy innovations spurred the transformation towards the new economy –greater exporting, more participations in global trade, more opportunities for all (Austin et. al 2010). Information firms gradually clustered during the post-recession period, and we observed that there are 40 cities in our sample experienced job growth during 2009 – 2015. We summarized the cities with job growth during 2009 – 2015, and we observed that those cities all had relatively developed stock of production inputs for information firms in 2009. The graph of cities with significant job growth during the post-recession period is presented below. We observed that larger cities, in general, tended to have better economic recovery outcomes because of their more diversified and developed stock of production inputs for firms. According to the discussions above, we made our general hypothesis that cities with more diversified set-ups for producers experienced better post-recession economic recovery, and typically, cities with more developed stock of inputs for information firms (not manufacturing firms) would have better economic performance during 2009 – 2015.

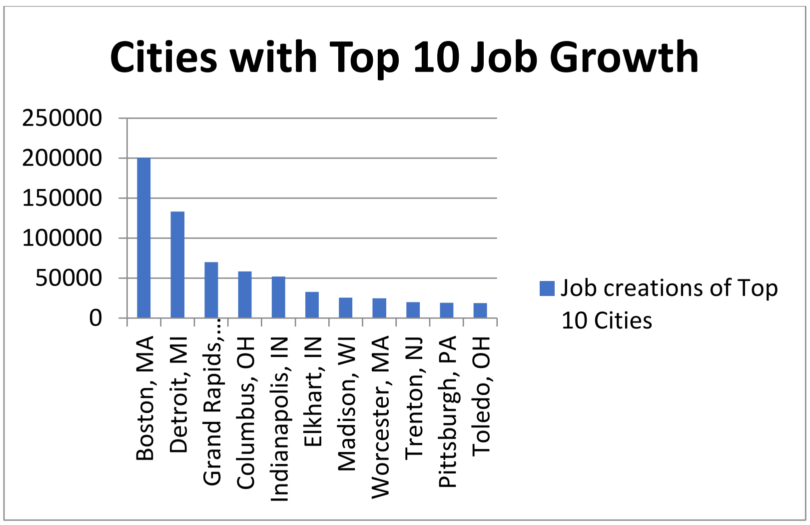


Figure 4

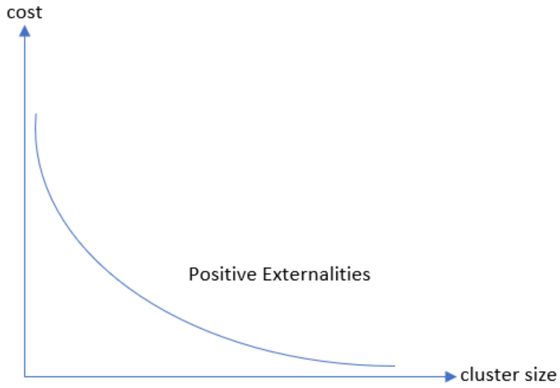
To test that whether it was the stock of production inputs for information firms or manufacturing firms that contributed to the post-recession job growth and economic recovery of Rust Belt cities, we will first introduce the fundamental theory for clustering to build up the hypothesis for the empirical study in Section 2.

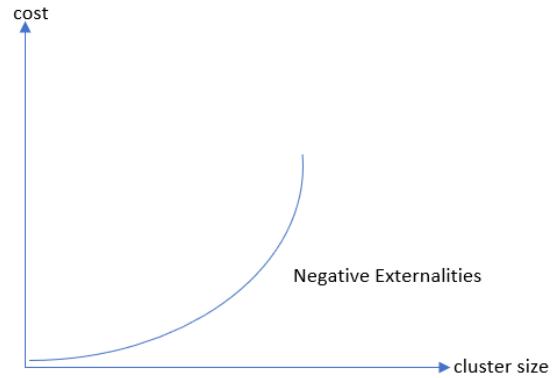
2 Theory

2.1 Fundamental Theory of Clustering

In this section, we will introduce the fundamental theory of clustering from which we develop the hypothesis and the empirical model in Section 3. We will discuss about the general mechanism of clustering and specifically explain our empirical focus on agglomeration, which helps us build up the hypothesis for the empirical study.

According to the fundamental theory, clustering describes the process of firms locating close to one another, and by locating near each other firms could reduce cost by intermediate goods and information sharing, labor pooling, and labor matching (O'Sullivan). In other words, locating near each other generates positive externalities for firms to reduce production costs, and this cost-reduction process is called agglomeration. However, clustering generates negative externalities as well, for instance, the cost of congestion, meaning that if there are too many firms locating in the cluster, wages and prices of land are going to grow, and firms could no longer reach their goal for cost minimization. The following graphs present the positive externality and negative externality of clustering.





Initially, as the number of firms in a cluster increases, or as the stock of production inputs for the producers becomes more developed, the production cost of firms will decrease because of easier labor pooling, labor matching, intermediate goods and information sharing (as shown by Figure 4). However, as the number of firms grows, or as the stock of production inputs for the producers are overly developed, the production cost would start to increase because of increasing wages and prices of land, and firms in the cluster would suffer the problem of congestion (as shown by Figure 5). Clustering is the process that combines the positive and negative externality above at each quantity level of firms. As presented by the graph below, the curve with negative slopes before the trough are stages that positive externalities exceed the negative ones, and vice versa.

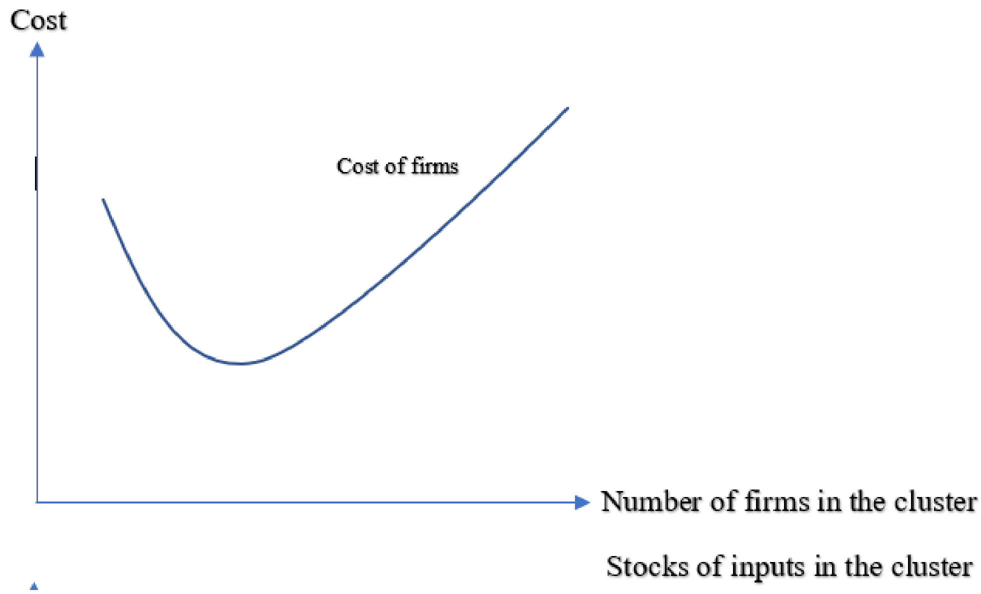


Figure 5

The above clustering mechanisms explain the reasoning that if marginal firms recognize the agglomeration economy of a cluster, the firm would decide to locate in the cluster and stock of production inputs in the cluster would then become more developed.

2.2 Clustering Theory on Information and Manufacturing Firms

During 2009 – 2015, clustering of Rust Belt information firms were still in the stages where positive externalities exceeded the negative ones, whereas clustering of manufacturing firms rarely happened since the stock of production inputs for manufacturing firms were so developed that they had little incentives to cluster and might face the problem of congestion once they decided to locate near each other. Therefore, in this research, we only examine the overall positive externalities – agglomeration economies – that were associated with post-recession job growth and economic recovery of Rust Belt cities. The fundamental theory of clustering works differently on information firms and manufacturing firms, and both cases will be discussed as follows.

Clustering for information firms is presented by the graph below:

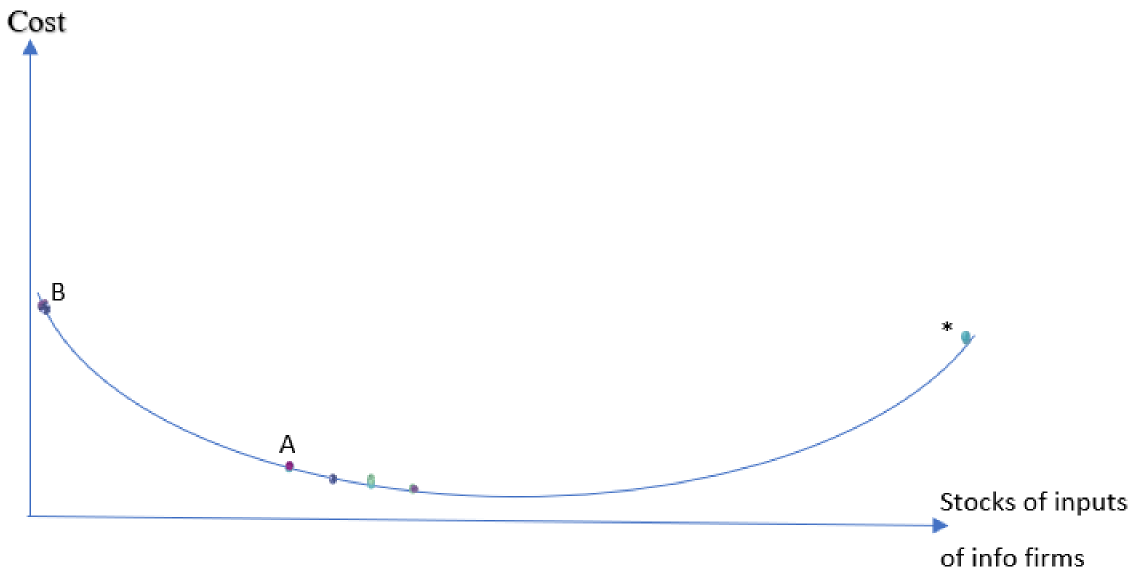


Figure 6

According to the discussions above, City *A* would be chosen by any marginal information firm to locate because it has a stronger agglomeration economy with higher level of stock of inputs for information firms compared to City *B*. Marginal firms would continue recognizing the higher agglomeration in City A and as they keep choosing City A to locate, agglomeration from clustering diminishes with the negative externalities gradually exceeding the positive ones. That is, with too many firms locating inside the cluster and thus overly developing the stock of production inputs, the problem of congestion starts to appear. Again, as we mentioned in the first paraph of this section, most of the Rust Belt cities did not have the problem of congestion during 2009-2015 for info-firm clusters, and so we eventually come up with this stretched-out curve to present the clustering of information firms, which implies that the problem of congestion for info-firm clusters is far in the future.

On the other hand, the stock of production inputs for manufacturing firms were so developed that infrastructures for manufacturing were nearly ubiquitous. Besides, lots of manufacturing firms offshored to reduce their labor costs, and so the remaining manufacturing firms post recession were more capital intensive. Given the discussions above, manufacturing firms had little incentives to locate near each other, and they would even suffer the negative externalities because of developed labor unions which hindered them from const minimization. Thus, in an extreme case, we present the post-recession clustering of manufacturing firms as follows, which shows no agglomeration post recession.

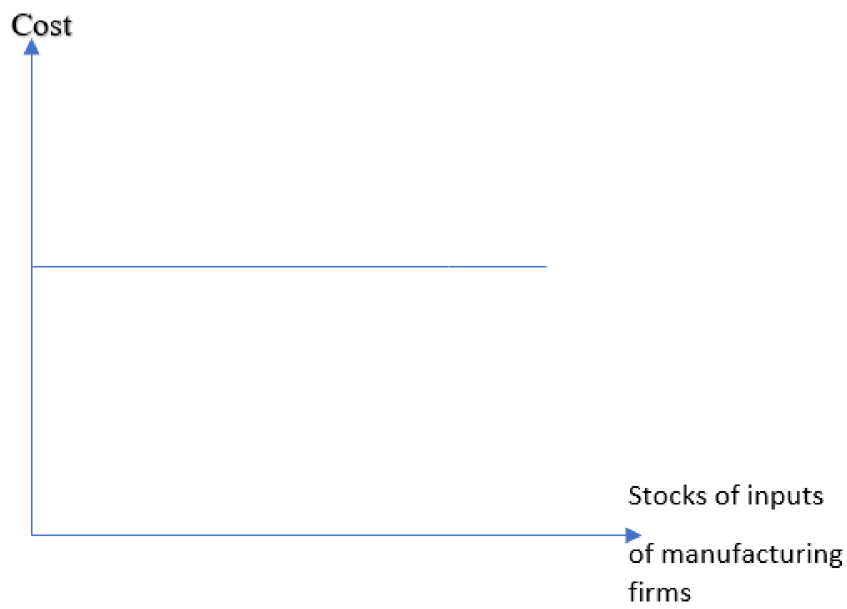


Figure 7

Since clustering of information firms presented agglomeration and clustering of manufacturing firms did not during the post-recession period, and since firms need to recognize agglomeration to develop the stock of production inputs to revive the economy of the cities, we restate our hypothesis for the empirical study that strong agglomeration for information firms and weak agglomeration for manufacturing firms, implies a better recovery in Rust Belt cities with an existing large stock of information firm production inputs.

3 Model

3.1 Model Specification

We designed a cross-section model to test the concluding hypothesis in Section 2.2. The right-hand-side variables – stock of production inputs of information and manufacturing firms – are extracted from their production functions, and each production factor is discussed below.

The general production function is written as follows:

$$(1) \qquad q = f(k, l, i)$$

The amount of output produced by individuals and firms is a function of the input of labor, capital, and resources of infrastructure. In equation (1), q is the amount of output produced by individuals and firms; k denotes the factor of capital; l is the factor of labor, and i is the factor of infrastructure.

For manufacturing firms, in this research, we specify k as intermediate goods from supply companies, and l as labor pooling for manufacturing firms, whereas i is the shipping infrastructures for manufacturing firms. In contrast, information sharing is crucial for information firms. For production function of information firms, l is specified as labor pooling, and k is specified as the price of land, and i is specified as infrastructures for communication technology, information sharing (including access to research and development institutions and government), and transportation technology for professional jobs. Variables are extracted from the production functions of information and manufacturing firms, and the they will be discussed in detail in Section 3.2. For the left-hand side of the model, we use job growth from 2009 to 2015 of Rust Belt cities to indicate the economic recovery because it is a key indicator for economic vibrancy. We also changed the response variable to test the robustness of this model and the results are provided in Appendix.

The cross-section model is written as follows:

$$(2) \qquad P_{i(t-tp)} = f(l_{it}, k_{it}, i_{it}, f_{it})$$

where $P_{i(t-tp)}$ is the Rust Belt cities' job growth from time t[4] to time tp, l_{it} is a vector of labor pooling that is specified as labor quality, labor availability, and labor cost of city i at time t; i_{it} is a vector of characteristics of Infrastructures in city i at time t, which includes the shipping infrastructures for manufacturing firms and transportation and communication technology for information firms. i_{it} also includes factors that indicates the accessibility of information firms to research and development institutions. The communication technology does not have many variations among Rust Belt cities, and so we assume the communication technology is the same among the 51 Rust Belt cities, and we did not include the factors of communication technology into the cross-section model. f_{it} is the local fiscal characteristics of city i at time t. The model gets insights from the binary logit model from previous research (Debertin, Pagoulatos, and Simths; Krisel, Deaton, and Johnson) which is based on location theory and the model of cluster formation that predicts the probability of a city with certain settings of economic factors at a specific point of time.

[4] In this research, t is specified as 2009, and tp is specified as 2015

3.2 Data and Variables

51 Rust Belt cities were used to specify the cross-section model, and the list of the cities are provided in the Appendix. The dependent variable, number of job creation in a city during 2009 – 2015, is a proxy for economic recovery. If a firm recognized agglomeration, the firm would choose the city with the best stock of production inputs, by which the cluster of that city would start to grow, and new jobs would be generated by better performance of existing firms and new entrants, promoting economic recovery and revitalization. All the right-hand-side variables in the cross-section model are described below.

In the local labor market, factors that measure the labor cost, availability, and quality were shown to be important to attract new firms to come (Kriesel and McNamara 1991) according to previous research (Smith, Deaton, Kelch; Sulaiman and Hushak; Kuehn, Braschler, and Shonkwiler; McNamara, Kriesel, and Deaton). The cross-section model includes four labor measures according to production functions of manufacturing and information firms. The annual wage of the Rust Belt cities in 2009 in inflation-adjusted dollars, WAGE, is included as a measure of labor cost. This variable is hypothesized to have a negative association with job creation, as long as the labor productivities of these cities are held constant. That is, if labor productivity is held constant in the model, it is assumed that a city with a lower wage in 2009 could create more jobs during 2009 – 2015 than other cities. The number of people who have master's degrees or higher of Rust Belt cities in 2009, EDU, is a variable that indicates labor quality as what previous research (Rosenthal and Strange) did in models that measure agglomeration. Besides, EDU also accounts for the innovative culture in a city, and it is a proxy for entrepreneurship as well, given the positive association of the number of people who have high-level of education with the strength of innovation in an area. Thus, EDU is a variable that accounts for labor quality and productivity as well as innovative culture and entrepreneurship in a Rust Belt city in 2009. This variable is hypothesized to have a positive association with job creation from 2009 to 2015. The unemployment rate of Rust Belt cities in 2009, UNEMP[5], is a measure of labor availability of a city according to Kriesel and McNamara's empirical studies. From this perspective, this variable is hypothesized to have a positive association with job creation from 2009 to 2015. MANU, the city's manufacturing jobs in 2009, is a proxy for the size of the manufacturing industry, and the importance of manufacturing industry in that city. This variable is hypothesized to have a negative association with job creation from 2009 to 2015, because the overall hypothesis of this research is that the manufacturing presence is not essential to generate new jobs in a climate that the dominant industry of most of the Rust Belt cities is shifting away from manufacturing, and there might be trade-offs between developments of production inputs of manufacturing firms and those of information firms, meaning that more developed manufacturing production inputs left less room to build up stock of inputs for information firms. MANU is also a proxy for manufacturing firms' labor pooling, and it is also hypothesized to have a negative association with job creation. The data of the four measures of the labor factor in the cross-section model is from the 2010 U.S. Census on the database of United States Census Bureau (www.census.gov).

[5] Unemployment rate, on the other hand, is used as a measure of economic performance in other studies. Thus, a city with a high unemployment rate is often seen as a city with depressed economic performance. However, this does not conflict with the hypothesized relationship of the unemployment rate and job creation in this research. From the business cycle and growth theory perspective, the cities went down a lot also had the potential to go up a lot, because the economic shock did not destroy the basic infrastructures that help those cities to develop faster than others.

Median Home value of Rust Belt cities in 2009 in inflation-adjusted dollars, HOME, is a proxy for the price of space because home values are linked to office space values. However, we do not simply treat this variable as an indicator of cost in the cross-section model. Median home value, on the other hand, is a measure of amenity quality of a city, given that if everything else is held constant, home value is an illustration of the desirability of household to live in the area, and the more desirability of household, the more amenities in that city, and the higher the price of space in that city. People will give up some of their wages to move to a city with better amenities, and firms are attracted to that city because they know that their workers will be happier with better amenities, but at the same time firms do not need to pay their workers much. The rationale is explained by the graph below, where H_2 illustrates the wage-price of land indifferent conditions for cities with better amenities compared to H_1, and F is the indifferent combinations of firms. At the equilibrium of H_2 and F, we could see that better amenities leads to higher land price and lower wages. Therefore, the variable HOME is hypothesized to have a positive association with job creation. The data of Median Home value is from the 2010 U.S. Census.

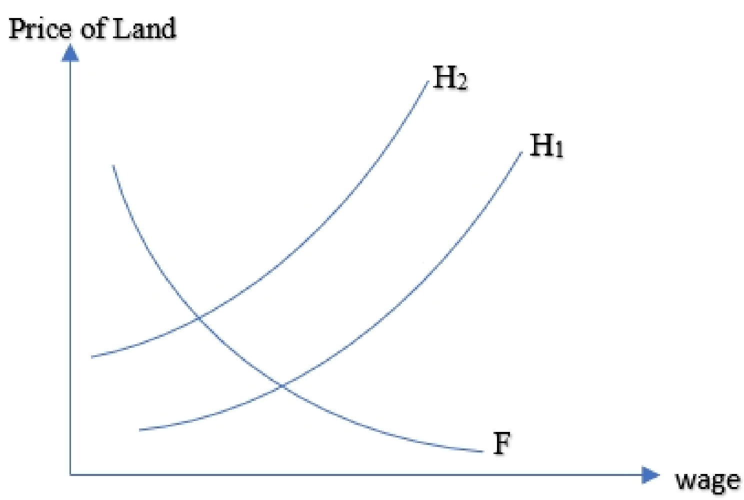


Figure 8

GOV, is a dummy variable that measures whether a Rust Belt city's government is County Seats or State government. The value of this variable is 1 if a city has a County Seats or State government, and 0 otherwise. According to the information firm production function, access to government for information sharing is important. The closer the firms are to the government, the easier for information sharing, which will lead to greater firm entry. Thus, this variable is hypothesized to have a positive association with job creation from 2009 to 2015. Corporate tax rate at a state level, TAX, is used as an indicator for the business-friendly climate in Rust Belt cities. The higher the corporate tax rate, the less welcoming the new firms are to a city. This variable is hypothesized to have a negative association with job creation from 2009 to 2015. Data of government factors are from the official websites of the 51 cities' governments.

According to the production function of information firms, distance to supply companies and markets is an important factor for firms in the location decision-making process. In this research, a city that has a population above 500,000 is considered as a hub for economic activities. DISTANCE, a measure of how close a Rust Belt city is to a hub, indicates the proximity to more supply companies and markets, and so the closer the city is to a large city, the more business activities the city could engage, and the more jobs were created. Thus, this variable is hypothesized to have a negative association with job creation during 2009 – 2015. The data of distance in miles of a city to all large cities in the Rust Belt that have a population above 500,000 is from Distance Calculator at GlobeFeed.com.

Variables that indicate infrastructures for manufacturing firms are also included in the cross-section model. Based on the overall assumption of this thesis, the variables of infrastructures of manufacturing firms are expected to be statistically insignificant, because they are not highly related with the development of information firms which created most of the new jobs during 2009

– 2015. RAIL and Port are dummy variables that measure the city's presence of freight rails and ports for shipment. HIGHWAY is the city's number of interstate highways that accounts for one of the transportation factors of manufacturing firms. These variables are all hypothesized to be statistically insignificant of the model. FLIGHT, the city's scheduled flight departures of Rust Belt cities in 2009, measures the infrastructure for professional jobs and information firms, because this type of transportation is used more often for information firms than for manufacturing firms. This variable is hypothesized to have a positive association with job creation from 2009 to 2015, since more flight departure means more information sharing activities were happening, which reduces costs for firms and increases the number of job creation. Data of the infrastructure variables are from the Bureau of Transportation Statistics, www.bts.gov.

Table 1: Definitions of Variables

Variable Names	Definitions
Variables of Labor Factors	
WAGE	the city's Annual Wage in 2009 Inflation Adjusted Dollars
EDU	the city's Number of People with master's degree or higher
UNEMP	the city's Unemployment Rate (%)
MANU	the city's manufacturing jobs
Variable of Land Price	
HOME	the city's Median Home Value in 2009 Inflation Adjusted Dollars
Variables of Fiscal Support	
GOV	whether the city's government is county seat or state government
TAX	state corporate tax rate (%)
Variable of Access to Supply Companies and Markets	
DISTANCE	the city's distance (in miles) to large city in Rust Belt that have population greater than 500,000
Variables of Infrastructure	
RAIL	the city's presence of freight rail
HIGHWAY	the city's number of interstate highways
PORT	the city's presence of port
FLIGHT	the city's scheduled flight departures

Table 2: Summary Statistics of Cities with Positive Job creation from 2009 to 2015

Variables	Mean Whole Sample	Mean Cities with Positive Job creation	Std. Dev. Whole Sample	Std. Dev. Cities with Positive Job creation
WAGE	35359	36112	7661	8393
EDU	10508	11004	14641	14641
UNEMP	11.6	11.48	4.29	4.29
MANU	7726	7544	7549	7549
HOME	139566	145668	88963	95816
GOV	-	-	-	-
TAX	5.26	5.12	2.58	2.31
DISTANCE	2225	2238		514
RAIL	-	-	-	-
HIGHWAY	1.96	1.93	1.61	1.57
PORT	-	-	-	-
FLIGHT	19238	20434.3	37847	40045

4 Results

4.1 Results of the Model

A cross-section regression model is used to estimate the economic recovery – indicated by job creation from 2009 to 2015 based on factors from the production functions of manufacturing and information firms. Table 2 presents the cross-section regression results for two specifications of the model. Model 1 is the regression on the whole sample of the 51 cities, and this model is statistically useful according to the Global F test, and Model 1 explains about 77 percent of the variation of job creation from 2009 to 2015. Model 2 is the regression on cities that have positive job creation during the post-recession period, this model is statistically useful according to the Global F test. Model 2 explains about 87 percent of the variation of job creation during the post-recession period. The two-tailed null hypothesis is rejected at a significant level of 0.1 for four variables: EDU, UNEMP, HOME and FLIGHT. MANU is at the borderline of being statistically significant. RAIL, HIGHWAY, PORT are highly insignificant. The results of Model 2 are similar to those of Model 1, and the variable EDU is more significant in this model. Although the number of observations of Model 2 is relatively small and the model has smaller degrees of freedom, the results still provide valuable information on how factors from the production function of information firms affects the post-recession job growth. The results are generally consistent with the hypotheses we made in Section 2.

EDU, number of people with masters' degree or higher in a city in 2009, was included in the model as an indicator for labor quality and labor pooling for information firms, and it is positively associated with job creation during 2009 – 2015. Holding all else constant, if a Rust Belt city had one more worker with a master's degree or higher, the city would have about 2 jobs being created from 2009 to 2015. This measure was statistically significant and supported the hypothesis that labor quality and labor pooling of information firms influences job creation and the value of clustering and agglomeration. FLIGHT, the number of scheduled flights in a city in 2009, is an indicator of infrastructure for information firms, and it is also positively associated with job creation during 2009 - 2015. This result is consistent with the expectations in Section 3 that the infrastructure for professional workers' information sharing is positively associated with the value of clustering and agglomeration. UNEMP, the unemployment rate, was included as a measure of labor availability of a city in 2009, and it is positively associated with job creation during 2009 - 2015. This result is consistent with the assumptions in Section 2 that labor availability is positively associated with job growth and the value of clustering and agglomeration: more available labor for labor pooling. HOME, the city's median home value in 2009, is a measure of land price and quality of amenities in the model, and it is positively associated with job creation during 2009 – 2015. This result is consistent with the model and the theory we discussed in section 2 that holding all else constant, firms will be attracted to cities with better amenities, and so the result matches with the expectation that the variable HOME is positively associated with the value of clustering and agglomeration.

MANU, the number of manufacturing jobs in a city in 2009, is a measure of labor pooling for manufacturing firms. This variable has a p-value of 0.12 in Model 1 and is statistically significant in Model 2. The result suggests that there is a negative association of the number of manufacturing jobs in a city in 2009 with job creation during 2009 – 2015. This result is consistent with the general assumption in Section 2 that cities with a better stock of inputs for information firms experienced more economic growth along with the increasing value of clustering and agglomeration than cities with a better stock of inputs for manufacturing firms. In other words, characteristics of cities that facilitate clustering of information firms contributed to most of the job growth during 2009 – 2015. According to the results above, stock of inputs for manufacturing firms of a city presented few or even negative impact on job growth of Rust Belt cities during 2009 – 2015.

RAIL, the presence of freight rail in a city in 2009, and HIGHWAY, the number of interstate highways in a city, and PORT, the presence of ports for shipments in a city, are variables for infrastructures of manufacturing firms, and their statistical insignificance support the hypotheses in Chapter 2 that clustering and agglomeration of manufacturing firms contributed little to job creation from 2009 to 2015.

The factor of labor cost (WAGE), accessibility to supply companies and markets (DISTANCE), and fiscal support (GOV and TAX) were presented as statistically insignificant on estimating job creation from 2009 to 2015. We did not dichotomize labor cost for manufacturing firms and information firms, because of their historical economic similarities that these 51 Rust Belt cities' heavy dependence on manufacturing industry, and so there might be problems that we did not hold enough variables constant to present the association between labor cost and job creation. We did not include the industry share as a variable into the model because of the multicollinearity problems of industry share and the variables that we selected to indicate labor pooling for both manufacturing firms and information firms. DISTANCE, a variable of a city's distance (in miles) from a large city (a city with a population greater than 500,000), measures the accessibility to supply companies and markets. This variable is statistically insignificant. The potential explanation is that most of the cities in the sample are large cities that already have sufficient access to supply companies and markets, and so the variable DISTANCE does not fully measure the accessibilities as we expected since we do not hold economic scales as constant. In further research, we should dichotomize the economic scales of the sample to measure the proximity to supply companies and markets. The variable GOV is a dummy variable that measures the general access of firms to local governments. However, the size of the government and other active programs should be considered as well to specify the association between accessibility to government and job creation. We did not include these factors into the model because of the limitations of data and the difficulties to quantify government programs. Potential variables that could be added to this model and their problems are discussed in detail in the Appendix.

The cross-section model in section 3 test to see what types of stock of production inputs of a Rust Belt city in 2009 were associated with the job growth during 2009 – 2015. The regression results are consistent with the hypothesis in Section 2 that more diversified Rust Belt cities with more developed set-ups for knowledge productions had a better post-recession economic recovery.

Table 3: Regression Results

	Whole Sample Job Creation	Cities with Job Gains Job Creation
WAGE	0.1841 (0.543)	-0.031 (0.4826)
EDU	1.483** (0.791)	1.721** (0.4785)
UNEMP	2793.8** (996.5)	4672.01** (1369.59)
MANU	-0.8209 (0.5223)	-1.0303* (0.5463)
HOME	0.1722* (0.099)	0.1339 (0.1172)
GOV	-16925.94 (0.112)	-10155.38 (15667.75)
TAX	507.43 (1318.73)	-1450.127 (16644)
DISTANCE	-5.293 (8.791)	2.5098 (9.266)
RAIL	-2621.8 (7465.69)	-16548.29** (7544.673)
HIGHWAY	-1481.2 (2416.6)	2782.10 (2609.2)
PORT	-9181.6 (8250.7)	-11792.48 (9841.15)
FLIGHT	0.4191** (0.1243)	0.3452** (0.1491)
Constant	-47519.07** (20314.54)	-65101.68** (24059.15)
Observations	51	38
R^2	0.77	0.87

Source: United States Census Bureau, Bureau of Transportation Statistics, Distance Calculator – GlobeFeed.com
Note: Standard errors in parentheses, * p<0.10, ** p<0.05

4.2 Access to Research Institutions

In the process of variable selection, we initially include the variable of a city's access to R1 or R2 institutions into the cross-section model in Section 3 because the access to research and development institutions is crucial for information sharing and labor pooling for information firms regarding to the production function of information firms and the fundamental clustering theory. However, we delete this variable because of the problem of multicollinearity from the cross-section model. We tried three variables to help measure the access to research institutions, and all of them present correlations with the variable EDU, FLIGHT, and HOME at rates that exceed 0.6.

Firstly, we tried a dummy variable to measure if there is a presence of R1 or R2 institutions in a Rust Belt city in 2009, and the result of this dummy variable suggested that the presence of R1 or R2 institution contributes little in estimating job growth during 2009 – 2015. This is not consistent with our expectation that access to R1 or R2 institutions plays an important role in information sharing which promotes innovations and job creation. We came up with two potential solutions for this inconsistency: either filter the dummy variable as the presence of R1 institution in a city or change this variable into a continuous one.

For potential improvements, we first change the variable into a continuous one to include more information about the R1 and R2 institutions in Rust Belt cities. R1 and R2 institutions vary from sizes and academic resources, and we assume these variations made a difference in information sharing of Rust Belt cities. We use the number of college students' enrollment in a city to measure the factor of access to R1 and R2 institutions, because the number of enrollments indicates the size of the research institutions and helps to show the scales of these institutions. However, this continuous variable is highly correlated with the variable EDU at a rate of 0.9 and is correlated with FLIGHT at a rate that exceeds 0.6. Meanwhile, we realize that EDU, though not perfect, could measure a city's access to R1 or R2 institutions. If a city has a presence of R1 or R2 institutions, the city would potentially have more people with masters' degree or higher. Thus, we choose to drop this continuous variable given the trade-off between the problem of the potential risk of omitted variable bias and the problem of multicollinearity. Instead, we run a simple linear regression of job growth during 2009 – 2015 on the number of college enrollments in 2009 of the 51 Rust Belt cities, and the result shows that the number of college enrollments in 2009 is positively associated with job growth during the post-recession period at a significance level of 0.001. The simple linear regression results suggest that access to R1 and R2 institutions of Rust Belt cities influences the economic recovery during 2009 – 2015. We then change the measure of R1 or R2 access of Rust Belt cities to a dummy variable that only accounts for the presence of R1 institutions. We assume that the difference of research activeness between R1 and R2 institutions would play a role in estimating the post-recession economic recovery and filtering the dummy variable into a variable that only accounts for the presence of R1 institutions would potentially solve the problem of multicollinearity. However, the results did not show positive associations of the presence of R1 institutions with job growth during 2009 – 2015 as what we expected. The potential explanation would be that graduates of Rust Belt cities are very mobile and given that they do not need to stay in those Rust Belt cities, many graduates leave those Rust Belt cities and so the presence of R1 institutions is less important in estimating the job growth and the post-recession economic recovery.

Therefore, we tried different measures of the access to R1 and R2 institutions of Rust Belt cities in 2009, but we decide to drop this variable from the cross-section model because of the problem of multicollinearity. However, the factor of access to R1 and R2 institutions are still valuable in explanting the job growth during the post-recession period of Rust Belt cities and we should come up with other methods to measure the accessibility to research and develop institutions of Rust Belt cities in future studies.

5 Conclusion

The stock of inputs in Rust Belt cities for information firms in 2009 play significant role in estimating Rust Belt cities' post-recession job growth and economic recovery. Rust Belt cities with more post-recession job growth and better economic recovery were cities that were more developed in stock of production inputs for information firms. Marginal information firms recognized agglomeration and were attracted to cities with a better stock of inputs, such as more highly educated workers for better labor matching, more access to air travels for information sharing, more opportunities for innovations, and so on. Thus, more jobs are being created because of the better performance of existing firms and new entrants. The self-reinforcing mechanism of agglomeration for information firms promoted the revitalization of Rust Belt cities. On the other hand, due to the lack of incentives to cluster and little agglomeration, the stock of inputs for manufacturing firms had few associations with post-recession job growth of Rust Belt cities. Therefore, for the purpose of revitalization, local government should shift gears from developing the stock of inputs of manufacturing firms to improving quality for aviation and education services that help further formation of clusters of information firms and the self-reinforcing process of agglomeration. Furthermore, cities that were little diversified or have relatively small scales of production set-ups for information firms need to work even harder to revive.

Appendix

1. List of 78 Rust Belt Cities

Table 4: List of 78 Rust Belt Cities

States	Cities
Connecticut	Bridgeport, Danbury, Hartford, New Haven
Illinois	Bloomington, Champaign, Elgin, Evanston, Decatur, Peoria, Rockford, Springfield
Indiana	Bloomington, Gary, Elkhart, Evansville, Fort Wayne, Anderson, Indianapolis, Kokomo, Lafayette, Muncie
Massachusetts	Boston, Cambridge, Waltham, Springfield Worcester
Michigan	Ann Arbor, Battle Creek, Dearborn, Detroit, Pontiac, Southfield, Taylor, Warren, Flint, Grand Rapids, Wyoming, Kalamazoo, Lansing
New Jersey	Jersey City, Newark, New Brunswick, Camden, Trenton, Vineland
New York	Albany, Schenectady, Buffalo, Rochester, Syracuse, Utica
Ohio	Akron, Canton, Cincinnati, Cleveland, Elyria, Columbus, Dayton, Springfield, Toledo, Youngstown
Pennsylvania	Allentown, Bethlehem, Erie, Lancaster, Pittsburgh, Reading, Scranton
Rhode Island	Providence
Wisconsin	Eau Claire, Green Bay, Janesville, Madison Milwaukee, West Allis, Oshkosh, Racine

Table 5: List of 51 Rust Belt Cities of the Sample

States	Cities
Connecticut	Bridgeport, Hartford, New Haven
Illinois	Bloomington, Champaign, Decatur, Peoria, Rockford, Springfield
Indiana	Bloomington, Elkhart, Fort Wayne, Indianapolis, Lafayette, Muncie
Massachusetts	Boston, Springfield, Worcester
Michigan	Ann Arbor, Detroit, Flint, Grand Rapids, Kalamazoo, Lansing
New Jersey	Trenton, Vineland
New York	Albany, Buffalo, Rochester, Syracuse, Utica
Ohio	Akron, Canton, Cincinnati, Cleveland, Columbus, Springfield, Toledo, Youngstown
Pennsylvania	Allentown, Erie, Lancaster, Pittsburgh, Reading, Scranton
Rhode Island	Providence
Wisconsin	Eau Claire, Janesville, Madison Milwaukee, Racine

2. Test of robustness

Population change is another variable that can be used to indicate the post-recession economic recovery. Table 5 presents the regression model of population growth from 2009 to 2015 of 53 Rust Belt cities on the 12 variables, and the model is named as Model 2. We could see that the results of Model 2 are consistent with the conclusion we reached in this thesis. Production factors of information firms were associated with the post-recession economic recovery of Rust Belt cities.

As shown by the table below, the number of people with masters' degrees or higher in 2009 was positively associated with population growth from 2009 to 2015, meaning that the labor pooling for information firms influenced the post-recession economic recovery of a Rust Belt city. However, instead of being an indicator of the infrastructure of information sharing of information firms, FLIGHT is, on the other hand, an indicator of population mobilization. Thus, the number of scheduled flights in 2009 was negatively associated with population growth from 2009 to 2015. In this case, the variable FLIGHT did not provide us with valuable information of how infrastructures of information firms can affect the economic recovery. In other words, we need to hold the population mobilization to be constant to discuss the effects of the infrastructure of information firms in future research.

Moreover, there are some problems to have population growth as a proxy for economic recovery. Variables about birth and mortality rates, climate, and other factors that potentially affect population growth in a specific area need to be controlled in the model, because population growth cannot simply be treated as the growth of population brought by the economic recovery. In other words, we should differentiate the population growth that was attributed to revitalization. However, population growth could still be a rough proxy for the recovery of a city since it included the growing economic vibrancy.

Another way to test the robustness of the model in section 3 is to expand the number of observations and to see if a larger sample helps to validate the hypothesized relationships between job creation and the 12 variables in section 3.

Table 5: Regression Results

	Model 1 Job Creation	Model 2 Population Growth
WAGE	0.1841	0.1074
	(0.543)	(0.0861)
EDU	1.483**	0.3372**
	(0.791)	(0.0661)
UNEMP	2793.8**	-63.833
	(996.5)	(168.18)
MANU	-0.8209	0.1083
	(0.5223)	(0.0844)
HOME	0.1722*	0.0066
	(0.099)	(0.0149)
GOV	-16925.94	291.388
	(0.112)	(0.849)
TAX	507.43	-150.746
	(1318.73)	(213.11)
DISTANCE	-5.293	0.701
	(8.791)	(1.431)
RAIL	-2621.8	-834.603
	(7465.69)	(378.888)
HIGHWAY	-1481.2	-888.10**
	(2416.6)	(378.888)
PORT	-9181.6	161.93
	(8250.7)	(895.06)
FLIGHT	0.4191**	-0.0783**
	(0.1243)	(0.0206)
Constant	-47519.07	-4792.2
	(20314.54)	(3574.19)
Observations	51	53
R^2	0.77	0.74

Source: United States Census Bureau, Bureau of Transportation Statistics, Distance Calculator – GlobeFeed.com
Note: Standard errors in parentheses, * p<0.10, ** p<0.05

3. Potential variables that could be added to the model and their problems

There are variables that we did not include in our model in section 3 but were statistically significant in estimating post-recession job growth. The number of patents, and population density can also be indicators for information sharing. These two variables are correlated with the variable EDU, FLIGHT, and UNEMP with a rate that exceeds 0.6. Due to the problem of multicollinearity, we did not include them in the final model. However, they provide useful information for future research to explore how information sharing affects economic recovery, and vice versa.

We also explored the association between job creation from 2009 to 2015 and labor force productivity in 2009. Labor force productivity in 2009 is positively associated with job creation during 2009 – 2015. The cross-section model in section 3 combined education and wage together to take labor force productivity into account. Again, if we directly include labor force productivity into the model, it has the problem of multicollinearity. Since we need to include EDU as an indicator of labor quality and labor pooling of information firms, we choose education and wage to be combined as an indicator of labor force productivity. However, the direct indicator of labor force productivity can be included in future research models to explore the effects of competitiveness of labor on economic recovery. The following table presents the simple linear regression results of job creation during 2009 – 2015 on the variables discussed above.

Table 6: Simple Linear Regression Results

	Job creation	Job creation	Job creation
Number of Patents	64.00**		
	(5.459)		
Population Density		35.04**	
		(12.30)	
Labor Force Productivity			0.535**
			(0.220)
Constant	-2406.4	-3140.8	-30186.1
	(2913.8)	(7650.2)	(18909.4)
Observations	53	53	53
R2	0.729	0.137	0.104

Source: U. S. Cluster Mapping: http://www.clustermapping.us

Note: Standard errors in parentheses * p<0.10, ** p<0.05

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