2015

A Cross-Regional Comparison of Fabricated Metals' Manufacturing Sector Resiliency

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This is to certify that the doctoral dissertation by

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Abstract

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MA, Ashland Theological Seminary, 1998

MBA, University of Chicago, 1974

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

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Abstract

Fabricated metals' manufacturing sector employment in the United States declined following the onset of the 2008 recession. Premium compensation and benefits afforded to employees within the manufacturing sector amplified the negative effects of recessionary job losses. Using the regional macroeconomic complex adaptive systems (CAS) framework, the purpose of this study was to examine the geographic distribution of job losses, recovery rates, and adaptive behavior after the recession for the fabricated metals manufacturing sector by measuring and comparing effects in 50 East North Central division MSAs and 50 South Atlantic division MSAs in the United States. Independent sample *t* tests compared average job level change rates for the tested regions. Significant differences in mean job loss rates for the two divisions occurred between 2008 and 2010 and in mean job recovery rates between 2010 and 2012. A multiple regression model analyzed the relationship of the dependent variable post-recession employment level changes with the independent variables defined as workforce demographic changes and establishment level changes as indicators of adaptive behavior. Results revealed a significant relationship between the dependent variable and shifts in the workforce demographic profile but did not reveal a significant relationship between the dependent variable and changes in the number of firms engaged in this sector. This study forms the genesis of background data for measuring cross-regional performance in the presence of external shocks and serves as a foundation for developing incentive models based on thriving sectors and regions for individuals, organizational groups, and society as a whole in engendering economic growth and well-being.

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Dedication

This dissertation is dedicated to my parents, William F. (deceased) and Katherine S. Holt, and my siblings, Sylvia L. Holt (deceased), Kathy (Holt) Peters Cole, and Alvin O. Holt (deceased). The spirit of excellence and perseverance pervaded our family's household, and our parents encouraged us at all times to pursue the attainment of our goals. As a Minister in the Body of the Lord Jesus Christ, I pray that this work will contribute to the betterment of the lives of working individuals in the United States.

Acknowledgments

I would like to acknowledge the guidance and assistance offered by my dissertation committee Dr. Jeffrey Prinster, Dr. Godwin Igein, and Dr. Janice Spangenburg. I especially thank the chair of my committee, Dr. Jeffrey Prinster, for his encouragement and wisdom as my mentor throughout my academic term at Walden University.

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Chapter 1: Introduction to the Study

Introduction

The United States Great Recession began in January 2008. The National Bureau of Economic Research Recession Dating Procedure recognized maximum and minimum economic activity levels by monitoring "real GDP, real income, employment, industrial production, and wholesale-retail sales" (National Bureau of Economic Research, 2008, par. 2). In January 2008, the Business Cycle Dating Committee marked peak economic activity in December 2007 (National Bureau of Economic Research, 2010). The recession had ended, and a sustained recovery began in the third quarter of 2009, based on national economic indicator measurements (National Bureau of Economic Research, 2010). The end of December 2007 until the beginning of June 2009 marked the 18-month recessionary period.

Although U.S. manufacturing employment numbers declined starting in 1979, the rate of job losses accelerated during the recession. Total manufacturing sector losses amounted to 2 million jobs or 15% of the base from the recession's peak to its trough (Barker, 2011). After the trough, manufacturing job losses continued to occur, affecting all subsectors. Barker (2011) stated that the durable goods sector sustained 75% of job losses, led by the transportation equipment industry and fabricated metal manufacturing products. The Institute for Supply Management confirmed the existence of structural employment losses within the manufacturing sector as the index of manufacturing activity reached a 30-year low in 2008 (as cited in Kelter, 2009). Despite an observed deterioration in national manufacturing employment after the recession and the

disproportionate adverse effects upon the younger male, blue-collar, less-educated groups, some regions or sectors displayed outcomes that contradicted the observed national pattern. In classifying regional concentrations of industrial firms within certain sectors as complex adaptive systems (CAS), empirical tests of existing secondary data can isolate characteristics of participating agents to determine the types of system adjustments that engendered sustained or growing post-recession regional industrial employment.

In Chapter 1, I will present an exposition of the background of falling manufacturing employment and the importance of this sector to the quality of life of prospective workers in the manufacturing sector. In the problem statement, I will outline the issues addressed in this paper and will further explore those issues within the research question and hypotheses sections. A description of the theoretical foundation and conceptual framework will follow where regional economic systems defined as industrial clusters will represent complex adaptive systems. A list of the keyword definitions for this paper will follow the research nature, design, and methodology description. A discussion of the assumptions, the scope, delimiters, and limitations of the research design will lead into an exposition of the significance of the study and its implications for social change.

Background of the Study

In 2007, uncertainty arose due to the volatility stemming from risky investment strategies within financial markets while demand and nominal gross domestic product (GDP) fell (Dore & Singh, 2012; Love & Mattern, 2011; Stiglitz, 2011; Sumner, 2013).

Consumer debt levels rose as funded consumer spending fell. Wages remained stagnant or declined, and income inequality widened (Dore & Singh, 2012; Lambert, 2011; Stiglitz, 2011). Artificially inflated real estate values funded prerecession consumer spending and demand (Love & Mattern, 2011; Sumner, 2013). An overabundance of capital created unstable markets (Dore & Singh, 2012; Florio, 2011; Lambert, 2011; Stiglitz, 2011) and unwarranted debt levels. As of 2011, Michigan Surveys revealed pessimistic estimates of income, consumption, and personal savings rates on the part of consumers (French, Kelly, & Qi, 2013).

As productivity increased, the demand for labor fell and consumer income declined (Dore & Singh, 2012; Dugger & Peach, 2013; Stiglitz, 2011; Sumner, 2013). Unemployment accelerated and persisted (Love & Mattern, 2011; Sumner, 2013), while capital availability contracted and constrained investment (Dore & Singh, 2012; Florio, 2011; Stiglitz, 2011; Sumner, 2013). Government entities responded to investment and employment figures with insufficient policies (Florio, 2011; Helper & Wial, 2010; Love & Mattern, 2011; Stiglitz, 2011; Sumner, 2013), and stimulus programs demonstrated limited effects (Blinder & Zandi, 2010; Dugger & Peach, 2013). Ohanian (2010) noted that the persistence of unemployment proceeded from sustained high wage levels at above market rates. Recent work emphasized the persistence of wage and job growth within the higher and lower-skilled levels of the workforce while mid-skill level employment and wages deteriorated. (Autor & Dorn, 2013; Canon & Liu, 2014; Hyatt & McEntarfer, 2012). This distribution of growth and shrinkage within labor strata also existed within industrialized countries outside of the United States (Flanagan, 2012, p.

55). Vojtovich (2011) examined the relationship between changes in national GDP and changes in employment before and after the 2008 recession and found that employment levels did not recover in tandem with the GDP recovery. This outcome stemmed from risk perceptions, productivity enhancements due to technological innovation, and improved information management (Vojtovich, 2011).

Katz and Lawrence (2011) suggested that post-recession employment no longer paralleled the earlier patterns of economic recovery during the 21st century. Within the United States, a lower consumption of goods and continuous productivity growth contributed to employment shrinkage while wages fell due to global competitive pressure and educational deficiencies within the workforce (Katz & Lawrence, 2011). Indicators of the weakness in manufacturing employment included a decline in average production, lower nonsupervisory weekly hours worked, lower manufacturing average weekly hours, and reduced overtime hours (Kelter, 2009). Factory workweek hours and associated statistics could also point to economic downturns. Diffusion indices measured the dispersion of job losses across industries. According to the diffusion index for manufacturing, the scope of job losses in 2008 reached the lowest level observed since 2001 (Kelter, 2009).

Manufacturing employee wages and benefits averaged higher values than levels observed within other sectors. Proximity engendered innovation among manufacturing plants and enabled the employment of more science and technology workers than any other business group (Helper & Wial, 2010; Langdon & Lehrman, 2012). Innovation and collaboration provided incentives for manufacturing growth (Helper & Wial, 2010;

Langdon & Lehrman, 2012), but U.S. public policy did not support that growth (Fraser & Freeman, 2011). Low-income, less-educated, workers experienced entrenched long-term unemployment patterns within the industrial sector (Sum, Khatiwada, McLaughlin, & Palma, 2010) as the recession disproportionately and negatively affected the blue-collar occupations (Fraser & Freeman, 2011). Suggested incentives to generate manufacturing employment growth entailed technical innovation stimuli, a favorable foreign exchange policy to enhance competition, and overall economic policy in support of domestic, industrial employment (Fraser & Freeman, 2011; Helper & Wial, 2010; Langdon & Lehrman, 2012; Stiglitz, 2011).

The need for relatively higher productivity and lower turnover provided a justification for the premium wage and benefits levels within manufacturing. Including employee fringe benefits in the measurement of wages, real manufacturing wages rose 16% between 2000 and 2010 while nonmanufacturing wages rose 11% in the same period. Langdon and Lehrman (2012) attributed this to the rapid increase in manufacturing employer contributions to benefit costs. The total compensation premium within manufacturing in 2011, as measured by Langdon and Lehrman (2012), totaled 15% overall for all educational levels, and the premium grew in each educational level between 2000 and 2011. Hicks (2013) acknowledged a post-recession wage and unemployment rate gap existed due to widening differences in educational levels among Indiana workers. The movement of jobs from tradable (mostly manufacturing) to non-tradable (service) industries because of changing consumption patterns led to increased demand for more highly educated workers. A “skills gap” (Hicks, 2013, p. 104) resulted

from this shift, as the workforce educational composition did not match employers' demand.

For young men, the pronounced growth in the wage gap between those holding bachelor degrees versus associate or high school educations over the period 1975 to 2005 increased abruptly during the period of 2005 to 2008. In combination with an external change to equilibrium conditions, technological advances and gaps in employment rendered midlevel positions unnecessary, so that wages permanently widened after the 2008 recession (Hicks, 2013). Employment losses affected some demographic classifications of workers more than other classifications. Young non-degreed males in blue-collar positions suffered extreme levels of job losses. Although blue-collar workers comprised 22% of the workforce before the recession, 67% of job losses occurred in the blue-collar sector (Sum et al., 2010). Historically, government policy rarely worked toward stimulating growth in industrial employment (Fraser & Freeman, 2011). Hence, by isolating those regional manufacturing clusters that flourished after the onset of the 2008 recession, blue collar manufacturing employment opportunities are identifiable.

On a national basis, a permanent unemployment curve shift followed a gap between workforce skills and labor needs, and the inability of workers to relocate to the geographic locations of job openings (Hicks, 2013). Employment patterns shifted, which disproportionally affected some demographic groups. The manufacturing sector historically contributed premium-level wages and benefits to the workforce and stimulated innovation (Helper & Wial, 2010; U.S. Department of Commerce, 2012), but

manufacturing employment fell 15% between December 2007 and December 2009 (Fraser & Freeman, 2011).

Employment within the manufacturing sector provided a wage premium that in turn supported a sustained middle class. Manufacturing wage compensation premiums remained steady throughout the 2008 recession but grew during the entire period from 2000 to 2011. Langdon and Lehrman (2012) asserted that manufacturing workers reached relatively higher educational levels within all employment classes, which made this sector instrumental in establishing U.S. economic competitiveness and creating a stable, well-compensated workforce.

Researchers examined quarterly, longitudinal employment data for private business sectors and geographical regions (Abowd & Vilhuber, 2012; Andersson, Davis, Freedman, Lane, McCall, & Sandusky, 2012; Bjelland, Fallick, Haltiwanger, and McEntarfer (2011; Blau & Shvydko, 2011; Hyatt & McEntarfer, 2012). Bjelland, Fallick, Haltiwanger, and McEntarfer (2011) studied the flow of workers between employers and recognized the continuous rationalization of labor between companies and industries in response to technological and economic shocks. They found that older workers or highly educated workers demonstrated lower propensities to relocate, and that there were no observable differences between the movements of male and female workers (Bjelland et al., 2011). For the period 1998-2010, a study of nine states indicated lower job-to-job flows, a higher frequency of long-term unemployment, and greater wage losses after the recession compared to earlier periods in the time series.

Earnings gains due to job flows kept pace with prior periods for all groups except those moving into long-term unemployment (Hyatt & McEntarfer, 2012).

Based on an application of the decomposition method to wage levels reported in the longitudinal employer household dynamics (LEHD) between 1992 and 2003, a reallocation of employees among firms, and residual (unknown) effects engendered higher wage inequality. For manufacturing, enhanced earnings in the 10^{th} percentile of earners followed the closure of lower-paying, inefficient firms, while the 90^{th} percentile benefited from the demand for highly paid skilled workers by high paying companies (Andersson et al., 2012). Higher-skilled workers moved to higher paying firms in response to technology-based skill demands within a process named "sorting" (Andersson, Davis, Freedman, Lane, McCall, & Sandusky, 2012, p. 799).

The LEHD infrastructure, and its derivative, the quarterly workforce indicators (QWI), serve as longitudinal databases and arose from a process that matched employees and firms for 98% of the private sector employers within 47 states. The availability of the LEHD database as a resource facilitated research efforts to measure the recession's impact on labor composition, earnings, and movement (Abowd & Vilhuber, 2012; Hyatt & McEntarfer, 2012). The database aided in modeling wage inequality, worker retention, and job flow patterns for various periods within the data series and comparisons to external series (Andersson et al., 2012; Bjelland et al., 2011; Blau & Shvydko, 2011). The literature did not address comparisons of post-2008 recession interregional manufacturing employment losses within the United States.

Problem Statement

Unemployment rose in the United States during 2008 as GDP fell in successive quarters, causing an economic recession (Borbely, 2011). Regional manufacturing clusters existed within the United States. The manufacturing sector offered high wage jobs for blue-collar workers and stimulated exports. In this study, I identified statistically significant relationships between the resiliency indicators in regions representative of complex adaptive systems and began to isolate contributing factors to regional agility in recovering employment levels and industry viability during the post-2008 recessionary period. Regional manufacturing clusters included the characteristics of CAS where member agents displayed evolutionary responses to external shocks to maintain the system's viability (Beinhocker, 2007; Carbonara, Giannoccaro, & McKelvey, 2010; Felton, Gibson, Flew, Graham, & Daniel, 2010; Foster, 2011; Kirman, 2010; Navarro-Espigares, Martin-Segura, & Hernandez-Torres, 2011).

Essential to the sustainability of an economic system was the ability to adapt to unexpected developments, and this capability ultimately benefited individuals and organizations. Researchers did not identify and evaluate the resilient, adaptive, sustained U.S. based but regionally diverse manufacturing sectors in which employment remained stable or rose during and after the recession. Given the premium employee benefits and wages afforded manufacturing workers, sustained regional employment within this sector would produce a positive social change in the form of higher incomes for adversely affected demographic groups.

Purpose of the Study

The National Bureau of Economic Research ([NBER] 2010) reported that peak economic activity occurred in December 2007 and for this reason officially recognized that the recession commenced at that date. The NBER defined a recession as a "significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in production, employment, real income, and other indicators" (NBER, 2008, para. 2). When external or internal shocks occurred, adaptive traits within economic systems strengthened society. Researchers did not identify the resilient, adaptive, sustained manufacturing sectors within diverse regions of the post-recession United States.

This study identified a previously robust regional manufacturing sector and assessed its employment resiliency after the economic recession of 2008-2009. The study assigned comparisons of changes in the workforce gender composition and firm population as independent variables and sustained or increasing employment opportunities as the dependent variable within the selected regions using quantitative methods. Innovative, robust, and adaptive industries that responded favorably to the recession can contribute to the long-term viability of regional economies within the United States. The exposure of investors to optimal business formation models can be an outcome of the results of this study.

Research Questions and Hypotheses

This study examined economic sustainability by comparing the depth of employment losses among diverse regions within the fabricated metals manufacturing

sector after the 2008 economic recession in the United States. Based on the theoretical framework of treating regional industrial macroeconomic systems as CAS (Beinhocker, 2007; Foster, 2011; Kirman, 2010), this study evaluated internal reactions to external shocks by the fabricated metals manufacturing industry within diverse localized economies within the United States. CAS theory maintained that, while reacting to external threats, open complex systems underwent evolutionary changes within a dynamic network of internal factors and inputs. Resiliency stemmed from constituent linkages, optimization of technology, workforce evolution, and diversification in regional manufacturing sectors in the immediate aftermath of the recession. Favorable employment moves reflected the presence of these resiliency factors (Beinhocker, 2007; Foster, 2011; Kirman, 2010). This study compared and measured the relative strengths of diverse subsystems as a means of determining why regional industry groups demonstrated uneven levels of resiliency.

The research questions encompassed comparisons of outcomes for the regional subeconomies represented by the fabricated metals manufacturing sector firms for metropolitan statistical areas (MSA) within the East North Central and South Atlantic geographical divisions of the United States. Quarterly reports included employment, establishment, and demographic data for each metropolitan and micropolitan statistical area within each of the divisions under examination. The number of MSAs within the East North Central division that reported fabricated metals manufacturing employment in the first quarter of 2008 (1Q2008) was 162, and within the South Atlantic division, the number was 144.

Research Question 1

1. Were there regional differences in post-recession manufacturing sector unemployment rates within the United States?

μ1 = Average rate of change in the fabricated metals manufacturing jobs held in the 50 randomly selected MSAs contained in the East North Central division of the Midwest Region of the United States in the first quarter of 2010 versus the first quarter of 2008.

μ2 = Average rate of change in the fabricated metals manufacturing jobs held in the 50 randomly selected MSAs contained in the South Atlantic division of the Southern Region of the United States in the first quarter of 2010 versus the first quarter of 2008.

$H_0$1: There is no statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.

$H_0$1: Null Hypothesis: $\mu 1 = \mu 2$

$H_1$1: There is a statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.

$H_1$1: Test Hypothesis: $\mu 1 \neq \mu 2$

Research Question 2

2. How did workforce gender and firm makeup affect post-recession regional manufacturing employment levels in the United States?

Dependent Variable: y_i = Percentage change in total employees in the fabricated metals manufacturing sector within the East North Central division of the Midwest region of the United States or the South Atlantic division of the Southern Region of the United States from the first quarter of 2008 to the fourth quarter of 2012 for MSA *i*.

Independent Variables:

x_{i1} = Percentage change in the male fabricated metals manufacturing workforce from the first quarter of 2008 to the fourth quarter of 2012 in MSA i.

x_{i2} = Percentage change in the female fabricated metals manufacturing workforce from the first quarter of 2008 to the fourth quarter of 2012 in MSA i.

x_{i3} = Percentage change in the number of fabricated metals manufacturing establishments from the first quarter of 2008 to the fourth quarter of 2012 in MSA i.

where:

$y_i = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2+} \beta_3 x_{i3}$

And $\beta_{j\ is}$ the main effect of independent variable $x_{ij.}$

$H_0$2: There is no statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels.

β_1 and/or β_2 and/or β_3 are not statistically significant predictors of changes in fabricated metals manufacturing employment within a region.

$H_1$2: There is a statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels.

β_1 and/or $\beta_{2,}$ and/or $\beta_{3,}$ are statistically significant predictors of changes in fabricated metals manufacturing employment within a region.

Theoretical and Conceptual Framework for the Study

Theoretical Foundation

The theoretical framework for this study was complex adaptive systems (CAS) theory where regional economic entities represented resilient open systems that evolved and adapted over time and within space in response to economic shocks. Within CAS, constituent agents responded interactively to the surrounding environment after the occurrence of an event. Adaptive behaviors appeared in the context of CAS theory operating within economic entities represented by dominant regional manufacturing sectors (Martin & Sunley, 2007). In this sense, CAS exhibited adaptation via self-organization, emergence, nonlinear dynamics, and non-determinism while member agents reacted to external shocks.

AAdaptations and innovations occurred in the selected regions if the local economy operated as a CAS. Resilient economic systems demonstrated flexibility and survival capability after suffering from the onset of external shocks (Pendall, Foster, & Cowell, 2009; Tonts, 2011). Resilient economic systems returned to their initial states or improved conditions (Pendall et al., 2009; Simmie & Martin, 2010). The new or recovered status achieved after a shock reflected a new equilibrium (Simmie & Martin, 2010).

CAS theory provided the process context in which systems operated to survive and demonstrate resiliency (Pendall et al., 2009). Multistep, cyclical processes (Pendall et al., 2009) displayed spatial characteristics (Tonts, 2011) in response to external disruptions. Spatial adaptive behavior involved interscalar agents that operated through

time and distance within a multistage process, and engaged in iterative levels of resistance and recovery after the occurrence of an external event (Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010).

After external economic shocks occurred, nations and regions exhibited resilience through traits such as diversity, agility, and shared knowledge (Felton, Gibson, Flew, Graham, & Daniel, 2010; Navarro-Espigares, Martin-Segura, & Hernandez-Torres, 2011). Likewise, regional economies displayed resilience by acting as CAS (Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010; Tonts, 2011). Moreover, traditional economic models, replaced by complexity theory, noted that the recession's causes could be rooted in the absence of the interactivity and knowledge sharing necessary for sustained and agile complex systems (Kirman, 2010; Marien, 2009). CAS migrated toward change after an external shock by sharing internal feedback within a multidimensional framework, fostering creativity, innovation, and movement toward change (Avery, 2010; Carbonara, Giannoccaro, & McKelvey, 2010; Ellis & Herbert, 2011; Foster, 2010;).

Conceptual Framework

Industrial cluster theory wherein locational proximity engenders competitive advantage and resilience is the underlying conceptual framework for this study. In the aftermath of multiple recessions, a contrasting study of two UK regions indicated that one geographic area followed a trajectory of job growth, while the other region exhibited economic deterioration (Navarro-Espigares, Martin-Segura, & Hernandez-Torres, 2011; Martin, 2012b; Simmie & Martin, 2010; Tonts, 2011). When global technological

developments surpassed local technical capabilities, obsolete workforce skills led to economic decline. Businesses and industries failed to adapt to external events. If a region containing a well-educated workforce adjusted to external shocks by diversifying into high growth industries, encouraging entrepreneurship, and displaying innovation, then higher employment patterns followed (Martin, 2012b; Simmie & Martin, 2010). Total employee level change and total firm level change measurements within regions over time defined resilience. The nature of the external shock refined the definitions of resiliency and its variables (Martin, 2012b; Pendall et al., 2009).

Recent literature did not identify or discuss adaptive manufacturing regions and their characteristics within the United States after the 2008 recession. Comparative studies of pre- and post recession regional economies outside of the United States proliferate, yet minimal research focused on post-recession comparisons of locational adaptive activity within the United States. In domestic analyses of the recession's impact on manufacturing employment, scholars focused on job flows and earnings changes within individual states or a national level. Porter (2008) maintained that a regional competitive advantage arose from natural, geographical clusters. Simmie and Martin (2010) described types of regional economic resilience and adaptability within the theoretical framework of evolutionary economic geography. Carbonara et al. (2010) argued that clusters acted as CAS that demonstrated successful interactions by following certain structural and relational precepts. Stiglitz (2011) suggested that classical economic theory inadequately explained the 2008 recession's occurrence, aftermath, and

sources of recovery. Kirman (2010) stated that CAS should include economic systems that displayed nonlinear behaviors.

Nature of the Study

In this quantitative study, I compared changes in the fabricated metals manufacturing sector employment levels among regions of the United States after the 2008 recession. Based upon a North American Industry Classification System (NAICS) 3-digit classification code of 332 in 2007, the study calculated descriptive comparative pre- and post recession statistics for the top ranking national manufacturing employer group. The analysis consisted of a cross-regional analysis of the MSA employment data for the fabricated metals manufacturing NAICS sector for the East North Central and South Atlantic divisions as geographically defined by the U.S. Census Bureau. Applying an independent *t*-test model to employment changes between the first quarters of 2008 and 2010 within the East North Central division and the South Atlantic division of the United States determined if the difference in the average employment change within the top MSAs for each division displayed statistical significance.

Quarterly employment levels, gender composition, and firm levels for the first quarter of 2008 and fourth quarter of 2012 denoted the units of analysis for the second research question. The research strategy entailed a multiple linear regression comparing employment patterns for the selected manufacturing industrial sector before and after the onset of the 2008 recession. An analysis of male and female employment levels before and after the recession established whether a statistically significant relationship existed between changes in total job levels and changes in the gender composition of the

workforce for the two regions. In addition, a multiple regression model measured the relationship between changes in employment for the selected sampling unit and the number of firms within the MSA for the selected NAICS code 332.

Design

For the requisite number of MSAs within each region included in this study, accessed employment data covered each level of each independent variable after the onset of the recession in January 2008. Published LEHD-based QWI employment statistics located on and downloadable in Excel format from http://ledextract.ces.census.gov/ served as the dataset. An 80% Power level *t*-test of the equality of means between employment changes within the test regions established whether the two divisions formed two distinct regional economic systems of fabricated metal manufacturing sector activity. A multiple regression analysis determined the signficance level of the relationship of the workforce makeup with respect to gender and total firm levels to the change in absolute level of employment in the fabricated metals manufacturing sector as the recession ended.

Sampling Strategy

The population consisted of the total number of jobs or employee/establishment matches reported as of the first day of the selected quarters within the fabricated metals manufacturing sector. Test data covered the East North Central and South Atlantic divisions of the United States. The units of analysis were the MSAs that contained fabricated metals employees within the selected census divisions. Quarterly employment statistics for MSAs within the selected regions comprised the sampling

frame based on the data included in the QWI, a database that was included in and downloaded from the http://ledextract.ces.census.gov/.

Defined Terms

Current Employment Statistics (CES) Survey: A monthly survey of business establishments that provides estimates of employment, hours, and earnings data by industry for the nation as a whole, all States, and most major metropolitan areas since 1939. Employment data referred to persons on establishment payrolls who received pay for any part of the pay period that includes the 12th of the month. The count included persons at their place of work rather than at their place of residence and one for each payroll upon which they appear. The principal product or activity of an establishment determined its classification in an industry in accordance with the most recent North American Industry Classification System Manual (United States Department of Labor – United States Bureau of Labor Statistics, 2013).

Complex adaptive systems (CAS): Open systems where tensions and interdependence between member agents worked to foster change and adaptation through continual movement, as well as interactions in linear and multidimensional space on multiple levels (Espinosa & Porter, 2011).

County Business Patterns (CBP): CBP is an annual employment statistics publication for geographic areas and NAICS codes derived from U.S. Census surveys. The CBP series provided geographical and economic data by industry sector. This data series reported the number of establishments, employment during the week of March 12, the first quarter payroll, and annual payroll. Business establishments form the sampling

frame for this survey of data (United States Department of Commerce – United States Census Bureau, 2013).

Fabricated metals manufacturing (NAICS 332): "Industries in the fabricated metal product manufacturing subsector transform metal into intermediate or end - products other than machinery, computers and electronics, and metal furniture, or treat metals and metal formed products fabricated elsewhere. Important fabricated metal processes are forging, stamping, bending, forming, and machining used to shape individual pieces of metal and other processes, such as welding and assembling, used to join separate parts together. Establishments in this subsector may use one of these processes or a combination of these processes" (United States Department of Commerce – United States Census Bureau, 2014).

Fiscal policy: The financial policy of a government regarding government spending and taxation serving as a stimulus tool (Wessels, 2006, p. 178)

Great Recession/Recession/2008 Recession: The period between the end of December 2007 and the beginning of June 2009, where GDP fell for more than two consecutive quarters (National Bureau of Economic Research – Business Cycle Dating Committee, 2010).

Gross domestic product: "The total value of the goods and services produced by the people of a nation during a year, not including the value of income earned in foreign countries" (Wessels, 2006, p. 68).

Industrial cluster: A group of companies and institutions located within a geographic region with common interests, resources, and business foci where internal

collaborations and associations advance the goal of shared economic growth (Brenner & Muhlig, 2013; Porter, 2008).

Longitudinal Employer-Household Dynamics Program (LEHD): Located at the U.S. Census Bureau, the LEHD database originates from a cooperative effort among state unemployment reporting and collaborations between federal and state reporting entities. The database covers 47 states, is a job-based population and includes the connection between individuals and employers reported periodically. Matched relationships with external databases allowed for the collection of descriptive characteristics of the employers and individuals (Abowd et al., 2009).

Monetary policy: "Policy determining the level and growth rate of the money supply" (Wessels, 2006, p. 607)

Metropolitan statistical area (MSA): the U.S. Department of Labor Bureau of Labor Statistics defined the MSA. Each metropolitan statistical area must contain at least one urbanized area of 50,000 or more inhabitants. A micropolitan statistical area contained an urban core of at least 10,000, but less than 50,000, inhabitants. The largest city in each metropolitan or micropolitan statistical area was named a "principal city." Additional cities qualified if they met specified requirements concerning population size and employment. The title of each metropolitan or micropolitan statistical area included the names of up to three of its principal cities and the name of each state into which the metropolitan or micropolitan statistical area extends. Titles of metropolitan divisions included principal city names and in certain cases consisted of county names (United States Department of Labor – Bureau of Labor Statistics, 2012).

North American Industry Classification System (NAICS): The NAICS was the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. Developed under the auspices of the Office of Management and Budget (OMB), NAICS replaced the Standard Industrial Classification (SIC) system in 1997. The NAICS arose from a joint effort by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia to allow for a high level of comparability in business statistics among the North American countries (United States Department of Commerce – United States Census Bureau, 2013).

Quarterly Workforce Indicators (QWI): Quarterly employment statistics derived from a U.S. Census job-based frame delineated by geographic area and NAICS code. Demographic information provided included sex, age, educational level, and race. Derived from the LEHD series, the QWI provides employment statistics delineated by industry and geographic sectors (Abowd et al., 2009).

Quarterly Census of Employment and Wages (QCEW): Quarterly survey of business establishment employment and numbers based on geography and NAICS code. Derived from the Bureau of Labor Statistics Business Dynamics Statistics, the job-based frame captured employment levels, firm levels, ownership, and size. Employment statistical databases were not precisely the same as QWI statistics (U. S. Department of Labor - Bureau of Labor Statistics, 2014).

Recession: an Economic condition in which real GDP falls for two consecutive quarters (Wessels, 2006, p. 102).

Resilience: Ability of a system to adapt and reshape itself to return to or exceed its state after the application of an external shock or stimulus (Martin & Sunley, 2007; Maitland & van Gorp, 2009).

Assumptions

Although the recession occurred on a worldwide basis, in this study, I focused on regions within the United States only. This paper excluded external effects such as the level of foreign direct investment levels, investments in new enterprises, start-ups, and government stimulus packages. The period from January 2008 to June 2009 represented the period of the Great Recession, consistent with the definition provided by the National Bureau of Economic Research recession dating process (National Bureau of Economic Research, 2008; National Bureau of Economic Research, 2010). Manufacturing job losses particularly undermined the economy due to the relatively higher wage and benefit levels of manufacturing sector employees and the technical expertise found within its workforce (Fraser & Freeman, 2011; Helper & Wial, 2010; Langdon & Lehrman, 2012).

I assumed that the supply of labor could adequately meet demand for labor within the regions and industries under examination within the United States, given the increase in unemployment rates during the recession. Collaboration along vertical and horizontal structures, proximity, self-organization, innovation, and knowledge sharing described regional resiliency indicators (Carbonara & Giannoccaro, 2011; Ellis & Herbert, 2011;

Foster, 2010; Martin & Sunley, 2006; Martin & Sunley, 2007; Maitland & van Gorp, 2009; Nousala, 2009).

Regional industrial clusters in the form of business groupings pooled knowledge and resources to withstand external economic shocks. On a global basis, clusters developed from linkages among key industry agents within an environment of strategy, competition, resources and demand, (Brenner & Mühlig, 2013; Mizuki, 2014; Randelli & Boschma, 2012; Scott, 2012; Ter Wal & Boschma, 2011; Zheng & Jin, 2014).

The statistical analysis relied upon aggregated geographic data derived from U.S. Census records and Bureau of Labor Statistics records on employment, gender, and firm levels for selected MSAs and the fabricated metals manufacturing sector. Measurements included a sample of the MSAs as the units of analysis within the designated regions employing the identified worker population.

Scope and Delimitations

In this study, I analyzed the effects of the recession upon regional economies' resilience solely within the United States. In addition, the study addressed the fabricated metals manufacturing sector due to its relative size at the recession's start, the loss of employment in this sector, its disproportionately higher wage and benefit levels relative to other blue-collar occupations, and the major decline in employment nationwide. As a generator of export sales, manufacturing stimulated the national economy. The examination included two major employing regions and measured the differences in resilience between the two regions.

The fabricated metal manufacturing sector was the largest 3-digit level NAICS code manufacturing sector employer group at the beginning of the test period and, therefore, met the selection criterion for this paper. This sector intersected a broad set of industries with diverse end uses in the wider economy. The top MSAs fell within two distinct noncontiguous regions of the United States to provide a breadth of coverage. For the period 2008 to 2012, test employment data included hourly and salaried workers. The evaluation of effects on employment levels incorporated gender as a demographic delimiter. This paper excluded a measurement of the impact of the U.S. government's stimulus packages and initiatives, and the effects of federal funds provided to support the automotive industry. The QWI database omitted government employment data so that public sector effects do not appear within the scope of this paper.

Limitations

Data Imputation Effects. Generated from statewide mandatory establishment unemployment reports and U.S. Census records, the Quarterly Workforce Indicators (QWI) and Quarterly Census of Employment and Wages (QCEW) aggregated to form the Longitudinal Employer Household Dynamics Program database (LEHD) (Abowd et al., 2009). Imputation methods addressed missing or invalid data elements within the LEHD. Database cross-references and probability models sufficed to impute missing fields, where necessary (Abowd et al., 2009). No adverse affects of data imputation methods appeared with the data. Calculations indicated that the data fulfilled all requisite parametric test assumptions necessary to answer Research Question 1 and Research Question 2.

Disclosure Avoidance Methods. The application of "noise- infusion" distortions into the QWI database with the intent of protecting individual and establishment privacy constituted the test for analytical validity (Abowd et al., 2009, p. 197). The tests of the error distribution indicated that disclosure avoidance procedures did not cause statistical bias within the QWI (Abowd et al., 2006, Abowd et al., 2009). Privacy-driven masking of MSA-level firm data from the QCEW limited the number of available MSA records in the target group for Research Question 2 yet allowed for a sample size of the minimal 50 cases per region described in the research strategy in Chapter 3.

Face Validity. The QWI stemmed from firm level data collected and reported on a quarterly basis from 47 states. MSA-level employment reports based on county-level aggregations for a selected NAICS code produced the sample for this paper. Underlying pairings of masked individual identifiers and personal census data supplied the demographic workforce descriptors (Abowd & Vilhuber, 2011; Abowd et al., 2009).

Content Validity. All MSAs within the targeted regions provided test data, with the exception of firm level data. The sample size exceeded the required target necessary to obtain a power of 80%. Recent studies of trends in employment within the United States accessed the publicly-available QWI and the private access LEHD (Abowd et al., 2009; Abowd & Vilhuber, 2012; Abowd & Vilhuber, 2011; Andersson et al., 2012; Bjelland et al., 2011; Blau & Shvydko, 2011; Helper, & Wial, 2010; Hyatt & McEntarfer, 2012).

Empirical Validity. An observation that the design and inferential tests match and measure the intended research topic and that the results indicate the existence of an

actual relationship or effect establishes the presence of empirical validity (Frankfort-Nachmias & Nachmias, 2008). Several recent papers measured economic resilience as job growth (Boianovsky & Trautwein, 2010; Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010). Likewise, this paper defines resilience in terms of employment growth.

Construct Validity. Linear models measured the relationship between regional employment and external resiliency indicators such as housing price strength, government spending as a percentage of GDP, GDP per capita, inflation, and labor migration in several studies (Abowd & Vilhuber, 2012; Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012).

This study applied a multiple regression model to post-recession employment data, workforce demographic changes, and firm level changes in order to compare regional resiliency.

Confounding Variables. Potential confounding variables considered for this research design included the regional impact of oil prices, utility prices, and interest rates on employment gains. However, the lack of availability of relevant data for each of the MSA-level units of analysis on a quarterly precluded the incorporation of these potential confounding variables.

Significance

Significance to Theory

This study expanded the body of research that addressed the survival of U.S. cross-regional manufacturing sectors and the maintenance or growth of post-Recession employment. Researchers did not discuss comparisons of the adaptive ability between or

among U.S. manufacturing regional economic clusters after the 2008 recession. The goal of this research was to demonstrate the linkage between CAS theory and regional resilience in the face of recessionary effects and to measure the impact of workforce composition and firm characteristics upon the economic survival of a region. This paper tested the manufacturing sector under review for adaptive behavior. Additional insight will provide input toward the development of targeted employment expansion strategies and workforce development within depressed regions, specifically in relationship to lucrative manufacturing sector employment.

In the presence of external shocks or changes, systems must adapt to survive (Carbonara et al., 2010). CAS theory applied to networks, firms, industrial sectors, regional economies, and macroeconomic systems (Carbonara et al., 2010; Ellis & Herbert, 2011; Foster, 2010). Dynamic and fluid systems featured diverse, interacting agents that openly communicated and shared internal feedback while migrating toward change (Avery, 2010; Ellis & Herbert, 2011; Foster, 2010). In this study, I applied CAS theory to the East North Central and South Atlantic divisions of the United States to assess how changes in the workforce and firm makeup for these regions after the 2008 recession reflected economic recovery. Change, defined as higher employment, stemmed from self-organized interactions among diverse agents to reform the overall structure and engender survival after external shocks (Avery, 2010; Carbonara et al., 2010; Ellis & Herbert, 2011).

Significance to Practice

Physical proximity and the commercialization of core technologies and networks contributed to the formation of a successful economic regions as evidenced by business combinations and public funding to stimulate investments (Brenner and Muhlig, 2013; Mizuki, 2014; Zheng & Jin, 2014). Smaller firms within clusters or regions attracted experienced talent and external financing that otherwise might not be available. Small and medium-sized enterprises (SMEs) shared information from within the industry to successfully sell and manufacture products within new markets (Randelli & Boschma, 2012). SMEs used linkages and interactions afforded to them within geographical clusters to position themselves to participate in new, global markets (Randelli & Boschma, 2012).

Enhanced knowledge-based human capital, continuous growth, and the dispersion of common technologies, generated and strengthened linkages among firms. Inter-agent connections took the form of cross-border linkages or remained within a single country's borders. During the process of cluster development, technology-based industry expansion took the form of a longer vertical supply chain or a wider horizontal diversification within an industry. Resilient industrial clusters encompassed increasingly stronger and broader networks of firms well-equipped to react to external threats (Brenner & Muhlig, 2013; Mizuki, 2014; Randelli & Boschma, 2012; Ter Wal & Boschma, 2011; Zheng & Jin, 2014).

Significance to Social Change

The results of this study can inform and direct the recruitment of companies from the most resilient sectors into targeted regions and ultimately produce long-term economic growth within those regions. An added benefit of the outcome of this research could be the genesis of background data as a foundation for the development of financial incentives for thriving sectors. Targeted individual career planning and employee training models could also result from this analysis. All constituents or agents could gain from new private and governmental policy direction toward educational initiatives tailored to the needs of resilient industries within a given region.

Positive social change could occur within society, public and private institutions, and for the benefit of individuals, as the application of CAS to economic regions yields an understanding of how districts maintained or surpassed their pre-recession viability. An understanding of adaptive strengths within geographic areas and industries could enhance job opportunities for individuals and increase the overall economic well-being of society.

Summary

Job erosion within the manufacturing industry accelerated during the Great Recession on a national level. A partial rebound in employment subsequently occurred, but the identity of the rebounding regions is unknown. A skills gap prevailed within the workforce, so that highly educated workers retained compensation premiums while blue-collar workers continued to lose premiums. In this study, I examined differences in the recession's impact on specified regions within the United States to determine if post-

recession resilience related to the workforce demographic makeup and the firm level changes within the region and sector.

This quantitative study design evaluated and compared population attributes for diverse groups of data. After accessing public secondary data, an independent means *t*-test determined if statistically significant relationships, associations, or differences existed for employment within the fabricated metals sector among the selected United States geographic regions following the Great Recession. A multiple regression statistical model revealed contributing factors to adaptive behavior.

Chapter 2 presents a literature review of recent work covering the nature of resiliency, a description of geographic economies as CAS, the causes of the Great Recession and its impact on employment. The literature review will include a survey of the literature that addressed the application of inferential methods to comparisons of population behaviors.

Chapter 2: Literature Review

Introduction

Lower U.S. employment levels and GDP values followed the onset of the recession in 2008. The U.S. government and the Federal Reserve System provided monetary and fiscal responses. Although the advent of these reactive measures intended to offset the effects of the recession upon the U.S. population and its economic system, unemployment and slow growth persisted until after the designated upturn in the second quarter of 2009.

Stiglitz (2011), Sumner (2013), and Varjavand (2013) advanced several approaches to explore the causes of the recession in efforts to identify remedies for its impact. Researchers provided analyses and comparisons of demographically diverse international locales, contrasting industries, and multiple regions to isolate and measure differences among the effects of external shocks (Belussi & Sedita, 2009; Bhattacharya & Dasgupta, 2012; Dugger & Peach, 2013; Navarro-Espigares et al., 2011). Surveyed, available literature did not address comparisons of the impact upon employment within pre-existing, traditionally robust manufacturing industries within geographic regions of the United States after the 2008 recession. Additionally, traditional economic models did not provide complete expositions of the causes, extent, and length of the recession (Beinhocker, 2007; Stiglitz, 2011) or a theoretical framework in which to understand this economic phenomenon.

In Chapter 2, I will present a literature review that will begin with a description of the search strategy and search terms used to locate recent research pertinent to the topic

of regional economic adaptive behaviors in light of external shocks. The review will describe the processes inherent to CAS and apply them to adaptive regional behavior residing in industrial clusters. I will present evidence of resilience within nations and regions, and extract attributes to develop a model of resilience in the aftermath of the recession. Following is a discussion of the cause of the recession and its impact on firms, employment, and the manufacturing sector. An analysis of the adaptive characteristics of industrial clusters as CAS will integrate theories surrounding the intervention of diverse factors and their impact upon employment patterns. The discussion topics will include research methodologies that applied to comparisons of regional systems and populations to corroborate the selected research design for this study.

Literature Search Strategy

To locate sources for the literature review, I accessed the Walden University Library, using the Thoreau interdisciplinary search mechanism to reference articles published primarily within the period 2008 to 2014. A search within Google Scholar also supplied titles of pertinent and original articles. Cross-referencing those titles with the Walden University database provided a verification of peer-reviewed status. The literature review incorporated works cited within seminal and recent critical studies. Search terms encompassed the following: *recession, 2008 recession, employment, unemployment, regional economics, resiliency, resilience, economic recession, complex adaptive systems, evolutionary economics, path dependency, manufacturing employment, regional employment, clusters, cluster theory, United States, Porter, Beinhocker, Foster, Martin, LEHD, QCEW, QWI, United States Census, and US Census.*

Theoretical Foundation

Complex Adaptive Systems

Open CAS stressed information sharing between internal system agents and external factors via permeable borders (Espinosa & Porter, 2011). System survival depended upon rapid internal adjustments in recognition of impending external changes. Inflexible conventional vertical hierarchies did not readily respond to a dynamic environment, and the process-based functionality of CAS adapted spatially to external stimuli. The following six elements comprised CAS behavior within an organization: (a) spontaneous bottom up organizational adjustment,(b) feedback among agents, (c) evolutionary behavior, (d) advent of unique configurations, (e) emergence of a high level structure out of underlying complexity, and (f) adaptations occuring at cutting edge locations (Espinosa & Porter, 2011, p.57).

Buckley, Schwandt, and Goldstein (2008) claimed that CAS illustrated the presence of change processes within social and economic systems. Within this model, systems did not move toward equilibrium and eventual entropy but adapted to internal and external events to restructure themselves on a continuous basis. Innovation and creativity strengthened adaptation mechanisms. Buckley et al. identified six components of CAS: (a) tensions, (b) dependency of agents upon an understanding of the environment's structure, (c) continual movement between states, (d) nonlinearity and diversity to facilitate selection, (e) changeability and irregularity, and (f) multilevel and spatial interrelationships to foster coevolution. Each of the components advanced the CAS adaptive process and capability.

Evolutionary macroeconomics predicted and contemplated an economic growth system where structures remained intact over time as replication and selection within those systems ensured sustainability (Foster, 2010, p. 11). Evaluating and adopting inherent, dynamic norms identified as "meso-rules" (Foster, 2010, p. 14) included an understanding of an industry's evolutionary changes. The potential of an industry's sustainability and growth, the likelihood of new firm entry, and increased innovation would follow activity within the parameters of an industry's "meso-rules" (Foster, 2010, p. 14) when operating as a CAS.

A CAS organizational model possessed internal dynamics that stimulated positive change and evolution to an enhanced state in the presence of external disruptions (Avery, 2010). This approach applied systems, scientific methods, and data analysis to business management issues. Avery (2010) asserted that U.S. business management teams attempted to apply Deming's management methods, including lean manufacturing and total quality management, before first understanding the systems theory underlying each method. When CAS principles appeared within an organization, the entire entity gained an advantage and value from the actions of its components' innovative and creative behavior.

Ellis and Herbert (2011) proposed an application of CAS theory to a quality management structure and process. The paper listed the four elements of CAS as "multiple agents with schemata, self-organizing networks, coevolution, and system adaptation" (Ellis & Herbert, 2011, p. 34). Internal network feedback gave rise to universal, inclusive solutions. Systems responded to changes by enacting structural and

process alterations that could be observed in transformed decision-making and modified hierarchies.

Carbonara et al. (2010) examined the makeup and behavior of CAS as embodied within geographical clusters, regional economies, and industries. Overall CAS actions manifested while diverse agents interacted internally among themselves and externally with agents within their surroundings. Operating within a continuous evolutionary state and without a singular authority, agents "self-organize[d]" (Carbonara et al., 2010, p. 27) and became a new, evolved system. Continuous environmental disturbances could lead to either order or to chaos as the CAS moves in and out of fluctuating states.

Carbonara et al. (2010) assigned seven attributes to CAS: (a) diverse agents with different objectives, (b) status between equilibrium and chaos that arose after an external jolt, (c) coevolution as a means of adaptation where agents interacted with each other and the environment, (d) self-organization and structural emergence based on learning in the face of tensions presented, (e) nonlinear interactions additive and multiplicative effects, (f) butterfly effect where smaller actions can be leveraged to produce substantial systemic effects, and (g) scalability in that a common structure appeared at all levels in a fractal pattern where cause and effect relationships replicated themselves.

An application of CAS theory to industrial clusters and regional economic structures indicated that geographical clusters (GCs), displayed all of the characteristics of CAS (Carbonara et al., 2010, p. 29). The concentration of members at all levels of the supply chain, as well as lateral relationships within an industry located within a region, illustrated the diversity of members or agents. The presence of public and private

organizations reflected the heterogeneity of a regional CAS. Citing the example of the microelectronics industry's emergence within Silicon Valley, self-organization in that instance implied the usage of indigenous variables and attributes to stimulate growth and adaptation while discarding superfluous attributes (Carbonara et al., 2010).

The effects of nonlinear interactions multiplied as the system became flexible because of feedback from its diverse agents. Reactive adjustments occurred within the system and extended beyond individual firms. The introduction of a new concept by one firm that ultimately influenced activity within an entire industry revealed the presence of the butterfly effect, for example. Examining a distribution of businesses by size and noting that it followed a power law format confirmed scalability (Carbonara et al., 2010).

Carbonara et al. (2010) analyzed geographic clusters (GC) to ascertain where GCs displayed characteristics of CAS and remained competitive. A sports district in Montebelluna, Italy appeared as an example of a vibrant GC that demonstrated CAS traits. Within this district, product offerings expanded into harmonizing and replacement lines. Vibrant regional industrial centers stimulated growth by growing and changing the core offerings and markets of the relevant sector (Carbonara et al., 2010, p 34). Other GCs activated local mechanisms that fostered competitive continuity. Adaptive GCs established industry groups and optimized research results for usage within the region. Carbonara et al. (2010) maintained that these activities within sustained GCs characterized CAS. All seven qualities of CAS as delineated enabled a GC to adapt successfully to external competitive pressures.

CAS theory applied to networks, firms, industrial sectors, regional economies, and macroeconomic systems (Carbonara et al., 2010; Ellis & Herbert, 2011; Foster, 2010). In the presence of environmental shocks or changes, systems could either collapse or expand (Carbonara et al. 2010). Dynamic and fluid systems featured diverse, interacting agents that openly communicated and shared internal feedback as they continually migrated toward change (Avery, 2010; Buckley et al., 2008; Ellis & Herbert, 2011; Espinosa, & Porter, 2011; Foster, 2010). Creativity and innovation generated inventive solutions to external disturbances (Buckley et al., 2008; Ellis & Herbert, 2011) or pre-existing internal rules created system stability and resilience (Foster, 2010). CAS entailed spatial, non-linear relationships (Buckley et al., 2008; Carbonara et al., 2010; Ellis & Herbert, 2011; Espinosa, & Porter, 2011), and the system structure displayed fractal qualities (Carbonara et al., 2010). Self-organized interactions among diverse agents to reform the overall structure for survival after external shocks led to change (Avery, 2010; Buckley et al., 2008; Carbonara et al., 2010; Ellis & Herbert, 2011; Espinosa, & Porter, 2011). Table 1 presents the CAS concepts.

Table 1

Complex Adaptive Systems Concepts

Buckley et al.	**Espinosa & Porter**	**Foster**	**Avery**	**Ellis & Herbert**	**Carbonara, Giannoccaro, and McKelvey**
Tensions	Feedback	Evolutionary Macro-economics	Internal Dynamics	Multiple Agents	Diverse Agents
Agents		Inherent Rules	Whole as Sum of Parts	Networks	Vacillation between Equilibrium and Instability
Movement	Spontaneity	Sustainability	Systems Analysis	Adaptation	Coevolution as the Environment changed
Spatial/Diversity	Evolution	Innovation	Scientific Methods	Coevolution	Learning and Self-Organization
Open Systems	Unique Forms		Data Analysis	Collaborative	Additive and Multiplicative Effects within Spatial Environment
External Energy Resources	High Level Simplicity		Innovation	Feedback	Leveraging of Small Actions = Butterfly Effects
	Adaptive at the Edges		Fluidity and Unpredictability	Spatial	Replication and Scalability of Outcomes on Multiple Levels
			Information within Confusion and Turmoil	Realignment of Hierarchies	
				Multilevel Decision-making	

Complex Adaptive Systems and Regional Resilience

Maitland and van Gorp (2009) defined regional adaptive capacity within the context of CAS. Dynamic economic entities continuously gained and lost constituents when goals shifted and evolved. In an examination of the development of congruent policies among groups of information technology-related regional policy-making agents, adaptive capacity arose from "variation, interaction and selection" (Maitland & van Gorp, 2009, p. 23). An analysis of organizations within Europe and South Africa revealed common behavioral characteristics that engendered group-based expanded capabilities.

An even division of variety and homogeneity among the connected agents within a regional system provided a range of alternative resources and flexible, reactive measures after the introduction of change. Maitland and van Gorp (2009) characterized this process as "harmonization and competition" (p. 29) and the attribute as "variation" (p. 28). Adaptation demanded "interaction" (Maitland & van Gorp, 2009, p. 29), an activity that originated from activity among network agents. The involvement of all levels of a hierarchy in the act of developing solutions ensured an adequate consideration of all alternatives (Maitland & van Gorp, 2009, p. 29). The third critical component within adaptive systems involved selection activity, which subjected potential actions to rejection or adoption in order to achieve a successful transition.

The comparative study of regional policymaking entities in the European Union and South Africa also yielded three adaptive activities. Epistemic communities or groups of experts formed within or outside of the organization (Maitland & van Gorp, 2009). Diverse members built capacity and shared knowledge while constituents collaborated

within multilateral relationships to resolve issues and develop policies. Specific conditions pertinent to the agent's needs produced selected tailored solutions (Maitland & van Gorp, 2009). Constituent groups accessed needed expertise or mustered financial resources in order to adapt to change within regional economic entities. Diverse solutions developed as experts' accessibility to multiple constituents provided innovative solution sets across the spectrum of the entity's membership (Maitland & van Gorp, 2009).

Martin and Sunley (2007) stated that complexity theory offered an explanatory framework for economic and natural systems, but one constructed these contexts with difficulty. Martin and Sunley referenced Krugman's allusion to complexity in relationship to colocations, and industries and cities' self-organization. Although difficult to model mathematically, self-organization appeared within complex systems (Martin & Sunley, 2007, p. 576). CAS displayed "non-linear relationships between its parts, have emergent self-organization, internal spontaneous self-organizing adaptation, [and] co-evolutionary interactions" (Martin & Sunley, 2007, p. 577).

Carbonara and Giannoccaro (2011) evaluated the impact of four types of proximity upon adaptability within industrial districts. Carbonara and Giannoccaro recognized that geographical, organizational, cognitive, and social proximity promoted invention. A configuration of "medium level of geographical, cognitive and social proximity combined with low organizational proximity" engendered the highest adaptive capacity (Carbonara & Giannoccaro, 2011, p. 433).

Nousala (2009) analyzed the steel housing industry within Australia and promoted the idea of interactions as necessary for developing a collective memory. SMEs lacked an understanding of methods for enhancing sustainability, and Nousala suggested that industry groups resolved common challenges by drawing upon knowledge and experiences. Expanding an industry cooperative group to engage larger firms, as well as all levels of the supply chain, enhanced the breadth of common knowledge and broadened the impact of technological advances within the sector. Nousala (2009) indicated that knowledge shared via interactions and communications among sector-specific SMEs produced growth and stability. Proximity facilitated resource sharing and trust among firms within a location or industry (Carbonara & Giannoccaro, 2011).

A progressively positive trajectory demanded interactions among all levels of a system where partners, subordinates, and superiors contributed to sustainability (Maitland & van Gorp, 2009; Martin & Sunley, 2007). The selective appropriation of external technology and innovation supplemented the use of existing internal expertise within effective systems (Maitland & van Gorp, 2009; Martin & Sunley, 2007). Diversity within the initial system's composition promoted a continual development of varied solutions and ideas. Extensions of related industries from within existing systems or sectors represented a manifestation of resilience (Martin & Sunley, 2007). Adaptive behavior required system felicity awareness when selecting solutions in concert with retaining self-interest as a priority. System collaboration and interaction encompassed knowledge and resource sharing to develop suitable and efficient solutions (Maitland & van Gorp, 2009). Table 2 presents CAS resilience.

Table 2

Complex Adaptive Systems and Regional Resilience

Maitland & van Gorp (2009)	**Martin & Sunley (2007)**	**Carbonara & Giannoccaro (2011)**	**Nousala (2009)**
Variable Solutions	Complexity Theory Spatial, Self-organization, Interaction, Adaptation	Industrial Districts as Complex Adaptive Systems	Industrial Sector as Complex Adaptive Systems for Competitive Standing
Interaction Within Hierarchy	Uncertain Framework Construction	Geographical, Cognitive, and Social Proximity	Promotion of Scalability
Selection of Optimal Group Solution	Self-organization and Colocations		Interactions within Hierarchy
Expert Communities			Leveraging Common Knowledge
Collaboration			Communicating Technological Innovation
Leveraging of Resources			

The Origin of Wealth and Complexity

Beinhocker (2007) depicted the origins of classical economics beginning with Smith and Mill. Tracing the evolution of economic theory from its moral and political base through evolving efforts to reduce economic behavior to empirical models, Beinhocker asserted that traditional models fell short when depicting actual behaviors and scenarios. Over time, principles of physics influenced the development of mathematical models within this discipline and created an expectation of a natural equilibrium state. Smith and Pareto's foundational concepts pointed toward wealth optimization as an outcome of mutually self-interested behavioral patterns.

Developments of the 20th century entailed the moderation of markets and attainment of equilibrium via the pricing mechanism. New ideas included the applicability of macroeconomic principles to microeconomic behaviors and contemplation of technological innovation as the source of increased capital productivity and per capita income. The simplicity and inefficiency of traditional approaches stemmed from imperfect access to information, ineffective external events, and inconstant equilibrium states. The inexact balance between supply and demand signified by inventory balances and the existence of arbitrage pointed to the inadequacy of classical models (Beinhocker, 2007, p. 56-58).

Beinhocker (2007) provided an account of the 1984 Santa Fe Institute meeting between economists and scientists that challenged the conventional economic assumptions. Borrowing concepts from physics and systems theory, Beinhocker proposed a modern model to describe economic activity. Entropy described the movement of a system from order to disorder (Beinhocker, 2007, p. 68). While closed systems did not interact with external stimuli or agents, open systems received energy or input from external sources and expended waste or unused material to the outside (Beinhocker, 2007, p. 69). Open systems contemplated that inbound energy or renewal resources offset the tendency to settle on a resting point or disintegrate. External stimuli facilitated the system's movement from disorder to order on a continual basis. Closed systems advanced toward a state of rest or a final status while open systems moved toward an unknown or elusive the end state. An open system fluctuated and moved from one state to another without resting or reaching equilibrium. Given this distinction, open

systems in which constituents reacted to each other and the environment as a means of adapting to change, defined CAS.

Beinhocker (2007) maintained that mathematically based, closed system views of traditional economic systems implied a movement toward a state of equilibrium or rest and ultimately created less order. On the other hand, borrowing from the principles of physics, economics could be a complex adaptive system with disequilibrium where inputs fought disorder and increased complexity. Beinhocker indicated that regional open economic systems tended toward growth while other, closed systems, moved toward inertia and decomposition (p. 73). Beinhocker called this view of economic systems based upon alternative mathematical concepts as "complexity economics" (p. 73).

Beinhocker (2007) created a new economic model and refuted the utility of classical equilibrium-based models in explaining wealth creation and resilience within modern economies. Open systems survived based on external input and demonstrated attributes of CAS. CAS consistently adapted and continuously exhibited self-renewal. Without the addition of outside energy resources, systems came to rest and eventually ceased to exist.

Resilience, Complex Adaptive Systems, and Regional Economies

Tonts (2011) embedded a definition of regional economic resilience within a multidimensional context. Variability within economic, social, political, and institutional factors contributed to regional economic resiliency. Local economic survival depended upon activity within space and not on linear processes. Comparative studies encompassing interregional relationships and adaptations provided insight into the nature

of resilience (Tonts, 2011). Interpreting regional economic development processes while recognizing the significance of time and space incorporated both evolutionary economics as well as complexity theory (Tonts, 2011). Complexity theory allowed for self-management and internal organization by an unbound collection of agents in response to external shocks. Multiple scales and connections operated within a movable bounded space while exchanges occurred during interactions. Adjustments in the macro environment affected the microenvironment and vice versa (Simmie & Martin, 2010).

Pendall et al. (2009) and Tonts (2011) defined resilience as the recovery of a system over time after the occurrence of a shock, or the preservation of pre-shock outcomes. Within this model, resilience encompassed temporal aspects and entailed a process in which agents interacted to adapt to structural internal shocks and external events (Tonts, 2011). Martin's (2012b) definition of resilience originated with its Latin antecedent which meant to "leap back to or to rebound and alternatively to recover a previously held form after a disruption or shock" (p. 4). A resistance to shocks and a quick rebound to a pre-shock status or equilibrium constituted "engineering resilience" (Martin, 2012b, p. 4). Within the context of complexity theory, an even higher level of adaptation occurred where system aspects interacted spatially to adapt to circumstances. Adaptive complex systems exhibited mutability and a lack of constraints. The CAS framework clarified the activity of regional economies as spatial considerations; the explanatory model accomodated adaptive behavior and internal organization (Pendall et al., 2009; Tonts, 2011).

Resilience within a complex adaptive system manifested within a 4-step cycle where adjustments to external and internal events and to circumstances demonstrated diverse levels of resilience (Pendall et al., 2009). The four steps of survival encompassed "exploitation, conservation, release and reorganization" (Pendall et al., 2009, p. 77). Simmie and Martin (2010) maintained that, in the presence of external shocks, resilient regional economies cycled through four phases, including destruction and recovery as changes occurred in each level of each constituent variable (p. 36).

Based on the Martin and Sunley model, Pendall et al. (2009) identified seven attributes of CAS to regions. Regions displayed internal linkages, received input from external sources and operated over a dispersed area. Activities and inputs exhibited consistency while being subjected to external fluctuations. Sporadic processes arose in response to external fluctuations and led to permanent changes. Smaller business subsystems comprised a regional structure where reactivity influenced outcomes. While structural advantages enhanced resilience, the multistage and multilayered architecture of complex adaptive systems provided strength as larger systems encompassed smaller systems. Within nested systems, adaptive activity occurred at each level within "feedback loops" (Pendall et al., 2009, p. 78). Pendall et al. (2009) differentiated shocks emanating from a small local event from shocks that originated globally yet reverberated locally. Multiple shocks could continue over time, and related shocks appeared within a cascading framework. The time required for recovery related to the severity or magnitude of the shock modified by the size of the system under evaluation (Pendall et al., 2009, p. 80).

Pendall et al. (2009) examined the structure and characteristics of CAS as a framework to display resilience within a region. The performance of variables defined as population growth, home ownership, and employment rates could demonstrate adaptive qualities. The nature of the shock defined the resilience assessment (Pendall et al., 2009, p. 82). Simmie and Martin (2010) placed resilience within an adaptive environment where a region changed and reshaped itself over time as various types of economic or technological shocks occurred. Resilient systems existed within a time continuum and geographic areas. A research approach in which the observation and comparison of smaller subsystems to large-scale, longer-term adaptations would benefit the development of meaningful research designs. Current research on resilience lacked meaningful criteria to measure its effects (Pendall et al., 2009, p. 83).

If continuous development and knowledge acquisition resulted in a transformation over time, resilience accumulated within regional industrial bases and native institutions. The definition of resilience shifted from merely a state of being to a process (Simmie & Martin, 2010, p. 31).

Simmie and Martin (2010) applied the panarchy adaptive cycle model to a case study comparison of two regions within the United Kingdom over a period of 45 years. The Cambridge region employment trajectory continually moved upward into an environment of national recessions and technological advances. The region participated in the four cycles of adaptation and demonstrated resilience through the formation of new firms, internal innovation, and stable employment. Within Cambridge, internally

developed knowledge accompanied increased entrepreneurship, enterprise formation, and employment in existing and new industries (Simmie & Martin, 2010, p. 41).

In contrast, the United Kingdom region of Swansea suffered from employment declines due to the loss of traditional manufacturing (Simmie & Martin, 2010). The Swansea area never recovered from the adverse impact of global innovation upon its internal structure, nor did internal agents within that region adapt to become competitive with external markets. Foreign direct investment (FDI) into the area brought with it innovation, but the influx only briefly improved the local economy as global firms moved production to regions that possessed the internal technical expertise and internal innovation.

Regional resiliency and the associated need for recovery methods became important topics in the aftermath of the 2008 recession (Martin, 2012b). Martin indicated that the recessions of the 1980s, 1990s, and 2008 imposed uneven results upon different geographic areas. A system that anticipated and reshaped itself to lower the impact of a shock and maintained a pattern of growth illustrated adaptive resilience (Martin, 2012b, p. 4). Manifestations of adaptive resilience included new firm formations, the onset of innovation, and the emergence of new industry sectors or new financing sources. The regional employee base evolved and improved by gaining new and emerging skills or educational levels. Martin recognized that some regions adapted to economic conditions more readily than other regions (p. 11). The four dimensions of resistance, recovery, reorientation, and renewal defined resilience. Interactions and linkages operated within

the contexts of the region's economic legacy and culture as firms, industries, and the labor pool participated in change.

In a comparative study, Martin (2012b) indicated that the northeast region of the United Kingdom reached a new equilibrium (hysteresis) after the 1979-1983 recessions, but experienced continual employment losses over time as manufacturing jobs disappeared and reliance upon public sector employment proved to be an ineffective adaptive measure (p. 25). On the other hand, the southeast area exhibited minimal resilience traits initially but later demonstrated robust recoveries. The southeast region adapted by realigning from low growth to high growth industries and diversification (Martin, 2012b, p. 24). Although equivalent employment losses within the two regions occurred during the 2008 recession, concerns remained regarding an over reliance on the public sector for job creation in the northeast region.

Martin (2012b) concluded that defined resilience required further clarification and exploration. Additional inquiries incorporated a comparison of the reaction and recovery stages between or among regions using firm or workforce level indicators. A suggested design included an examination and comparison of reactions and recovery using advanced time series methods while incorporating cross-regional affects. An analysis of resilience comprehended the effects of external economic or social shocks (Martin, 2012b).

The ability to recover and demonstrate flexibility after the occurrence of an external shock defined resilience within economic systems (Pendall et al., 2009; Tonts, 2011). An added dimension to resiliency involved a post-shock return to the initial state,

and/or an improved condition and new equilibrium (Pendall et al., 2009; Simmie & Martin, 2010). CAS represented the process context in which systems operated for survival and demonstrated resiliency (Pendall et al., 2009). The processes included multiple steps, cyclicality, (Pendall et al., 2009) and a display of spatial characteristics (Tonts, 2011). Observed adaptability involved interscalar agents operating over time and distance through a multistage process that involved stages of resistance and recovery after an external event (Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010).

Martin (2012b) and Simmie and Martin (2010) compared two regions within the United Kingdom during a period that included several recessions. The comparative studies revealed practical aspects of resilient behavior insofar as the two regions experienced dissimilar outcomes. One region followed a trajectory of job growth while the other region demonstrated a decline in employment. Economic decline transpired when global technological developments surpassed local capabilities, outdated skills prevailed in the workforce, and businesses and industries failed to adapt to external events. Employment levels increased in the presence of a well-educated labor pool, diversification into high growth industries, encouragement of entrepreneurship and innovation (Martin, 2012b; Simmie & Martin, 2010). Measuring employee and firm levels within regions over time operationalized resilience. Definitions could be further refined based on the nature of the external shock (Martin, 2012b; Pendall et al., 2009). Table 3 presents aspects of resilience in regional economies.

Table 3

Resilience and Regional Economies

Tonts	**Pendall, Foster & Cowell**	**Martin & Simmie**	**Martin**	**Martin & Sunley**
Multidimensional	4-step Recovery Cycle Over Time	Recovery of form and position	Adaptive Resilience Rebounding to previously-held form	Path Dependency
Economic Interaction	Internal Resources	External Stimuli	Multi-stage Progressive Improvement	The Past affects the Future
Social Interaction	External Stimuli	Continual Development	New Business Formation	
Political Interaction	Continuous Feedback	Acquired Knowledge	Application of Innovation	
Institutional Initiatives	Linkages	Integration of Process and Structure	Formation of New Industry Sectors	
Spatial	Geographically Dispersed	4- phase Recovery Cycle	Evolving Skills and Education	
Evolutionary	Fractal Structure/ Subsystems	Existing Assets	New Financing Sources	
Complexity	Embedded	Linkages and Connectivity	Resistance, Recovery, Reorientation, Renewal	
Interregional Interactions	Multiple Layers	Vulnerability	Employment as a Measure of Resilience	
	Multiple Shocks – Severity/ Frequency/Serial	Scalar	Reaction and Recovery	
	Agents = Variables	Multidimensional	Cross-regional differences	
		Complex Adaptive Systems		

A Post-recession Resilience Model - Economies

Montiel (2011) attributed resilience in emerging economies to agility, budgetary stability, foreign exchange controls, and inflation management. Briguglio, Cordina, Farrugia, and Vella (2009) credited pre-existing stabilizing central government policies, low spending, low debt levels, foreign exchange controls, and a well-trained workforce with contributing to resilience in small and emerging economies. On a national basis, resilience included agility and cohesive actions among agents. Changes in value-add and employment levels operationalized resilience (Navarro-Espigares et al., 2011). Felton et al. (2010) attributed the sustained functionality of certain creative industries during the recession to their relocation to rural areas with lower wages, lower occupancy costs, and communication-based collaboration that replaced proximity.

Practical indicators of regional economic resiliency involved the emergence of diverse new high-growth industries, new employee skills, and business formations. Adaptive, resilient regions optimized and leveraged existing resources to surpass previous employment levels. Differences in adaptive ability and resilience, demonstrated by continuous change and innovation in all dimensions and levels of economic agency, explained observed irregularities in post-recession economic recovery comparisons among regions. Sustained employment growth indicated resiliency within adaptive economic systems (Martin, 2012b).

Conceptual Framework

Industrial Cluster Configurations and Stimuli

Ter Wal and Boschma (2011) outlined a four-step evolutionary model of cluster formation that incorporated linkages but did not demand geographic proximity among its agents for initial effectiveness.

Initially, knowledge-based networks formed in response to a market demand or technological innovation and clusters expanded based upon the growth and interaction among member firms. Clusters reached a mature state when markets stopped growing, and innovation came to a standstill. Within this stage, linkages weakened for dispersed networks, and geographic proximity encouraged continued interactions. Clusters survived during this final phase when radical technologies strengthened and renewed networks among the clustered firms. This four-step model highlighted the importance of knowledge sharing to maintaining cluster viability within spatial networks of heterogeneous firms but admittedly needed additional empirical testing (Ter Wal and Boschma, 2011).

Brenner and Muhlig (2013) modeled cluster formation by applying a regression analysis to 200 cases from 159 articles. Brenner's three-stage theoretical framework outlined cluster development. In the presence of a triggering event, a self-augmenting group of commercial entities formed an industrial cluster. Brenner and Muhlig (2013) adopted Porter's four-sided diamond cluster framework that included firm tactics, competition, resources and market demand. The meta-study covered various periods, locations, and industries and yielded several basic findings. Inter-agent connections

wielded more influence upon cluster formation than location and industrial conditions. High tech clusters formed in the presence of research funds and capital (Brenner & Muhlig, 2013, p. 493). Cooperative activity propagated clusters in Asia while cities, networks, and culture stimulated cluster formation in western locations. Brenner and Muhlig (2013) stated that no differences appeared in the cluster formation conditions in less-developed country economies versus developed nations.

In response to global competition, Randelli and Boschma (2012) considered the development of "business groups" (p. 1963) in the form of vertical supply chain clusters within a region of Italy. Smaller firms benefited from the scale gleaned from linkages with larger firms while offering technical innovations to those larger firms within the hierarchy. In response to the external disturbance, business groups flourished within an environment of shared attributes. When significant business managers died, or the business complexity grew, establishments consolidated to share financial, marketing, and technological expertise.

Industrial Clusters and Technology

Widely implemented technology portals furthered the formation of vertical and horizontal industrial structures (Zheng & Jin, 2014). Cooperation among members encouraged technology sharing. Shared technologies stimulated linkages within the vertical supply chain and fueled industry sector growth. Horizontal structures grew from the application of joint techniques to diverse product offerings (Zheng & Jin, 2014).

Mizuki (2014) asserted that human capital development and linkages, rather than new technologies, stimulated software cluster growth within the Dalian region of China.

Local Chinese companies responded to Japanese firm investments in domestic worker training by developing workforce proficiencies in the Japanese language. Japanese investments in quality control skills, cost control skills, and on time delivery training produced an optimal outsourcing tool. Education and training programs grew in response to the needs of Japanese customers. Enhanced human capital within the Chinese region created a suitable environment for firm entry into the industry and the formation of multiple software complexes (Mizuki, 2014). Cross-border interactions and linkages fueled sustained commercial growth over the period of 1998 to 2013 and led to a viable, sustained cluster. Mizuki (2014) described a model that contradicted earlier technology-driven concepts of cluster formation and explained a human, knowledge-based interaction.

Industrial Clusters as Regional Economic Representations

Porter (2008) defined an industrial cluster as a group of companies and institutions within a geographical region with common interests, resources, and business foci. Internal collaborations and associations advanced the common good of economic growth. Clustered firms occupied every level of the vertical supply chain and formed horizontal relationships. Interconnected firms located together to optimize the usage of existing resources and expertise (Porter, 2008, p. 218). The competitive advantages of cluster-based regional economies developed from enhanced productivity, innovation, and new business formation. The presence of local competition and few alternative locations signaled an optimal cluster formation environment (Porter, 2008, p. 229).

External disruptions arose from technological developments that neutralized inherent regional advantages. The cluster required internally developed technologies to maintain its status rather than temporary technology imports. Porter (2008) stated that as higher-priced, higher-skilled labor expanded, and low wage labor moved offshore and overall employment could fall. In this instance, total employment did not accompany a vibrant local economic cluster (p. 261). Within an environment of knowledge-based qualities and stimulated innovation, Porter (2008) maintained that any industry became and remained vibrant and competitive. A viable sustained cluster drove growth within a country or region and created wealth for its stakeholders. In this context, employees, shareholders, suppliers, and the citizens of the surrounding community comprised the stakeholder group.

Clusters as Complex Adaptive Systems

CAS theory encompassed features and characteristics that denoted the presence of resiliency in the face of disruptions. Agents or members of CAS collaborated to achieve goals, evolve, and change for survival. Diverse agents operated in multidimensional and multistage environments. Innovation catalyzed the operation and viability of CAS and contributed to the strength and diversification of industrial groups. However, employment could fall temporarily as technological advances destroyed certain sectors while other industries formed.

Although primarily concerned with sustaining and growing the competitive advantage of geographical regions, Porter's (2008) definition of clusters incorporated certain features of CAS. Cluster sustainability demanded the presence of networks and

collaboration (Porter, 2008). Solidly performing industrial cores or dominant firms attracted similar companies and instigated growth. Innovation initiated economic growth and stimulated the formation of economic groupings. Launching original technologies into low cost dispersed production sites demonstrated sector adaptation and resiliency (Brenner & Muhlig, 2013; Mizuki, 2014; Randelli & Boschma, 2012; Ter Wal & Boschma, 2011; Zheng & Jin, 2014). Table 4 presents Clusters as CAS.

Table 4

Clusters as Resilient Complex Adaptive Systems

Regional Resilience	**Complex Adaptive Systems**	**Regional Clusters**
Agents	Self-Organization	Geographic Concentration
Agility/Recovery/Evolution	Interaction/ Hierarchy	Horizontal and Vertical Linkages
Continuous Feedback	Adaptive	Innovation
Networks	Leverage Internal Resources	Leveraged Resources
Applied Technology	Technological Innovation	Internal and Imported Technology
Linkages and Connections	Hierarchy	Knowledge-based Labor
Diversity and Variety		Industry Diversification

Literature Review

The 2008-2009 Recession and Complex Adaptive Systems

Kirman (2010) suggested that participants in economic systems networks interacted to determine the direction of the whole (p. 525). This view diverged from the

classical macroeconomic approach in which the whole reflected aggregated microeconomic behavior. The entire organization's behavior, for this reason, emanated from the collective interactions among its members. Within the definitive context of a complex adaptive system, the 2008 economic crisis arose from the convergence of several events. Global savings demands for higher interest rates encouraged the proliferation of non-traditional, high yielding instruments. Lower lending standards coupled with higher bank yield requirements also precipitated the recession. Marien (2009) described the 2008 economic crisis as a complex system failure that stemmed from an absence of adjustments and a primary focus on the system's parts rather than the system as a whole.

Kirman (2010) attributed the crisis to the interaction of six factors that concurrently caused the economic recession. An "evolving" system contained six interdependent factors (Kirman, 2010, p. 29). When viewing the macroeconomic environment as a CAS, Kirman (2010) maintained that when adopted behaviors fell short of historical norms, faulty internal dynamics generated instability. A financial downturn and associated economic recession developed when capital markets featured a lack of transparency, risk interdependncy prevailed, exposed assets reached historically high levels, and interlocking firms traded in an environment replete with hidden information.

During the economic crisis, inflexibility among system agents in the presence of change supported the view that the global macroeconomic structure displayed system characteristics (Kirman, 2010; Marien, 2009). A departure from historical configurations and the absence of internal balancing mechanisms could not offset unstable financial

market risk patterns (Kirman, 2010; Marien, 2009). Internal failings and rigidity within the macroeconomic scheme appeared within the context of the CAS model.

Macroeconomic Causes and Effects of the Recession

The Business Cycle Dating Committee of the National Bureau of Economic Research (NBER, 2008) defined a recession as a widespread decline in "real GDP, real income, employment, industrial production, and wholesale-retail sales" (par. 2). The committee performed an analysis of national quarterly GDP metrics, monthly employment, monthly income, and production indicators to arrive at published cycles. The committee monitored the depth and length of economic downturns while assessing whether the United States attained peak economic activity. The economic costs and lost revenue as consequences of the recession totaled $2.35 trillion, an amount that equaled 16% of U.S. GDP compared to a loss of 6% of GDP in the 1990s downturn (Blinder & Zandi, 2010). The NBER published a timeline of United States Business Cycle Expansions and Contractions and marked the beginning of the latest United States recession as January 2008. Peak activity occurred in December 2007 while the recovery began in June 2009 (NBER, 2009).

Several economists offered alternative models to the conventional belief that capital market failures and loose monetary policy brought about the recession. Sumner (2013) indicated that the recession originated from tight monetary policy in contrast to a broadly held view that loose monetary policy instigated the downturn. Stiglitz (2011) challenged the applicability of traditional economic models as forecasting and remediation tools for the 2008 recession. Underlying systemic economic changes limited

the ability of traditional approaches to reverse the recession's effects. In opposition to conventional theories on the fundamental causes of the 2008 recession, Ohanian (2010) asserted that rising labor costs contributed significantly to the downturn. Dinu (2010) called for recognition of the implicit subjectivity in economic modeling of events and consequences. Dinu asserted that although deductive approaches explained and explored phenomena, intuitive and subjective behavior framed actual activity and outcomes. Within this model, explanations of the 2008-09 recession resided within a continuum of scientific deductive reasoning and subjective observations of behavior. The dearth of original thought and alternate approaches to conventional economic theoretical methodologies hindered the crisis resolution process (Dinu, 2010).

Sumner (2013) cited commercial and residential real estate price deterioration as a contributor to the decline in nominal GDP. Stiglitz (2011) indicated that the structural shift in the economy from the manufacturing sector to the service sector within a background of increased globalization prolonged the recession. Stiglitz stated that this combination of events led to a sluggish return to productivity and an underuse of existing assets. Consequently, income from newly growing economic sectors fell short of replacing income produced within declining, relatively higher wage and higher productivity sectors. Income inequality, low savings, and elevated debt levels combined with generous savings and reserve levels in emerging markets contributed to the adverse impact of the recession (Stiglitz, 2011).

Conservative views of the recession's causes encompassed reliance upon consumer spending funding sourced primarily by household debt, high risk lending

stimulated by government policies, and low interest rates (Love & Mattern, 2011, p. 403). Higher private debt levels, wage stagnation, and growing income inequality led to the recession within the environment where substantial income redistribution occurred.

Florio (2011) asserted that housing price inflation began to recede in 2006 until the end of 2007. Florio cited a decline in real household income between 1999 and 2009 that followed an upward trend that appeared from 1967 to 1999. Income distribution among the quintiles of the U.S. population shifted during this period and contributed to "wealth inequality" (Florio, 2011, p. 11). Organisation for Economic Co-operation and Development (OECD) countries experienced increasing wealth inequality at the same time as global consumption grew. Income growth stimulated consumption in developing countries while higher household debt fueled growth in the United States. As additional evidence of falling domestic income, hourly wages (in 2009 dollars) increased in the United States by 75% during the period 1947 to 1972, but rose only by 4% per year between 1972 and 2009 (Florio, 2011). Blue-collar unemployment responded adversely to shocks in output. Personal savings rates declined from 1982 to 2005 while household debt as a percentage of GDP increased from 0.5% in 1970 to 14% in 2007 (Florio, 2011).

During the height and acceleration of the recession in the fourth quarter of 2008, government funding averted bank failures while employment fell (Ohanian, 2010). At the onset of the recession, marginal labor rates exceeded the marginal rate of substitution between consumption and leisure. Consequently, employment levels fell while wage rates remained artificially high. Artificially high wages caused variable job attrition rates in diverse industrial sectors at the inception of the 2008 recession (Ohanian, 2010, p. 5).

Lambert (2011) applied a regression analysis model to OECD economic statistics to predict consumer debt levels. Lambert concluded that conventional explanations of the recession's causes fell short by failing to consider the impact of lower wages as a percentage of GDP as a cause of higher consumer debt.

A sequence of deregulatory actions occurring during the period 1980 to 1999 expanded available credit and masked uneven income growth (Dore & Singh, 2012, p. 298). While the bottom 80% of the population experienced falling disposable income from 1984 to 2008, disposable income for the top 20% increased during that period (Dore & Singh, 2012). Based on a dynamic vector error correction model, revolving credit generated income and stimulated spending. After a sustained economic expansion had transpired during the period 2001 to 2007, credit-based spending within households with stagnant or declining real income (Dore & Singh, 2012, p. 306) triggered the contraction beginning in 2007. Subsequent credit constraints immediately led to lower consumer spending.

Real personal consumption expenditures fell during the 2008-09 recession but recovered more slowly than in any recession since 1974 (French et al., 2013). As a forecasting tool for future income and consumption growth, the Michigan Surveys Microdata outperformed past consumption and income growth, Treasury bill rates, and equity market results. Michigan Surveys Microdata forecasted lower nominal income growth for the 2008 recession than for any past recessions, and all levels of age and education forecasted lower income levels (French et al., 2013, p. 18).

As of the fourth quarter of 2012, Michigan Surveys reported expectations of two additional years of low consumption and low-income growth (French et al., 2013). Tight monetary policy in 2007 preceded artificially high interest rates (Florio, 2011). Macroeconomic indicators of the recession's approach included lower inflationary expectations (Sumner, 2013). Nominal GDP fell precipitously in the absence of Federal Reserve policy and fiscal stimuli. Fundamental changes took place within the economic structure, and these changes demanded innovative approaches (Stiglitz, 2011). Popescu, Popescu, and Popescu (2009) stated that rising public expenditures combined with falling tax collections led to the gradual decline in the world economy between 2001 and 2008.

As a prelude to the recession, a sequence of deregulatory measures beginning in 1980 and ending in 1999 expanded available credit and masked uneven income growth (Dore & Singh, 2012, p. 298). Stiglitz (2011) asserted that changes occurred in the banking system and led to instability. Monetary policy-related actions failed as deregulated banks took on greater risk but eventually curtailed credit availability. Banks held lower reserves while slowly restoring the availability of capital. Requisite banking spreads stifled access to credit, and the economy remained stagnant (Stiglitz, 2011, p. 627). Although debt levels increased, savings rates and reserves remained high within emerging markets and sovereign funds (Stiglitz, 2011). Tight monetary policy, government-encouraged home ownership, and rising financial firm debt as a percentage of GDP during the period 1997-2007 destabilized the U.S. economy (Florio, 2011). Lambert (2011) cited traditional views in which credit availability and low interest rates, coupled with surplus funds from developing nations, instigated the recession.

Monetary responses entailed interest rate reductions during the period of 2006-2012 (Dugger & Peach, 2013). Fiscal policy responses brought about the Economic Stimulus Act (2008), the Troubled Asset Relief Act (TARP), and the American Recovery and Reinvestment Act (ARRA). The temporary fiscal reactions (Dugger & Peach, 2013), coupled with Federal Reserve monetary policy, did not reverse the economic decline (Blinder & Zandi, 2010). A lack of government policy responses to exchange rate imbalances led to higher offshore investments and competitive disadvantages for domestic firms (Helper & Wial, 2010).

While nominal GDP growth historically averaged 5-6% per year, during the mid-2008 period this metric of economic growth reversed its trend and fell monthly through early 2009 (Sumner, 2013). Sumner (2013) indicated that this rate of deterioration last appeared 1930. Lower nominal income impeded consumers' and business entities' abilities to meet prior obligations. Nominal GDP growth of 5.5% until the second quarter of 2006 degraded to 2.6% until the second quarter of 2012 (Sumner, 2013, p. 22).

Within a deregulated environment, financial hubs welcomed the returns that accompanied an increased tolerance for system risk (Stiglitz, 2011). Shared risk provided advantages during economically stable periods but proved to be destabilizing during an economic contraction (Stiglitz, 2011) and conceptually represented irresponsible behaviors (Love & Mattern, 2011). Stiglitz (2011) maintained that erroneous and insufficient information promoted the securitization movement. Although designed to mitigate risk, derivative instruments' lack of transparency masked actual exposures of market participants (Stiglitz, 2011, p. 625). Heightened consumer debt levels (Lambert,

2011) and higher spending before the recession (Dore & Singh, 2012) followed the financial sector expansion (Lambert, 2011).

Dore and Singh (2012) graphically presented the extent to which securitized debt pools expanded from 1988 to 2009 while traditional financial instruments declined as components of total credit. Weaknesses in securitized debt ratings ultimately reverberated through financial markets and curtailed the availability of funds to commercial enterprises for ongoing operations.

In 2007, falling demand and declining nominal GDP (Love & Mattern, 2011; Sumner, 2013) emanated from the financial uncertainty created by high-risk investments (Dore & Singh, 2012; Love & Mattern, 2011; Stiglitz, 2011). Stagnant consumer wages and increasing income inequality (Lambert, 2011; Stiglitz, 2011) led to the use of higher consumer debt (Dore & Singh, 2012; Lambert, 2011; Stiglitz, 2011) as a funding source for consumer spending. Artificially inflated real estate values financed observed consumer demand before the onset of the recession (Love & Mattern, 2011; Sumner, 2013). Free-flowing capital availability created unstable market conditions (Dore & Singh, 2012; Florio, 2011; Lambert, 2011; Stiglitz, 2011) and unwarranted debt levels. As late as 2011, Michigan Surveys reported pessimistic predictions of consumer income, consumption, and personal savings (French et al., 2013).

As productivity increased, the demand for labor fell (Dugger & Peach, 2013) and consumer income declined (Dore & Singh, 2012; Stiglitz, 2011; Sumner, 2013). Unemployment accelerated and persisted (Love & Mattern, 2011; Sumner, 2013), while available capital contracted and constrained investment (Dore & Singh, 2012; Florio,

2011; Stiglitz, 2011; Sumner, 2013). Investment and employment levels suffered from insufficient government policy responses (Florio, 2011; Helper & Wial, 2010; Love & Mattern, 2011; Sumner, 2013, Stiglitz, 2011), while some stimulus program effects (Blinder & Zandi, 2010; Dugger & Peach, 2013) remained hidden or inconclusive. On one hand, Ohanian (2010) claimed that the sustained high wage levels at above market rates contributed to the persistence of unemployment. On the other hand, wage and employment growth within the higher and lower-skilled levels of the workforce persisted after the recession while wages deteriorated in mid-skill level employment (Autor & Dorn, 2013; Canon & Liu, 2014; Hyatt & McEntarfer, 2012). Figure 1 presents the recession continuum.

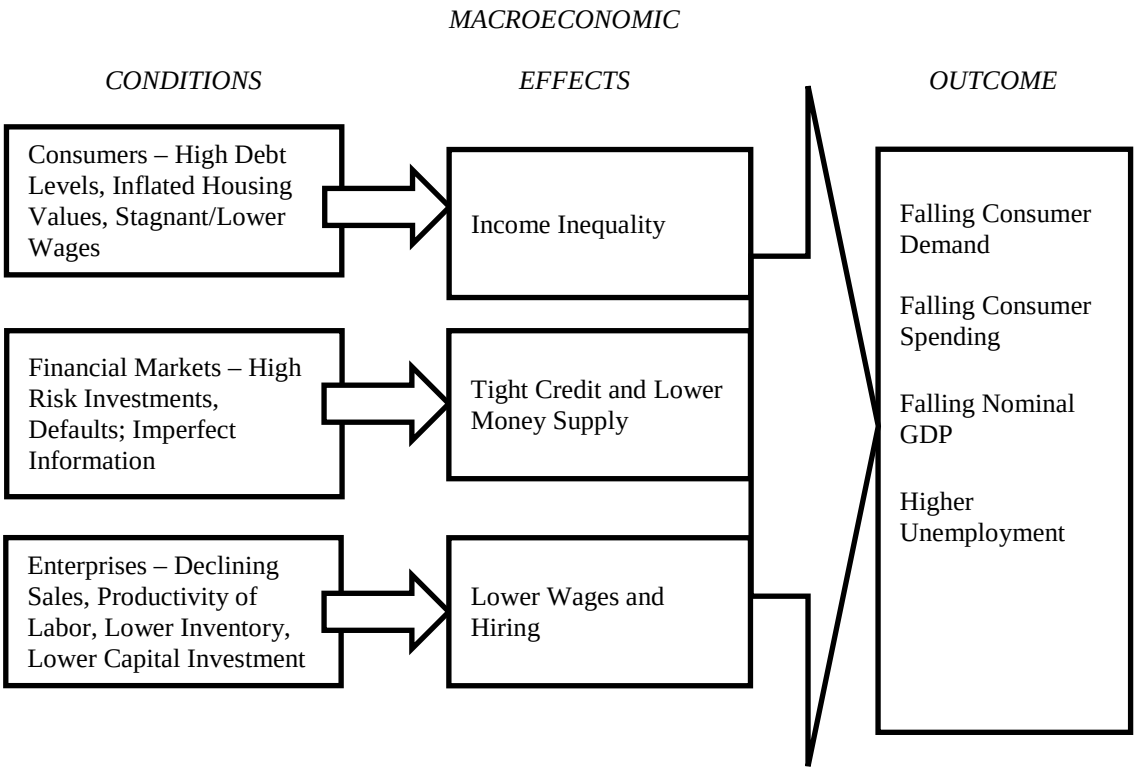

Figure 1. Great Recession Continuum

Firm Reactions

In contrast to concerns during historical recessions, small business owners identified weak sales as the most damaging consequence of the 2008 recession and responded accordingly (Sum et al., 2010, p. 99). Consumer spending fell in an environment of excessive negative media coverage, panic, deteriorating home prices, and the financial system breakdown (Dunkelberg et al., 2010).

Private employment as a percentage of GDP contracted more rapidly than in historical periods, and absolute employment levels fell at a higher rate than wages during the recession (Dunkelberg et al., 2010; Sum et al., 2010). Given production wage rates, pre-recession employment levels exhibited a higher than expected range (Dunkelberg et al., 2010). Inventory levels and prices adjusted in response to lower demand and consumer spending according to a National Federation of Independent Business survey (Dunkelberg et al., 2010). In a regional study of the North Carolina business climate, researchers reported that overcapacity in the existing economic framework generated resistance to new business formations (Jolley & Mendoza, 2011).

Bloom et al. (2013) reported the results of the Management and Organizational Practices Survey of 30,000 manufacturing plants after the recession under the auspices of the United States Census Bureau and the National Science Foundation. The adoption of structured management practices, in-depth measurement tools, and hard performance objectives accompanied positive reports concerning productivity, income, technological advancement, and expansion (Bloom et al., 2013). The surveyed manufacturers expanded the use of data collection as a performance measurement tool between 2005

and 2010. Management regularly discussed performance measurement tools with employees and physically displayed the measurements within the firm (Bloom et al., 2013). Multi-establishment firms gleaned innovative practices from external contacts such as trade groups, consultants, and supply chain members and enacted the practices within the firms.

Given the agility and responsiveness of business owners, the implementation of factor adjustments on the firm level rendered government and policy intervention unnecessary. Larger manufacturing companies displayed "structured management" practices, possessed a relatively educated workforce, exported, and resided mainly in the Southern and the Midwestern United States (Bloom et al., 2013, p. 4).

Business owners responded to the recession by lowering inventories and releasing employees in response to lower sales (Dunkelberg et al., 2010; Sum et al., 2010). Firms implemented lower pricing (Dunkelberg et al., 2010) and optimized capacity utilization instead of expanding or forming new businesses (Jolley & Mendoza, 2011). Bloom et al. (2013) indicated that surviving manufacturing firms adopted innovative management practices and analytical methods. Thriving organizations implemented new performance measurement methodologies, and respondents noted marked regional differences in the implementation of these methods.

Wages and Employment

From the onset of the recession in December 2007 until the end of the first quarter of 2009, reported employment abated (Bruyere, Podgornik, & Spletzer, n.d.). Establishments lowered hiring and increased layoffs to reduce labor costs. The second

quarter of 2009 reported improvements in the labor market although at a rate lower than observed prior to the recession. Bruyere et al. (n.d) noted that, during the recessionary periods of 1981, 1990-91, and 2001, total private employment recovered more quickly than in the period following the recession. Employment contractions primarily accompanied lower hiring at existing firms and not business closures.

Borbely (2011) analyzed the impact of the 2008 recession upon the employee population demographics within the United States. Less-educated displaced workers faced reemployment rates of 39.2% while displaced workers holding a bachelor degree or higher education level experienced a reemployment rate of 55.7% as of January 2010. Borbely (2011) reported that manufacturing workers accounted for 23% or 1.6 million of jobs lost by long-tenured displaced workers in January 2010 and reemployment rates for manufacturing workers averaged only 28.7% at the end of the same period.

Sum et al. (2010) examined the 2008 recession's impact on an array of demographic groups and found disproportionately high job losses for blue-collar workers, males, young adults, high school or lower educated workers, and low-wage workers. Although the blue-collar worker segment made up 22% of the workforce prior to the recession, 67% of job losses after the recession originated within that segment of the workforce (Sum et al., 2010).

A comparison of employment rates for 2007 and 2009 indicated that professional and managerial unemployment rose at a lower rate than blue-collar disciplines. Temporary job opportunities failed to mitigate the effect of long-term blue-collar unemployment so that labor surpluses prevailed in affected industries. As an example, the

ratio of unemployed workers to vacancies ranged from to a high of 34.8 for the construction sector to a low of 2.26 for the education and health industry (Sum et al., 2010). This difference persisted throughout all regions of the United States.

Woodward (n.d.) analyzed differences between unemployment rates among three levels of geographically defined economic regions within the United States. Geographic areas in which individuals lived and found employment defined labor market areas. Core-based statistical areas encompassed urban centers and contained a minimum of one county. Within the category of core-based statistical areas (CBS), metropolitan statistical areas contained core populations of 50,000 persons or more while micropolitan statistical areas' core populations ranged from 10,000 to 50,000 persons. While 84% of the U.S. population resided in metropolitan areas, 10% of the population resided in micropolitan areas, and 6% lived in the less-populated areas.

During the period 2000 to 2006, unemployment rates in the less populated areas exceeded rates in the more populated areas (Woodward, n.d.). During the period 2007 to 2009, unemployment rates converged toward equality among the three size levels. The observation applied to the strata of regional sizes within the micropolitan category as unemployment rates equalized among the three-micropolitan size levels as the recession progressed. Variances in employment levels of metropolitan areas occurred before and during the recession, but Woodward (n.d.) indicated that larger variations in unemployment rates appeared in comparisons of metropolitan areas with micropolitan areas. Woodward (n.d.) suggested that a larger core population size within a region

positively influenced the ability of that area to recover and sustain employment given an economic shock.

Post-recession analyses discovered that almost half of the entire re-hired workforce attained earnings at levels equal or greater than pre-recession income, (Borbely, 2011, p. 15) regional differences existed (Woodward, n.d.). A lower, less aggressive job recovery pattern emerged in comparison to past recessions (Bruyere et al., n.d.). The construction and manufacturing sectors experienced the largest job losses while service sector employment sustained its pre-recession levels (Stiglitz, 2011).

Employment and Innovation

Boianovsky and Trautwein (2010) reviewed Schumpeter's concepts on unemployment and its causes. Schumpeter labeled employment losses that followed depressions and lower demand,"creative destruction," and maintained that long-term economic growth required this effect (as cited in Boianovsky & Trautwein, 2010, p. 260). Employment changes represented a secondary outcome of productivity swings or resource allocations from lesser to more highly valued output. The effects of innovation rendered certain sectors obsolete and the demand for labor shifted to newly created products. The long-term timing of this shift led to a delay in re-employment of displaced workers. According to Schumpeter, during economic depressions, workforce reductions followed a regrouping and recovery process that reversed when the depression ended (as cited in Boianovsky & Trautwein, 2010, p, 241). Overall uncertainty, the lag in movements of workers from declining sectors to new divisions, and the lower demand for labor based upon reduced capital investment contributed to this temporary effect.

Cyclical recessionary factors, innovation, and creative destruction produced patterns of unemployment (Boianovsky & Trautwein, 2010, p, 241).

An employment taxonomy, implanted into a four-phase economic cycle, began with a recession where employment fell at a declining pace until it reached a point of recovery. The four phases of the cycle incorporated "prosperity, recession, depression and recovery" (Boianovsky & Trautwein, 2010, p. 247). Within this model, unemployment cascaded as increasing unemployment levels affected related industries. Within the four phases of a business cycle, extreme restrictive productive reactions based on the dearth of capital and overall uncertainty led to excessive unemployment levels. This model supported directing public policy-driven growth stimuli to innovative industries rather than to structurally diminishing sectors (Boianovsky & Trautwein, 2010, p, 254).

Diamond (2009) summarized the increasing regard for the significance of Schumpeter's work in advancing the importance of technological innovation to improving the well-being of society. In this view, the absence of innovation and the associated emergence of new industries culminated in a stationary or even a declining quality of life. Based on an analysis of Schumpeter's works during the period of 1956 to 2006, the theory of creative destruction became more important to economists while Keynesian-related works produced the opposite effect. Diamond asserted that this phenomenon reflected an adaptation of the view that creative destruction and innovation replaced the acceptance of governmental intervention policies as stimuli for growth (p. 537).

In the presence of technological advances and new innovative industries, temporary unemployment ensued during recessionary cycles (Boianovsky & Trautwein, 2010; Diamond, 2009). After labor market disruptions had taken place within a context of creative destruction, work patterns realigned geographically during the recovery process with disparate effects between regions (Boianovsky & Trautwein, 2010). New industries birthed from commercialized technology replaced government policy intervention in importance as a stimulus to economic growth (Diamond, 2009).

Manufacturing

Helper and Wial (2010) indicated that minimal government funding allocations existed for manufacturing research and development, and market identification. Government-affiliated funding entities did not recognize the geographic advantages of financing industrial group initiatives. Fraser and Freeman (2011) contrasted the lack of attentiveness to U.S. industrial employment strength among policy makers with historical actions where domestic industries benefited from tariff protection. Policies that supported investments in foreign locations, promoted free trade initiatives, and unprotected domestic labor supplanted historical protective strategies. Government actions excluded directives to encourage technology sharing among manufacturers and their supply chain participants. In addition to building and supporting economic development in the Midwest United States, support for enhanced manufacturing activity would increase exports and reduce the trade deficit (Helper & Wial, 2010).

Proposed federal proposals included the advent of a national research program directed to manufacturing-related structures and the integration of management and

workers into the planning of public policy planning. An additional suggested approach engaged natural regional or industry groups in competition for grants directed to essential investments. Potential employment-growth stimuli encompassed expanded funding for directed research and focusing benefits on high wage and highly productive industries (Helper & Wial, 2010).

Employment levels fell by an aggregate of 18% in capital investment-intensive industries (Sum et al., 2010). The manufacturing, construction, warehousing, and transportation industries realized the largest reductions in employment after the recession. The service, finance, and public administration sectors reported minimal losses or increased employment during the recession but these industries employed the lowest proportion of blue-collar workers (Sum et al., 2010, p. 10). Despite the negative impact of the recession on employment and family formation, and the ostensible permanency of these conditions, limited public policy responses appeared (Sum et al., 2010, p. 22-23).

During the 2008 recession, 31.2% of manufacturing jobs disappeared, and manufacturing output lagged national GDP by 4.7% (Helper & Wial, 2010). The loss of productive capacity also hindered product and process innovation as creative activities traditionally co- located near manufacturing plants. Given the average weekly manufacturing earnings advantage of 19.3% over the national average within private employers, and the relatively less-educated workforce, the loss of manufacturing jobs increased income inequality in the United States (Helper & Wial, 2010). The manufacturing sector competed against highly developed technological industries and low wage countries as an employer.

Langdon and Lehrman (2012) cited a rebound in manufacturing jobs from January 2010 to April 2012 as evidence of a positive outlook for future manufacturing opportunities. Manufacturing led all sectors in technological innovation, relative wage levels, benefit premium levels and cerain educational levels among its workers. Langdon and Lehrman (2012) asserted that the manufacturing sector relied upon and employed science, technology, engineering and mathematics (STEM) workers. The link between an increasingly well-educated manufacturing workforce and an intrinsic wage and employee benefits premium indicated the importance of this sector. In addition, STEM educated workers comprised 33% of college-educated manufacturing workers but only 10% of college-educated nonmanufacturing workers (Langdon & Lehrman, 2012).

A need for higher productivity and lower turnover demanded that average wages and benefits exceed competing industries. Real manufacturing compensation rose 16% between 2000 and 2010 while nonmanufacturing compensation rose 11% in the same period (Langdon & Lehrman, 2012). Langdon and Lehrman (2012) attributed this difference to the rapid increase in employer benefits contributions by manufacturers. The total compensation premium within manufacturing in 2011, as measured by Langdon and Lehrman (2012), amounted to 15% overall for all educational levels and grew for each educational level between 2000 and 2011. Employment within the manufacturing sector provided a wage premium that in turn supported a sustained middle class. Wage growth between 2000 and 2011 demonstrated that compensation premiums remained through the 2008-2009 recession. Langdon and Lehrman asserted that manufacturing workers attained higher educational levels within all employment classes and promoted this sector

as instrumental in establishing U.S. economic competitiveness and creating a stable, well-compensated workforce.

Manufacturing wages and benefits per employee exceeded levels found in other industries. Colocation of research facilities with manufacturing plants stimulated innovation, and science and technology workers represented a larger than average fraction of the manufacturing workforce (Helper & Wial, 2010; Langdon & Lehrman, 2012). Innovation and collaboration led to increased manufacturing growth (Helper & Wial, 2010; Langdon & Lehrman, 2012), but public policy within the United States ignored the potential for growth in this industry (Fraser & Freeman, 2011). Entrenched, long-term unemployment patterns prevailed among less-educated, low income, workers in industrial occupations (Sum et al., 2010), while blue-collar occupations experienced disproportionate adverse effects from the impact of the recession (Fraser & Freeman, 2011). Discussions of needed public policy changes addressed technical innovation stimuli, favorable foreign exchange policy to enhance competition, and overall economic policy in support of domestic industrial employment growth (Fraser & Freeman, 2011; Helper & Wial, 2010; Langdon & Lehrman, 2012; Stiglitz, 2011).

Research Design and Methodology

Measurement Objective

I assessed the disparities in the impact if any, of the 2008 recession to local economic systems of the United States in this study. Of specific interest were differences in regional employment patterns within the fabricated metals manufacturing NAICS industry code before and after the recession. This study analyzed the correlation between

the pattern of job changes over time (before and after the recession's onset) and space (across regions).

The objective of this research was the discovery of patterns or relationships within the data to support the concept of economic regions as CAS. Multiple agents or sectors within an economy can interact in response to external shocks and demonstrate cyclical behaviors that lead to the attendant stages of recovery. This approach required the accumulation of metrics based upon empirical inquiries performed upon numerical data. An analysis of historical data can provide evidence of statistically significant relationships between economic resilience and adaptive factors.

Quantitative Research Approaches

The works of Comte, Mill, and Newton exemplified the foundations of quantitative research methods. A post-positivist view asserted that underlying causes produced effects even within an environment of unknown human behavior. The observed world appeared as a set of discrete items and events subject to measurement. The testing of reality led to an increase in knowledge (Creswell, 2009). Positivist and post-positivist conceptual frameworks generated scientific methodologies and experiments so that measurement, observation and testing (Creswell, 2009), enhanced understandings of reality. The inference of the veracity and validity of a hypothesis followed the failure to reject that hypothesis due to the impossibility of knowing the absolute truth. Knowledge expanded based on the collection and measurement of data. Research generated explanations of situations and explained interrelationships among variables (Creswell, 2009, p. 7).

Leedy and Ormrod (2001) stated that deductive logic began with a statement of proposed truth or a hypothesis. The study of data as an outgrowth of the scientific method's origins during the Renaissance period revealed meaning. A sequence of problem recognition, hypothesis development, and data gathering defined research methods. Data analysis procedures helped to establish the adequacy of the hypothesis toward resolving the question at hand.

Quantitative tests evaluated and assessed theoretical ideas objectively by incorporating a process that examined and measured connections among variables. Statistical methods surveyed and analyzed numeric information generated from instruments or tools. Testing sought a replication of outcomes and subsequent application of those outcomes to the general population. Theoretical testing eliminated and controlled for bias and investigated explanations attributable to factors other than the test variables (Creswell, 2009).

The deductive approach to testing and quantitative research formed the rationale for the quantitative model. The process began with the development of a theory or theories regarding laws governing the structure of the world. The formulation of a theory led to the construction of hypotheses and research questions. Definitions of variables operationalized the theories while authentication proceeded from tests of the relationships among variables. Variables received scores after the completion of observation and testing (Creswell, 2009, p. 57). Based on whether tests supported or refuted the theories, reformulation and revisions took place, and the testing cycle began again.

Quantitative research question formulations demanded a structure that examined the relationships among variables. Research hypotheses incorporated predictions and measured assessments using statistical procedures. Testing mechanisms defined inferences concerning certain populations. Hypothesis development involved comparisons and descriptions of relationships between dependent and independent variables. Measurements of dependent and independent variables provided the foundations for theoretical testing (Creswell, 2009).

Quantitative researchers evaluated connections among incidents and events and examined circumstances, as they existed. Behavioral measurements provided comparative data for groups at an instant or over an extended period. Data captured at a given time and subjected to analysis generated conclusions. After additional testing, the conclusions then extended to larger populations of events. Probability sampling among the population under study minimized or eliminated bias (Leedy & Ormrod, 2001).

Within quantitative research designs, hypotheses and research questions phrasing could be directional or non-directional. A directional hypothesis predicted the relationship between independent and dependent variables while non-directional hypotheses stated a theory. Descriptive or inferential research queries addressed attributes and relationships among concepts (Creswell, 2009).

Quantitative research strategies included experiments and non-experimental designs. Experiments examined how or whether one action or treatment influenced a subject or outcome by controlling for the presence of the treatment. Data collection occurred before and after the application of treatments to the sample. Hypotheses

construction required narrow delimitations and definition. True experiments demanded the random assignment of subjects while quasi-experiments called for fewer restrictions. Survey research strategies generated quantitative data for analysis on a longitudinal basis or across sectors (Creswell, 2009, p. 12).

In the late 20th century, alternative research strategies arose and included multiple variables and complex causal models. Complex correlational models such as factorial and repeated measure designs represented modern developments during that era. Precise testing of collective, causal phenomena among variables became possible when the intricacy of models increased (Creswell, 2009). In the presence of multiple independent variables, effects, and interactions, factorial designs evaluated and analyzed correlations (Leedy & Ormrod, 2001).

Experimental or causal comparative designs sufficed as structures for hypothesis testing (Leedy & Ormond, 2001). While experiments required the manipulation or imposition of an action upon subjects, at times ethical requirements required the use of causal comparative studies. Similar to correlational designs, causal comparative research referenced the past to identify causes of current conditions. Causal comparative research studies combined two aspects of quantitative research designs but established cause and effect only after identifying confounding variables (Leedy & Ormrod, 2001).

Quantitative research designs generated numeric measurements based on structured predefined contexts. Survey instruments gathered information from closed-ended questions posed during interviews or gathered from observations. Numeric data measurements of goal attainment, viewpoints on ideas and issues, and event occurrences

emerged for statistical analysis. This type of data analysis and interpretation furthered the body of knowledge and understanding in response to the research question (Creswell, 2009). Quantitative research strategies also encompassed the interpretation of descriptive data (Leedy and Ormrod, 2001). This design required a valid collection method and a minimization of bias based upon the selected sampling technique.

Quantitative model designs applied to research objectives in the presence of several circumstances and assumptions. The study results addressed an audience that encouraged and understood the usage of quantitative designs while the researcher accepted the existence of a determinate actuality. The research question construction implied a confirmation of a hypothesis or predicted an event. Circumstances where an extensive body of literature existed from which to extract existing theories employed quantitiative designs. Quantitative methods applied in circumstances constrained by a short period for completion combined with an extensive area of study (Leedy & Ormrod, 2001). A quantitative research design required detail and precise definition. Although frequent interaction with a number of people might not be necessary, quantitative research demanded competency in deductive thinking, statistical methods, and technical writing (Leedy & Ormrod, 2001).

Research Designs – Comparative Quantitative Studies

Identifying and explaining underlying causes of observed outcomes required a deductive approach to problem-solving. Various researchers employed diverse approaches and applied purely quantitative or mixed methods strategies to reveal

statistically significant differences in populations while incorporating defined variables and population parameters into their respective models.

Arboretti, Bonnini, and Salmaso (2009) studied the connection between career expectations and preparation among three groups of Ph.D. graduates from three separate disciplines. Bamezai et al. (2011) sampled diverse sections of the population of India to assess the impact of internet usage upon print media. Fielding and Fielding (2008) re-examined attitudes of maximum-security prisoners by accessing archived data collected by a different research team (Cohen and Taylor) decades earlier. Nara (2010) contrasted types of anxiety reactions among the populations of the China, Japan, and the United States. Oliva-Moreno, Zozaya, and Lopez-Valcarcel (2010) juxtaposed populations of two regions of Spain and measured attitude differences toward health-related life quality.

Brady and Lee (2014) selected 17 democratic countries and analyzed the reasons government spending changed as a percentage of GDP during the period 1971 to 2008. Statistical models employed included F-tests and Chi-Square tests of means. Government spending continued to decline in most countries but increased slightly during the 2008-09 recession. Within the sample, falling government spending followed globalization, the adoption of the Euro, and high unemployment. Brady and Lee did not identify significant positive effects during periods of growing government spending and recognized the necessity of additional research.

Grycova (2013) applied linear regression models to publicly accessible secondary data in order to review inequalities between the northern and southern regions of Italy during the period 1995 to 2009. Noting discrepancies dating from the Middle Ages,

southern regions exhibited higher unemployment rates and lower GDP per capita than northern sections of Italy. An ordinary least squares regression model evaluated the relationship of regional unemployment to law enforcement, capital investment, human capital, and innovation indicators. Although statistically significant relationships appeared for several regions and factors, definitive conclusions required additional investigation and analysis.

For the period 1996-2008, Kochetkov (2012) utilized a regression model to secondary data to compare inflation to unemployment rates in Latvia. Based on the hypothesis that unemployment varied negatively with inflation, additional independent variables within the model included governmental configurations, educational levels, and investment indicators. Kochetkov (2012) detected a statistically significant negative relationship between inflation and unemployment.

Niebuhr, Granato, Haas and Hamann (2012) examined the relationship between regional unemployment and labor migration between the western and eastern sections of Germany. Eastern regions displayed lower GDP and higher unemployment levels in comparison to the western counties of Germany. The linear regression analysis employed in the study identified wages and unemployment rates as dependent variables and forms of mobility as the independent variables. Empirical results based on secondary data for 430 separate counties for the period 1995 to 2005 suggested that a statistically significant connection existed between unemployment and labor mobility.

Comparative research problems and questions appeared within the surveyed literature in the form of several types. Researchers compared the behaviors, attitudes and

attributes of individuals within distinct populations and nations (Arboretti, Bonnini, & Salmaso, 2009; Bamezai et al,2011; Fielding & Fielding, 2008; Nara, 2010; Oliva-Moreno, Zozaya, & Lopez-Valcarcel, 2010). Studies covered differences between regional performance and reactions to economic conditions (Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012). Other studies compared differences based on the demographic diversity of individuals within one location (Arboretti, Bonnini, & Salmaso, 2009; Nara, 2010; Oliva-Moreno, Zozaya, & Lopez-Valcarcel, 2010). Quantitative models assessed the economic standing of local macroeconomic systems within comparative research strategies referenced in the literature (Brady & Lee, 2014; Grycova, 2013; Niebuhr, Granato, Haas & Hamann, 2012).

Data Selection

Survey methods generated quantitative data within the literature under review. Bamezai et al. (2011) employed multistage cluster and stratified sampling procedures within four regions to select news users and industry representatives as participants for surveys and telephone interviews. Simple random sampling methods sufficed for the selection of survey participants in 2008 within the United States, Japan, and China (Nara, 2010).

Oliva-Moreno et al. (2010) selected non-institutionalized individuals from two regions within Spain as participants in a comparative study. The selection process entailed stratified sampling for one region and 3-stage cluster sampling for the other in preparation for administering surveys during the period 2004 and 2006. Arboretti et al.

(2009) collected information via survey to cover discrete points in time that occurred one year and three years after the graduation date of two cohorts of multidiscipline Ph.D. program graduates.

Allan and Kemp (2011) utilized secondary data culled from an Australian nongovernmental organization collection stemming from a larger action research project. The secondary data outlined medical treatment details for each stratum of the target population. Published secondary data that originated from international agencies and published research papers populated a macroeconomic study of world employment pattern (Chennappa, 2009). For the period 1997 to 2007, global descriptive statistics covered worldwide population groups in nine regions.

Isolating the causes of regional economic differences in unemployment and government involvement required the availability of public secondary data from extended periods and widespread geographical areas. Selected research papers explored relationships over periods ranging from 10 years to 25 years and applied empirical tests to secondary data within several European countries (Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012) and and across national boundaries (Brady & Lee, 2014).

In some instances, a thorough investigation of causal relationships between phenomena represented by static data depended upon the accessibility of public or private external datasets. Some research relied on the availability of macroeconomic and personal demographic census data within the European Economic Community or other public or governmental entities. Comparative analyses of regional divisions within

countries, between countries, and within the international sphere established whether statistically significant differences between regions appeared within certain population parameters.(Allan & Kemp, 2011; Arboretti et al, . 2009; Bamezai et al., 2011; Brady & Lee, 2014; Chennappa, 2009; Grycova, 2013; Kochetkov, 2012; Nara, 2010; Niebuhr, Granato, Haas & Hamann, 2012; Oliva-Moreno et al,. 2010).

Research Strategies

Using existing published data, Allan and Kemp (2011) presented descriptive statistics that outlined treatment outcomes for two demographic segments of the population within a selected region of Australia. A chi-square test of independence measured differences in categorical data. The Maraschilo procedure posthoc analysis isolated additional differences between distinct population segments.

Survey-based integrated categorical ratings formed the basis for a Global Satisfaction Index calculation using a nonparametric combination of dependent rankings (Arboretti et al., 2009, p. 1332). Descriptive statistics and box plot presentation formats allowed for a comparison of satisfaction among three academic disciplines. An application that measured heterogeneity between cohort groups involved the computation of four nonparametric normalizing test statistics based upon frequency indices (Arboretti et al., 2009).

Bamezai et al. (2011) compared Internet usage among Indian regions and demographic groups using survey-based data from a sample of the populations of selected geographic areas. Levels of internet usage within the four sampled regions

appeared as descriptive statistics and in narrative form and indicated the comparative advantages of internet usage versus print media.

Nara (2010) examined perceptions of anxiety in response to 19 risk events within the populations of the United States, Japan, and China. Based on survey results, a multivariate analysis of variance statistical model provided country-based anxiety level rankings using Wilks λ^2 statistic. All 19 measured dimensions of anxiety reported statistically significant *F*-values, and the paper included country rankings for each dimension using the Tukey HSD posthoc comparison method.

Oliva-Moreno et al. (2010) evaluated health-related quality of life issues within two Spanish regions using the EQ-5-D instrument where five dimensions represented aspects of health-related quality of life. Descriptive statistical tables presented age-sex group scores for each dimension. An ordered probit model calculated the marginal effects of being in one of four health levels, within a range of good to bad, as input to the generation of an ordinal proxy for the HRQOL index. The paper presented calculations of the statistical significance of the marginal effect for each health level, region, and age/sex group, from a base demographic reference (Oliva-Moreno et al., 2010).

Secondary data from World Bank Reports, International Labor Organization publications, Millennium Development Goal Programme documents, and Planning Commission of India comprised the basis for an analysis of global employment trends (Chennappa, 2009). Published research reports supplied additional data for the designated period of 1997-2007. Descriptive statistical tables presented analyses of

regional and demographic employment trends. Narrative passages explained the effects of national macroeconomic policies upon current and potential employment levels.

For a dependent variable defined as government spending as a percentage of GDP, Brady and Lee (2014) performed a multiple regression and defined globalization, unemployment and currency changes as the independent variables. Grycova (2013) applied an ordinary least squares regression model to determine if regional unemployment in Italy varied with the presence of law enforcement, innovation, and investment.

Kochetkov (2012) tested a hypothesis that unemployment varied negatively with inflation for regions within Latvia. The regression model design named governmental arrangements, local educational attainment and investment levels as independent variables. Niebuhr, Granato, Haas and Hamann (2012) developed a linear regression model to understand the relationship of unemployment to labor mobility for the eastern and western regions of Germany. Descriptive statistical tables and graphs supplemented empirical test results presentations in some research presentations (Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012).

Comparative studies included those contrasting independent population characteristics and those that measured relationships in order to define correlations. Institutionally generated survey data and publicly accessible databases comprised the data sets for testing. Quantification of certain dependent variables required the application of transformational formulas. Descriptive statistical tables supplemented inferential test results by presenting comparative demographic indicators and distribution percentages

(Arboretti et al., 2009; Bamezai et al., 2011; Chennappa, 2009). Other papers focused on reporting the statistical significance of relationships among the defined variables when referencing results based on inferential methods including analysis of variance, multiple regression, and nonparametric tests (Allan & Kemp, 2011; Nara, 2010; Oliva-Moreno et al., 2010).

Secondary Data Research and LEHD/QWI Data

Abowd et al. (2009) referenced QWI data in observing the differences in job growth due to recalls for males and females in Illinois and Montana. Using graphic representations of trends in relative percentages and absolute values of jobs held by males and females, Abowd et al. (2009) reported that female workers demonstrated a higher probablity of being hired for new jobs than to be recalled during periods of job creation (p. 190). Potential additional studies of this phenomenon addressed stratification by industrial sector, age group, and geographical region within each state using QWI data. , The availability of segmented data on a fundamental level allowed for a build up of comparative categories and groupings and rendered the application of a decomposition methodology unnecessary.

Bjelland et al. (2011) examined the flow of workers between employers and recognized the continuous rationalization of labor between companies and industries in response to technological and economic shocks. Personal “supply-side” (Bjelland et al., 2011, p. 493) dynamics such as geographic movement, initial entry, retirement, and improvement of overall conditions contributed to labor force dynamics. The study omitted calcuations of impediments to worker movement. The makeup, starting and

endpoints, and wage and salary information for the transitory labor pool provided the focus for the study.

Selected LEHD data supported empirical approximations of worker flows based upon several factors. Features such as employer-employee linkages, longitudinal tracking of worker movements, and the availability of demographic descriptors substantiated the suitability of the LEHD database as a source used to measure and examine worker movements. The examination of six million private sector jobs and 200,000 to 360,000 flows from and to employers each quarter excluded any indication of the presence of sampling error. Measurement error could be possible within industry affiliations or earnings; a limitation to the presentation of descriptive statistics only precluded the need to discuss non-sampling error (Bjelland et al., 2011, p. 493). The 2% bias in worker identification coding in the core LEHD produced the effect of a false report of work interruptions at a given firm and minimally affected aggregate worker movement measurements between firms (Bjelland et al., 2011, p. 497). Over a 3-state region during the period of 1998-2003, within-state job movement investigations illustrated a high correlation between employer-to-employer flows and employment growth within the evaluated states. Although minimal gender differences in job flows appeared in the results, older workers and, to a lesser degree, highly educated workers experienced lower separations (Bjelland et al., 2011).

Hyatt and McEntarfer (2012) delineated changes in labor flows in a post-Great Recession environment and identified adjustments and reactions to that event. Job-to-job flows fell while extended unemployment occurrences increased in frequency after the

Great Recession. Higher wage losses ensued in the post-recession environment in comparison to earlier periods within the time series. A pilot of nine states' LEHD job flow data provided data for the observation and measurement of any movement between primary positions (Hyatt & McEntarfer, 2012). The frame included persons employed in one position within the sampled states (Hyatt & McEntarfer, 2012). For the period 1998-2010, inefficient labor rationalization negatively influenced individuals' earnings as extended unemployment followed the Great Recession. Findings included falling job-to-job flows and associated lower opportunities for higher earnings during the Great Recession, but rising job-to-unemployment flows (on an extended basis) during the same period.

Hyatt and McEntarfer (2012) observed that earnings gains due to job flows kept pace with earlier periods for all groups except those moving into long-term unemployment. Earnings losses for the long-term unemployed exceeded losses during previous periods. The largest decline in job mobility occurred for the group changing primary jobs or experiencing a short-term move to unemployment. In an analysis of wage changes associated with movements from the residential construction industry, Hyatt and McEntarfer (2012) noted that earnings flattened or fell as workers moved to lower wage sectors. The work of Hyatt and McEntarfer (2012) demonstrated the utility of linked employer-to-employee data in understanding labor market dynamics.

As one of the indicators of the Great Recession, the magnitude of the housing price bubble varied among MSAs within the United States (Abowd & Vilhuber, 2012). Access to the QWI and Housing Price Indices (HPI) published by the Federal Housing

Finance Agency (FHFA) facilitated the identification of a relationship between local housing price bubbles and local employment, earnings, and job movement. QWI included new and destroyed jobs data and earnings for 98% of the private workforce employed within 357 MSAs and 566 micropolitan areas. HPI referenced single-family detached residences in 366 MSAs within the United States. Supplemental employment data from the Bureau of Labor Statistics (BLS) also formed part of the basis for the study. In all, the integrated data covered 354 MSAs and encompassed 84% of all workers in 2006. Jobs and earnings data for three consecutive months constituted the database for the study.

The mixed effects linear regression design named local labor effects as the dependent variable, and national and local housing price factors and national labor effects as independent variables (Abowd & Vilhuber, 2012). Randomized effects represented MSA variations, and national average coefficients. The model encapsulated separate MSA-specific effects and included an assumption of normally distributed random effects with means equal to zero. Criteria for selecting the top 35 MSAs incorporated the length of time the local HPI remained above the national average, the swiftness with which prices fell in advance of the recession, and a continuing price depression while other regions recovered. Abowd and Vilhuber (2012) observed that national employment separations outweighed employee hires after the recession's onset, but this relationship prevailed at an extreme level within the selected top 35 MSAs. Controlling for national labor conditions, HPI, and national flows, the paper addressed the marginal effect of local housing price movements on local labor flows (Abowd & Vilhuber, 2012). The standard

deviations of gross worker flow statistics, and gross job flows statistics indicated the existence of significant differences between the top 35 MSA worker flows and national observations. The large standard deviations attested to "heterogeneous" (Abowd & Vilhuber, 2012, p. 592) responses within the top 35 MSAs to the housing price bubble.

Blau and Shvydko (2011) compared the LEHD series with the Survey of Income and Program Participation (SIPP) to identify the relationship of fixed labor market factors with the likelihood of retirement by older workers. Proportions of young females and older workers within the workforce varied negatively with the presence of rigidity or fixed and mandatory work hours. Workplace rigidity accompanied technological advances that demanded fixed groupings of labor for effectiveness (Blau & Shvydko, 2011, p. 465-466).

Blau & Shvydko (2011) used a difference in differences regression model to assess the relationship of older workers' exit rates from the workforce with the age and gender makeup of that labor force. The research outcome revealed that as the portion of younger females and older workers increased, the likelihood that older workers separated from existing jobs decreased. Empirical evidence indicated that older workers experienced a comparatively higher incidence of flexible hours, and younger females and older workers participated at a low rate within workplaces exhibiting technology-related rigidly-defined hours. In this study, a logit methodology calculated the probability of an older employee remaining given firm descriptors and workplace hours flexibility (Blau & Shvydko, 2011, p. 472).

Blau and Shvydko (2011) found that outcomes remained unchanged after controlling for demographic and economic characteristics of the workforce. The study sample included 22,372 individuals while the number of person-months of employment data ranged from 471,104 to 473,034. Directionally, industry-level effects appeared to be equivalent to employer-level effects (Blau & Shvydko, 2011). In the presence of workplace rigidity, older males demonstrated a higher propensity to separate than older females, suggesting that that older males' need for workplace flexibility exceeded that of older females (Blau & Shvydko, 2011, p. 481). Given an aging U.S. population, this paper isolated those factors that contributed to the retention of older workers. The finding of a significant relationship between older worker retention and workforce composition did not provide clues at to how this conclusion will affect the overall economy (Blau & Shvydko, 2011, p. 483).

Andersson et al. (2012) explored wage inequality by accessing the LEHD infrastructure as an alternative data set to employee survey results. A decomposition method identified and measured the contributing factors to growing wage inequality in the United States. In addition to isolating the impact of worker-employer iterations on earnings, Andersson et al. (2012) supported the finding of the negligible role of industrial realignment in the growth of wage inequality. The study included descriptions of the evolutionary changes in worker populations, employer groups, and worker-employer configurations that led to wage inequality. An individual's wage level varied as a function of an individual effect, including education and skill level, and a firm effect that reflected factors contributing to above market wages.

For the period of 1992-2003, a decomposition method in the form of a series of equations separated changes in average earnings into measurable effects attributed to (a) human capital changes, (b) worker movement, (c) entity movement, (d) changes in worker-firm combinations, and (e) residual distribution changes (Andersson et al., 2012). As a data source, the LEHD infrastructure supplied the advantages of its near universal coverage of private sector employees, the capability of tracking workers' employment and earnings changes, and statutory requirements for accuracy. Andersson et al. (2012) analyzed data from the four available states that comprised the LEHD series for the tested period. The first step in measuring the contribution of unobservable traits to earnings inequality involved isolating a residual distribution within the decomposition procedure (Andersson et al., 2012, p 791).

From 1992 to 2003, the 90-50 log wage difference for manufacturing grew by .16 while the 50-10 log wage difference for manufacturing fell by .02 (Andersson et al., 2012). Only 57% of manufacturing firms in existence in 1992 survived until 2003. The reallocation of employees between firms and residual (unknown) effects drove wage inequality higher. "Sorting" (Andersson et al., 2012, p. 799) or the movement of higher-skilled workers to higher paying firms fulfilled the skill demands of technologically advanced companies. Residual effects pointed to higher earnings returns and compensation within technologically advanced firms (Andersson et al., 2012).

Within manufacturing, enhanced earnings for the 10^{th} percentile wage level followed the exit of lower paying firms, while the 10^{th} percentile did not benefit from the phenomenon where higher paying firms attracted highly paid skilled workers (Andersson

et al., 2012). Increased wage differentials within the manufacturing sector originated from residual effects (Andersson et al., 2012). Log earnings increased from 1992 to 2003 for the 90th percentile (.22), followed by the 10th percentile (.08), and the 50th percentile (.06) for the manufacturing category (Andersson et al., 2012). The substantive role of residual factors within the research results indicated the presence of higher rewards for unseen qualities and the contribution of these factors to growing earnings inequality.

Summary

The literature review included an array of published works that employed research designs structured for comparisons of population attributes and the measurement of relationships. Certain papers contained comparisons of the attitudes of separate groups toward health well-being, educational preparedness, anxiety, and Internet news acces, (Arboretti et al., 2009; Bamezi et al., 2011; Nara, 2010; Oliva-Moreno et al., 2010). Other papers reported on the use of parametric and non-parametric tests of the relationships between regional and national economic indicators to defined, independent variables during and before the 2008-09 recession (Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012). Comparative parameters within the reviewed papers included geographic location, socioeconomic status, and ethnic background. Surveys and publicly accessible secondary datasets provided numeric data for analysis within the research designs.

Researchers uncovered labor movement and composition patterns in the United States using the LEHD program data series in its basic form. Probabilistic methods and population analysis strategies used the QWI database contents in order to garner answers

to social questions. An exploration of the recession's effect on employment within regions with significant housing price reductions applied linear regression methodologies to LEHD-based QWI data and the HPI. Differences in the impact of the recession emerged for the MSAs that experienced higher housing price losses versus national averages (Abowd & Vilhuber, 2012). Job-to-job flows during the 1998-2010 period revealed an inefficiency in labor rationalization as wages dropped, flows from employment to unemployment increased, and higher-wage workers flowed to higher-paying firms (Hyatt & McEntarfer, 2012). This finding contributed to the knowledge of the origins of growing wage inequality and originated with a study using the job flow data within the LEHD (Hyatt & McEntarfer, 2012).

Labor adjustments occurred in response to external economic shocks and technological developments and incorporated geographic movements, entry, retirement, and improvements. Previously unidentified personal factors, or residual factors, also contributed to worker movements (Bjelland et al., 2011). For the period 1998-2003 and a 3-state region, older or more educated workers changed jobs less frequently than the general workforce did while neither effect varied with gender. Construction industry workers and professional, technical, and administrative employees experienced higher than average turnover (Bjelland et al., 2011).

To investigate the optimal work environment for older workers, Blau and Shvydko (2011) analyzed LEHD data, compared the series with the SIPP, and determined that workplace flexibility corresponded with higher than average proportions of older workers and younger females. By applying a logistic regression method to determine the

likelihood of job separation for designated age groups versus the portion of younger females within a firm's workforce, Blau and Shvydko found that higher fractions of younger females within the workforce indicated flexibility and related to lower separation rates among older workers. This effect remained unchanged when controlling for demographic and economic factors but prevailed more often for older males than for older females (Blau & Shvydko, 2011, p. 481).

An analysis of growing wage inequality in the United States revealed that a human capital effect, firm level differentials in the marketplace, the types of observed worker movements, and worker-firm combinations contributed to that inequality during the period 1992-2003 (Andersson et al., 2012). Residuals indicated the presence of intangible contributors, such as interpersonal skills, to wage premiums. Andersson et al. (2012) supported a model in which surviving higher-paying, capital-intensive, technologically advanced firms attracted higher wage, highly educated workers. Rates of increase in earnings within the 10^{th} percentile of manufacturing employees lagged those of the 90^{th} percentile, as less-sophisticated firms closed and demand for lower-wage workers fell (Andersson et al., 2012).

In the reviewed literature, research problems involving the identification of a relationship between population attributes or population comparisons cited national and international public and private secondary data sources for empirical analysis. Inferential methods applications ascertained the existence of statistically significant relationships. Descriptive statistical presentations added to the body of knowledge regarding the nature of global and regional economic trends (Chennappa, 2009). Public database repositories

of economic indicators and firm characteristics within several European Economic Community members formed the basis of several studies of relationships between unemployment and spending with the major cluster-related drivers. Univariate correlations, multiple regression, and analysis of variance techniques tested accessible secondary data to complete the comparative studies (Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012).

Regional employment pattern differences that appeared in the United States after the 2008 recession are the subject of this paper. Tests that are included in the research design addressed the effects of location, workforce gender composition, and industry firm configuration, upon employment changes described within the research design. The selection of this research design demonstrated the adoption of a deductive, post-positivist worldview and execution of the study required a level of proficiency in statistical analytical techniques. I established directional or causal relationships between phenomena and observed outcomes as represented in numeric data, when evident. The present study extended the body of knowledge concerning patterns of post-recession employment recovery by comparing the resiliency of manufacturing employment in two regions of the United States.

In Chapter 3, I will present the research design and rationale, the research question, and the methodology. A brief discussion of the background of the problem will precede sections devoted to descriptions of sampling procedures; data collection; and analysis, validity, and reliability. I will discuss the origins of the data inputs for variables defined in the independent sample *t*-test and multiple regression research designs

incorporated in this study. I will then describe the data collection methods and will discuss the data's validity and reliability.

Chapter 3: Research Method

Introduction

An effect of the 2008 recession included employment losses throughout the United States and within the manufacturing sector specifically (Fraser & Freeman, 2011). Manufacturing employment fell by 17% between January 2008 and February 2010 (Fraser & Freeman, 2011; United Department of Labor – Bureau of Labor Statistics, 2013). As of December 2012, less than 25% of the overall job losses in the manufacturing sector had returned (Fraser & Freeman, 2011; United Department of Labor – Bureau of Labor Statistics, 2013).

Within the fabricated metals manufacturing subsector, 50% of jobs lost came back by December 2012 (United Department of Labor – Bureau of Labor Statistics, 2013). An economic region's adaptive ability in the face of unexpected developments can be crucial to the ongoing sustainability of that economic system for the benefit of its resident individuals and its organizations. An independent sample *t* test to compared the rates of employment loss within the fabricated metals manufacturing sector observed in the East North Central division and the South Atlantic division of the United States. Multiple regression models isolated apparent adaptive measures among agents within the regions under review.

This chapter includes a detailed description and justification for the use of this research design in this study of employment patterns within the United States after the 2008 recession. I will explain how the methodology and design will answer the stated research questions and will discuss the problem statement's relevancy to the associated

design and approach. I will describe how secondary data generated from U. S. Census Bureau surveys of business establishments and state unemployment records, along with individual and establishment data generated from the Bureau of Labor Statistics formed the basis for this paper and served as research variable data sources.

Chapter 3 explains access methods for archival data, permissions, and procedures associated with collecting the data. This chapter depicts the validity and reliability of the empirical tests used to address the research questions, and a data analysis plan. I will discuss threats to validity and ethical concerns pertaining to the treatment of all data. Chapter 3 will conclude with a summary of the design and methodology employed in this inquiry.

Research Design and Rationale

Study Variables

Study variable definitions for Research Question 1 are as follows:

$\mu 1$ = Average rate of change in the fabricated metals jobs held in the 50 randomly selected MSAs contained in the East North Central division of the Midwest Region of the United States in the first quarter of 2010 versus the first quarter of 2008.

$\mu 2$ = Average rate of change in the fabricated metals jobs held in the 50 randomly selected MSAs contained in the South Atlantic division of the Southern Region of the United States in the first quarter of 2010 versus the first quarter of 2008.

Measured jobs data originated from unique employee establishment-matched records located within the LEHD-based QWI database and BLS-based QCEW database. Comparisons of jobs data constructed from the beginning of the first quarter of 2008 and

the beginning of the first quarter of 2010 formed the core of the analysis. The mean change μ_i was a simple arithmetic average of the change for the 50 sampled MSAs between the designated periods for region $_i$.

Study variable definitions for Research Question 2 are as follows:

Dependent Variable: y_i = Percentage change in total employees in the fabricated metals manufacturing sector within the East North Central division of the Midwest region of the United States or the South Atlantic division of the Southern Region of the United States from the first quarter of 2008 to the fourth quarter of 2012 for MSA i.

Independent Variables: For each division:

x_{i1} = Percentage change in the male fabricated metals manufacturing workforce from the first quarter of 2008 to the fourth quarter of 2012 in MSA *i*.

x_{i2} = Percentage change in the female fabricated metals manufacturing workforce from the first quarter of 2008 to the fourth quarter of 2012 in MSA *i*.

x_{i3} = Percentage change in the number of fabricated metals manufacturing establishments from the first quarter of 2008 to the fourth quarter of 2012 in MSA *i*.

Unique employee establishment-matched records located within the LEHD-based QWI database and BLS-based QCEW database aggregated into totals for MSAs within the division and formed the basis of the dependent variable y_i. Jobs data for the beginning of the first quarter of 2008 and the end of the fourth quarter of 2012 articulated the basis of the analysis. The arithmetic average of the change for the sample of 50 MSAs within the region $_i$ from Period 1 to Period 2 defined the dependent variable y_i.

Independent variables x_{i1} and x_{i2} measured the percentage change in the jobs held in MSA *i* occupied by male $_{(1)}$ or female $_{(2)}$ constituents from the time of the onset of the recession until the fourth quarter of 2012. Male and female employee jobs data populate the QWI reporting system for each MSA within the divisions selected. The calculation of the percentage change in jobs held by each constituent group encompassed a formula of Period 2 jobs less Period 1 jobs divided by Period 1 jobs. QCEW establishment data for each quarter reports independent variable x_{i3} data. The calculation of the percentage change in the number of establishments for MSA *i* is the Period 2 establishment total less the Period 1 establishment total divided by the Period 1 establishment total.

Research Design

This study analyzed differences in manufacturing employment patterns observed within the United States after the 2008 recession. Tests addressed locational, firm level changes and gender makeup effects upon overall employment level changes based on the stated research design. Two inferential tests explored the impact of the recession upon regional fabricated metals manufacturing employment. The tests identified regional differences in the recession's effect on employment and constituent agents' adaptive behaviors during the early stages of the recovery. Table 5 presents the research design.

Table 5

Research Design

Research Question	Inferential Test	Population	Sample
1. Were there regional differences in post-recession manufacturing sector unemployment rates within the United States?	Independent Sample *t* test	MSAs within the East North Central division (162) and South Atlantic division (144) of the United States, as defined by the United States Census Bureau	Sample of 50 MSAs each within the East North Central and South Atlantic divisions
2. How did workforce gender and firm makeup affect post-recession regional manufacturing employment levels in the United States?	Multiple Regression	MSAs within the East North Central division (162) and South Atlantic division (144) of the United States, as defined by the United States Census Bureau	Sample of 50 MSAs each within the East North Central and South Atlantic divisions

An answer to Research Question 1 arose from the execution of an independent means *t*-test of the average change in fabricated metals manufacturing employment for two geographic divisions of the United States from the first quarter of 2008 to the first quarter of 2010. Although the national recovery began as of June 2009 based on the National Bureau of Economic Research recession dating committee publication (NBER, 2010), manufacturing employment as a whole did not start to recover until March 2010. For this reason, the comparison of changes in employment levels covered the period between the first quarter of 2008 and the first quarter of 2010.

In Research Question 2, I demonstrated the relationship of regional employment changes after the recession to workforce gender composition and establishment characteristic changes. MSA level aggregations of fabricated metals manufacturing employment defined the unit of analysis while the comparative regions were the East North Central division and the South Atlantic divisions of the United States.

Fabricated metals manufacturing employment data separated by gender within the East North Central and South Atlantic divisions exists as secondary data found in quarterly and annually published online databases. Descriptive statistical tables described aggregated pre- and post recession regional employment statistics by gender within the fabricated metals manufacturing sector. An independent sample *t* test assessed the equality of means of the change in employment after the onset of the recession in the fabricated metals sector employment population by MSA within the East North Central and the South East divisions. A multiple regression model measured the relationship between regional changes in fabricated metals employment as the dependent variable and

changes in the gender makeup of the local workforce and number of firms as the independent variables to detemine local agent responses to the external shock of the 2008 recession. The percentage change in jobs held, percentage changes in gender, and percentage change in firms for the fabricated metals manufacturing sector for the specified regions over time appear on a continuous scale.

I designated the fourth quarter of 2012 as the cutoff for gathering statistics and measuring effects. This study began by analyzing changes beginning with the first quarter of 2008, the period designated by the NBER (2010) as the beginning of the 2008 recession. Although the start of the third quarter of 2009 marked the end of the recession (NBER, 2010), aggregate national manufacturing employment numbers began to recover as of March 2010 (United States Department of Labor – Bureau of Labor Statistics, 2013). Fabricated metals manufacturing employment nationwide recovered 50% of jobs lost by December 2012, but the remaining manufacturing sectors taken together recovered less than 20% of lost jobs during the same period (United States Department of Labor – Bureau of Labor Statistics, 2013).

Establishment-based geographically segmented data aggregated from geo-coded U.S. Census Bureau records proved to be an accessible and appropriate dataset for this study. Quarterly regional fabricated metal sector job totals for individual MSAs, reported by gender, were readily available for download in a usable format (Singleton & Straits, 2010). Personal and firm level identity masking applications preserved privacy, but aggregated regional economic and demographic variables in a consistent format could be retrieved for the entire country. The accessibility of historical monthly, quarterly, and

annual employment statistics provided longitudinal data for all geographic regions. Readily available demographic data offered a foundation for an analysis of social change (Singleton & Straits, 2010).

The use of secondary data in this study precludes the presence of reactivity between the subjects of the research and the researcher. In addition, the results are not "self-censored" so that the subjects cannot affect the results or create a premeditated outcome (Singleton & Straits, 2010, p. 403). Secondary data analysis allowed for the study of groups, systems, and networks, as opposed to an individual or a small group. This study entailed the isolation of effects on entire regions and individual MSAs (Singleton & Straits, 2010).

This study encompassed adequate sample sizes and included large and small MSAs within the general population. In this design, the availability of secondary data allowed for the application of the research design to several distinct periods and two regions (Singleton & Straits, 2010, p. 405-406).

Time and Resource Constraints

QWI and QCEW data are available for download from multiple websites sponsored by the U.S. Department of Commerce U.S. Census Bureau (n.d.) and the U.S. Department of Labor Bureau of Labor Statistics (2012). The selected time segments in this study encompassed January 2008 to December 2012; for this reason, the 6-month lag period involved in posting new data by the Census Bureau and the Bureau of Labor Statistics, coupled with the frequency of underlying reporting by establishments, did not pose time and resource constraints. Immediately after receiving Institiutional Research

Board approval on June 4, 2015, the relevant database download process from the U.S. Census Bureau and Bureau of Labor Statistics websites began and the test data retrieval process ended as of June 30, 2015.

Three limitations appeared during the data collection procress and affected the availability of firm level data, covariates, and national gender-based employment data as input to the multiple regression tests in response to Research Question 2. The first limitation concerned the minimal availabilty of data representing independent variable y_{i3} for the sslected sample MSAs. An initial sample selection from each division followed the proposed plan as each sample included the top 40 MSAs for each division and additional 10 MSAs representing every other MSA from the remaining alphabetically arranged list. The QCEW database masked establishment-level data for many MSAs selected to maintain privacy standards for MSAs that contained minimal numbers of establishments. Consequently, this finding necessitated a reformulation of the test sample in order to incorporate establishment data as an independent variable in the multiple regression test for Research Question 2.

A second limitation involved the minimal availability of MSA-level potential covariate measurements. Covariates contemplated for this study included quarterly MSA-level interest rate and energy price changes for the test period. Access to data points at the requisite level of detail within open databases proved to be limited or non-existent.

Lastly, quarterly, gender-delineated employment levels by three-digit NAICS code existed within the QWI database for each sample MSA. The derivation of MSA-

level data for each of the two test divisions arose from an aggregation of MSA level statistics for each state within the specified division. National, gender-delineated, quarterly employment data for three digit-level NAICS codes did not appear in any of the accessible, open databases. Hence, this study excluded comparisons of regional workforce gender composition effects upon employment levels with any observations on a national level.

Consistency with Earlier Research

The publicly accessible QWI and QCEW databases operated as sources for the data in this research design. The two databases originated from the LEHD program data. Descriptions of published, earlier labor and workforce-related research follows wherein access to the LEHD program data and/or its derivative databases within the context of inferential tests furthered inquiry concerning labor composition and movement.

Abowd et al. (2009) accessed QWI data to measure gender differences in job growth within two separate states. During job creation cycles, females appeared to find new employment more frequently than to be rehired (Abowd et al., 2009, p. 190). The research design in this study applied to the measurement of employment trend differences for industrial sectors, genders, and regions while utilizing the QWI database. Comparative data was available from the QWI database for demographic sections of the workforce. Graphic, descriptive analyses and charts appeared within the study as a presentation of the results.

The LEHD program data and its associated QCEW series and QWI database appeared in recent research as an instrumental component in gaining an understanding of

labor patterns within the United States. Probabilistic methods and population analysis applications for these series answered social questions. Mixed effects linear regression methodologies applied to QWI data based upon the LEHD, and the HPI, measured the recession's effect on employment within regions with significant housing price reductions (Abowd & Vilhuber, 2012).

Certain studies utilized the LEHD's longitudinal attributes to examine job flows within geographic areas and between industries and utilized descriptive statistics. Hyatt and McEntarfer (2012) evaluated the relationship between job-to-job flows and wage inequality during the period of 1998-2010. In response to external economic shocks and technological developments, personal factors impeded adjustments such as geographic movements, entry, retirement, and personal improvements (Bjelland et al., 2011). An analysis of the job change frequencies within a limited geographic area during the period 1998-2003 included LEHD-based descriptive statistics and profiled the demographic and industrial makeup of employee movement (Bjelland et al., 2011).

Blau and Shvydko (2011) evaluated LEHD data and compared the series with the SIPP to explain the relationship between older workers and workplace flexibility using a logistic regression methodology. Andersson et al. (2012) applied a decomposition method to the LEHD infrastructure to understand the relationship between employee turnover and wage inequality in the United States during the period 1992-2003. After employing a mixed effects linear regression research design, Abowd and Vilhuber (2011) concluded that the QWI series reliably predicted national job flows and supplemented existing series due to the availability of NAICS, gender, and age statistics. The LEHD

generated the publicly accessible QWI and reported on 98% of private employment in the 47 states in which data collection took place. Abowd and Vilhuber (2011) presented proof of the statistical reliability of national QWI projections (p. 2).

Research studies that pertained to population comparisons, economic well-being and the establishment of relationships also evaluated secondary data obtained from national and public sources outside of the United States. Inferential methods determined if statistically significant relationships existed between or among two or more factors. Other public governmental databases formed the basis of analyses of the relationship between commercial strength measured using a variety of delimiters and external labor-related factors.

Brady and Lee (2014) employed F-tests and Chi-Square equality of means tests to examine the relationship of government spending to GDP growth in 17 democratic countries. Grycova (2013) compared the progression of the economic well-being for two regions in Italy using an Ordinary Least Squares regression design and identifying external variables for which to measure statistically significant effects. Kochetkov (2012) applied linear regression design in a study to determine if inflation was statistically significantly related to employment in Latvia during the test period. Niebuhr, Granato, Haas and Hamann (2012) measured the effect of labor migration within Germany upon regional employment levels utilizing linear regression methods applied to secondary data.

In summary, research studies accessed the LEHD program data and its derivatives, the QWI and QCEW databases to analyze and evaluate labor migration, labor

makeup and the relationships between employment levels and external factors using descriptive statistical methods as well as parametric and non-parametric tests (Abowd et al,. 2009; Abowd & Vilhuber, 2011; Abowd & Vilhuber, 2012; Andersson et al., 2012; Bjelland et al., 2011; Blau & Shvydko 2011; Hyatt & McEntarfer, 2012). In addition, surveyed research papers applied univariate correlations, multiple regression analyses, and analysis of variance techniques to public databases external to the United States in order to measure the significance of independent variables upon forms of economic well-being (Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012).

The research design in this study conformed to the array of parametric and non-parametric inferential designs employed and reported in earlier research utilizing the public LEHD program data, the QWI database, and the QCEW database, These studies measured the relationship of employment levels with diverse intrinsic, demographic variables and external economic variables. This study's design is consistent with additional research studies that addressed regional economic comparisons outside of the geographic United States, accessed public databases and applied inferential, linear regression designs to achieve the objective of measuring and comparing regional economic conditions and their related factors.

Methodology

Methods employed in secondary data analysis encompass locating data sets that meet the requirements for testing the stated hypothesis and referencing the methodologies of other researchers in accessing that data set for other studies. The use of multiple

measures for one variable could mitigate the impact of indirect variables. Within this research study, measurements of the recession's effects derive from data reported within the QWI database (U.S. Census) and the QCEW database (Bureau of Labor Statistics). Explanations of the data gathering methods facilitated an understanding of the data's authenticity and an assessment of the reliability and validity of the model (Singleton & Straits, 2010, p. 410).

Inferential methods formed the basis for this quantitative study based on the objective of establishing if a relationship exists between job loss rates after the recession for two regions of the United States and isolating adaptive features. The model assessed the correlation between changes in the workforce composition and establishment attributes with the employment changes for each region. Referencing the NBER (2010) published cycle dating of expansions and contractions as a guide; the lowest point of economic activity prior to the 2008 recession happened in November 2001. Peak economic activity occurred in the month of December 2007, and the recession began in the first quarter of 2008. In addition, based on the business cycle dating system, the next trough occurred in June 2009. For this reason, while indicators in the fourth quarter of 2007 marked peak economic activity, the first quarter of 2008 signaled the beginning of the Great Recession (NBER, 2010).

Target Population

The population consists of the 620 MSAs with fabricated metal employees within the United States. The target population encompassed the total number of fabricated metals manufacturing jobs within all of the MSAs located within the East North Central

Division and the South Atlantic division of the United States. The respective totals of MSAs reporting NAICS 332 fabricated metals manufacturing employment within the East North Central and the South Atlantic divisions were 162 and 144. The two divisions together represented 49% of all MSAs within the United States that employed NAICS 332 fabricated metals manufacturing workers at the beginning of the recession.

At the onset of the recession, NAICS 332 sector employees in the East North Central and South Atlantic divisions accounted for 40.1% of national NAICS 332 employment. The remaining seven divisions of the United States only accounted for 59.9% of total NAICS 332 employment. Although wages for NAICS 332 non-supervisory and hourly workers remained below the national manufacturing average as of 4Q2012, wages for NAICS 332 employees recovered at a rate of 10.4% during the period January 2008 to December 2012 while overall manufacturing wages rebounded by 9.3% during the same period (United States Department of Labor – Bureau of Labor Statistics, 2015). Likewise, as of 4Q2012, national manufacturing employment registered a 12.9% decline from its pre-recession level while NAICS 332 national employment fell by 9.0% from pre-recession levels.

Within the manufacturing classification, companies in the NAICS code 332 fabricated metals manufacturing category led in national employment in 4Q2007. The selection of this manufacturing code stemmed from its overall impact on national employment and its economic integration with a diverse set of other business sectors. Prior to the beginning of the recession, NAICS code 332 was a robust sector and intersected with other manufacturing disciplines within the United States economy.

Sampling and Sampling Procedures

The population of workers matched with fabricated metals manufacturing establishments within the East North Central and South Atlantic United States during the period 2008 to 2012 formed the sampling frame. These selections reflected the observation of the scale of the total number of employees for each region meeting the sampling criteria before the recession. MSAs are geographic areas that contain a city of at least 10,000 persons for the purposes of this study and represent a collaborative economic unit based on a concentration of firms within the fabricated metals manufacturing sector.

Individual job definitions entail worker-establishment pairings and are available within the longitudinal datasets that generated and published by the U.S. Census Bureau (Census) and BLS. Multiple public internet-based sources of integrated employment statistics provided the data sets populating this model. Workforce gender attributes and firm characteristics formed an integral part of this research.

To obtain a representative sample from varied regions within the United States, a segmentation of the population of MSAs into regions and divisions was the first step in the sampling process. Further, selections of two major divisions within each of the Midwest and Southern Region, as defined by the U.S. Census Bureau, followed. Sample selection used representative sampling where selected MSAs represented concentrated employment groups within each division. For the selected MSAs, post recession job loss rates formed the dataset unit of analysis (Frankfort-Nachmias & Nachmias, 2008, p. 173). MSA rankings within each division stemmed from the total of fabricated metals

manufacturing jobs in existence at the beginning of the recession, for each MSA. The sample development began with the top 40 MSAs based upon employment levels in January 2008. The selection of 10 additional data points representing every second MSA from within the remaining alphabetically arranged list completed the sample to make up a sample size of 50 MSAs for each division. A deviation from this sampling method resulted from the finding that MSA-level establishment data masking eliminated some of the selected MSAs from the sample, and additional MSA selections arose from the alphabetically arranged list.

This method ensured that the sample represented a selection of MSAs that displayed cluster characteristics reflected in the magnitude of employment for the NAICS 332 sector within a concentrated geographic area. Manufacturing employment history and workforce gender characteristics originated from the QWI series while the QCEW database supplied the number of establishments for the selected MSAs within the sample, as appropriate. Appendix A presents the U.S. Census Regions.

An objective of this study included the generalization of its results so that an understanding of the 2008 recession's impact on employment within two distinct geographic divisions of the United States can be broadened to incorporate implications and additional testing for other regions. The selected sampling methods ensured that the measured parameters would be representative of the population parameters. A desired outcome of the sampling strategy was the minimization of bias in the selection process insofar as secondary data is used. Within this study, the MSA selection method

employed representative and random sampling methods (Frankfort-Nachmias & Nachmias, 2008).

Power Analysis

Two G-power a priori power analyses computed the required sample sizes for tests to compare job losses and system changes between two regions (Faul, Erdfelder, Lang, & Buchner, 2007). The first test family is the *t*-test with a desired $\alpha = .05$, an effect size of .8, and a power of .95. For this test, the required calculated sample size is 42 (Faul et al., 2007). The *F*-test multiple regression with 3 predictors, a desired $\alpha = .05$, an effect size of .8, and a power of .95 yielded a desired sample size of 26. An a priori power analysis calculated the sample size for this test with reference to the applicable, multiple regression statistical model. Given the planned sample sizes of 50 for each test the desired α, effect, and power levels were met.

The desired confidence interval, or the probability of correctly concluding there is no effect, was 95% for the inferential tests incorporated into this research (Field, 2009; Trochim & Donnelly, 2007, p.295). The probability or *p*-value of .05 measured the probability that the null or alternative hypothesis was correct, where, if the probability of the calculated statistic occurring is less than .05, the null hypothesis was rejected (Field, 2009, p. 53). The test of independent means was a two-tailed test due to the non-directional stated hypothesis, and the *p*-value was .05 (Field, 2009, p. 55). The multiple regression test *p*-value was .05, as the research question tested the statistical significance of the relationship of workforce demographic and firm characteristics with changes in employment.

Archival Data Collection and Access

Historical origins – QWI. Sourced from the U.S. Census Bureau and BLS databases, online-accessible source databases defined as the QWI and the QCEW stem from the LEHD database (Abowd et al., 2004). The creation of the LEHD benefited social science research by reporting, in an accessible manner, the links and interactions between individuals within households and the businesses that employed them. A research benefit of this database is the measurement of the impact of "technological and structural change on earnings, employment, and productivity" (Abowd et al., 2004, p. 224).

Private sector quarterly state unemployment records formed the core of the LEHD. The base integration record consisted of a masked individual ID to be linked to demographic personal census data, an employer ID number with links to a business register, and a Census business ID linked to economic census descriptive data. Figure 2 presents the LEHD program structure and derivation.

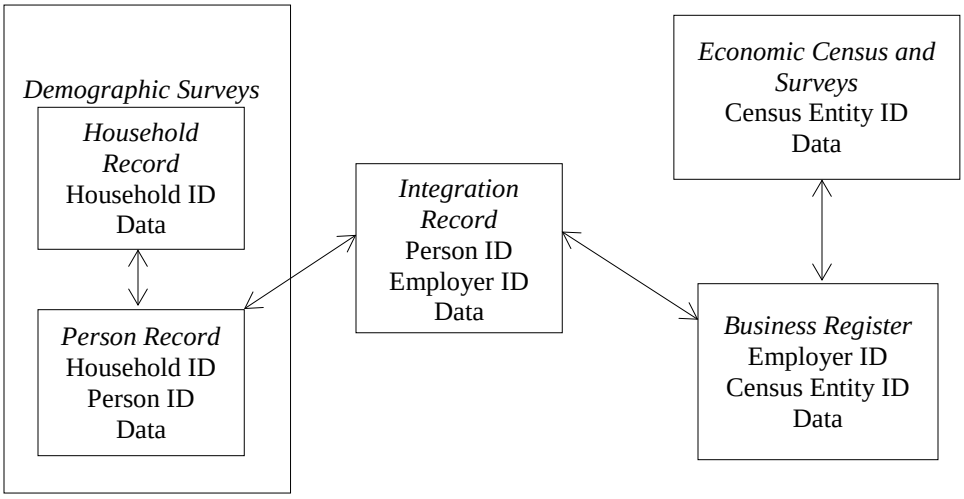

Figure 2. LEHD Program (2004)

Identifiers linked the databases as indicated in Figure 2 from Abowd et al. (2004). Repairs to missing links began with probabilistic methods followed by methodologies incorporating combinations of other descriptive data to achieve identification estimates. Individual demographic data extracts referenced the person identifier, and non-matches occurred at the rate of 4%. Business data extractions originated from federal employer identification links to economic censuses and surveys. Title 13 of the U.S. Code governed permission restrictions to data access for privacy. The LEHD infrastructure composition of integrated individual and business attributes permitted the selection of multiple sampling frames. The Person Characteristic File (PCF) database reported the demographics of (a) sex, (b) birthdate, (c) birthplace, (d) citizenship, and (e) race. The PCF file originated from a Social Security Administration (SSA) database (Numident file) comprised of SSA application records. Within this study, the demographic of sex appears in the empirical analysis as a parameter enabling an understanding of changes in workforce makeup (Abowd et al., 2009, p. 154).

Access points for the QWI, the primary subset of the LEHD, resided in public internet web sites. Geographic data at the level of Workforce Investment area (lower than MSA level) incorporated employment, job flow, industry, age, and gender from participating states by quarter. Aggregated employment data could be deconstructed to reveal employment gains and losses for designated geographic regions during set periods to uncover long-term developments and to provide control variables for regression analyses (Abowd et al., 2004).

One use of the LEHD included a deconstruction of employment patterns. Quantification of human capital employment components external to traditional demographic indicators explained earnings differentials and the effects of firm characteristics on worker outcomes (Abowd et al., 2004, p. 226). Researchers conducted analyses of the movement and location of employees, aging and employment, and detailed industry composition based on this database. Projected studies can address the evolution of the employer base into emerging industries and the integration of worker and firm characteristics. In addition, the aggregation of microeconomic data describing worker movements can reveal the adjustments intrinsic to worker behaviors in response to macroeconomic events (Abowd et al., 2004, p. 228).

Current status – QWI. Abowd et al. (2009) published the definitive work on the origins and composition of the LEHD program at the U.S. Census Bureau and the generation of publicly accessible QWI. The LEHD Infrastructure files provided the initial national statistical database directed to jobs or relationships between employees and employers, as opposed to focusing on households or establishments separately.

Abowd et al. (2009) discussed the genesis of the "core infrastructure" files for the integrated "job-based statistical frame that LEHD created" (p. 158). The SAS-based files, formats, and indices that made up the core infrastructure provided for valid empirical analyses that incorporated, job, employee, and establishment indicators. During the process of building the infrastructure files, census-generated demographic and economic data combined with raw files. An employment history file provided an earnings series for each state and quarter while the individual characteristics file reported

personal data over time and locational information. The employer characteristics file described establishment features and locations. Unprocessed data files arrived six months after the end of each quarter, and the QWI system reported data three months after the receipt of the basic files (Abowd et al., 2009, p. 159).

Based on the sample size and data attributes, the QWI data set will form the basis for each inferential test and statistical sample for this study. Although the QWI data series covers 95% of all private sector jobs in the United States and 98% of private sector positions in the 47 surveyed states, jobs data can be disaggregated and segmented into demographic characteristics, educational levels, industrial sectors, and geographic areas. Matches among state employment identification numbers, federal employment identification numbers, and personal social security numbers link persons and associated demographics with establishment level geographic and sector level employment statistics. Assurance of individual privacy preservation resulted from an encoding process that assigned a protected identification key (PIK) to mask the identity of the employee (Abowd et al., 2009). Within Figure 3, the following schematic presents this dynamic:

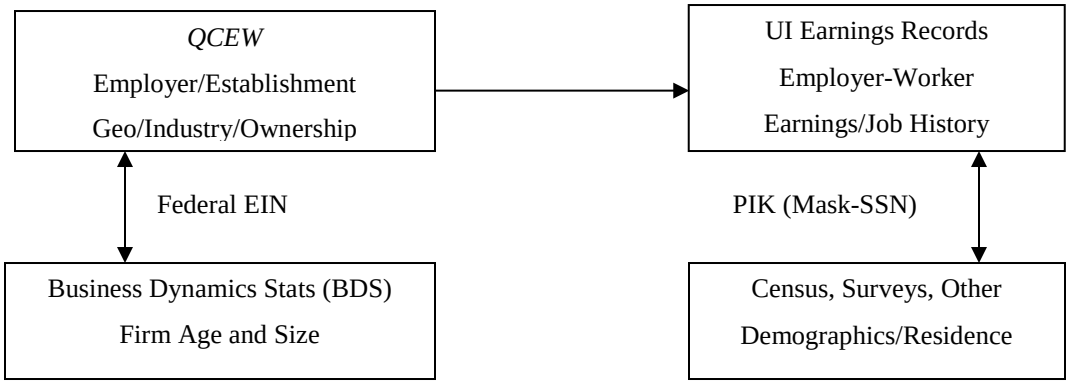

Figure 3. QWI Sources

The longitudinal series offered information regarding the workforce within the fabricated metals manufacturing sector and a longitudinal view of trends in its demographic makeup (U.S. Census Bureau; Abowd et al., 2006). Value imputations using probabilistic methods and logic supplied data in instances where unmatched records appeared (Abowd et al., 2009, p. 151). LEHD files contained the universe of employee-employer matches reported in statutory state unemployment insurance (UI) filing.

Within the LEHD, a Protected Identification Key (PIK) replaced individual social security numbers reported within state UI to mask the identity of persons. Reported individuals included those for whom a state unemployment insurance record existed (Abowd et al., 2009, p. 155). The usage of State Employer Identification Number (SEIN) identifiers for establishments precluded accounting for the work of one person for the same firm within several states. In this instance, work performed in several states counts as separate jobs within the QWI (Abowd et al., 2009, p. 156). The LEHD allowed for identifying multistate employment with one firm for one person as one job based on matches between SEIN and Federal Employer Identification Numbers (FEIN). Firm identity errors corrections proceeded from tracking successors to discontinued SEINs. A database of successor-predecessor relationships tracked links between successive identifiers and could be referenced for employment statistics and entity descriptors (Abowd et al., 2009, p. 158).

QCEW origins. The QCEW supplemented the LEHD infrastructure and consisted of a quarterly report to the BLS from individual establishments. Multi-

establishment firms filed separate reports for each establishment. The BLS and the Employment Security Agencies managed the Covered Employment and Wages (CEW) reporting system or ES-202 as a federal-state partnership. The QCEW name identified the collected data as reported to the BLS.

For each unique establishment reporting unit, the database collected the following: (a) employment, (b) payroll, (c) economic activity, (d) physical location, (e) employer identity (SEIN), (f) reporting unit's identity (SEINUNIT), (g) ownership information, (h) employment on the 12th of the month, (i) wages paid during the quarter, (j) NAICS code, (k) federal employer identification number (FEIN), and (l) MSA and geographical address (Abowd et al., 2009, p. 154). Significant fields for this study were employment, MSA, NAICS code, and the establishment attributes. The accessibility of this data set assisted in understanding the number of establishments reporting employment within the NAICS code 332, fabricated metals manufacturing, for the selected MSAs.

Reliability and Validity

QWI imputation. Imputation methods estimated missing or invalid values for LEHD data. Within the UI system, comparisons of reported employment data from the first month of a quarter to the contents of the CEW (ES-202) system resolved discrepancies. Database managers applied corrective statistical models to the raw data in instances of unsuccessful reconciliations (Abowd et al., 2009, p. 160) or reported incomplete QWI data.

If UI PIKs did not match the PCF, a state-specific logit model predicted the probability of an individual being male based upon ten employment and earnings-related data indicators within available data for that state. A multinomial logit entered the date of birth and used 10 implicates. If gender information could not be located in the PCF, then data from the CPS assigned the correct gender to the selected PIK (Abowd et al., 2009, p. 161).

BLS county statistics and UI wage records provided quarterly employment data in order to construct the QWI. Establishment geographic coordinates generated MSA information while the BLS database and LEHD provided the relevant NAICS codes. Disclosure-avoidance methodologies protected establishment level statistics within the QWI. Corrective entries for invalid codes or data within the ECF took place after applying cross-referencing methods incorporating data from diverse sources (Abowd et al., 2009, p. 167-168). Invalid code corrections also emerged from a multinomial predictive model where ratios found in the total population supported the imputation. Due to their significance, statewide distributions of NAICS codes sourced imputations of missing NAICS data (Abowd et al., 2009, p. 169). If imputation required access to longitudinal cross-references, the earlier SIC codes matched a paired counterpart within the NAICS code system.

The PIK-SEIN-SEINUNIT or a unique job made up the basic building block of the QWI. Indicators within this database included (a) employment, (b) earnings, (c) job creation, (d) turnover, (e) geography, (f) detailed industry, (g) worker gender, and (h) worker age (Abowd et al., 2009, p. 179-180). Weighting of QWI data achieved an

aggregation that harmonized with statewide quarterly private employment and agreed with the QCEW published by the BLS. Matching occurred so that the QWI and the QCEW only differed by .5% in reporting employment (Abowd et al., 2009, p. 182). Thus, the census- and UI-based QWI reported employment levels agreed with the BLS-based QCEW levels.

Where multiunit employers within one state reported data under a single SEIN, an imputation process provided matches of geographic and industry information for the respective employees and their workplaces. The distance between an individual'' residence and workplace, as well as the distribution of establishment locations and sizes for multiunit SEINs, served as input data to posterior probability predictive models for place of work imputations (Abowd et al., 2009, p. 176).

Analytical Validity of QWI and Disclosure Protection Methods

The application of a "noise-infusion" process to QWI data preserved the privacy of individuals and establishments (Abowd et al., 2009, p. 183). After introducing distortions into the establishment level indicators, aggregated statistics formed into geographic regions and/or industry groups. For this reason, distortions resided at the lowest level of measurement into aggregations. Published tables suppressed aggregations that contained less than three establishments or employees. Flags within the published QWI tables provided evidence of an estimate or a level of distortion (Abowd et al., 2009, p. 183-184). Distortion methods potentially applied to each indicator, and the direction and magnitude of the noise remained constant for a given workplace (SEIN or

SEINUNIT) for each successive period. Placement of distortions in the aggregated data maintained "cross-sectional and time-series validity" (Abowd et al., 2009, p. 184).

A determination of the effect of disclosure protection procedures upon the analytical validity of the QWI included an evaluation of bias in a county-SIC-age-sex unit of analysis distribution (Abowd et al., 2009, p. 197). With respect to the time series of distorted data and the distribution of errors for a first order serial correlation, the maximum bias (median of the distribution) of less than .001 for all variables included beginning-of-the quarter employment and full-quarter employment. Given the finding of tight error distributions, Abowd et al. (2009) agreed with Abowd et al. (2006) that no statistical bias existed in the QWI data after allowing for disclosure avoidance procedures (p. 200).

The full QWI dataset can be located online at http://lehd.did.census.gov/ and diverged from internally used tabulations due to the disclosure avoidance measures employed (Abowd et al., 2009, p. 200). An approved research proposal opened access to undistorted QWI files. The QWI relied upon existing data repositories from diverse sources and statistical models to improve the utility of this information. The accessibility of geographically specific economic and demographic data enhanced the potential for studies of a variety of areas of interest (Abowd et al., 2009, p. 204).

Data collection for this paper originated from QWI data elements that resided on the website http://ledextract.ces.census.gov/. The LEHD extraction tool allows for the creation of a CSV format file for download and subsequent conversion into a Microsoft Excel format and consists of QWI data for all MSAs in all states excluding

Massachusetts. The aggregated database elements by MSA for fabricated metals manufacturing establishments for each quarter included (a) total jobs at the beginning of the quarter (QWI), (b) number of female employees (QWI), (c) number of male employees (QWI), and (d) number of establishments (QCEW) per NAICS 332 – MSA.

Comparative studies of industrial regional adaptive behavior after the 2008 recession specifically addressed to employment within the fabricated metals manufacturing sector of the United States did not appear in the literature. Comparative inferential analyses of pre and post-recession regional economies, wage inequality, and worker retention uutilized publicly accessible QWI and QCEW data to measure labor flows and recessionary effects (Abowd et al., 2009; Abowd & Vilhuber, 2012; Andersson et al., 2012; Bjelland et al. 2011; Blau & Shvydko (2011; Hyatt & McEntarfer, 2012). The reviewed literature did not contain research specifically directed toward contrasting regional adaptive activity measured as employment gains or losses after the 2008 recession within the fabricated metals manufacturing sector in the United States.

Researchers compared the reactions of populations after an event and applied transformational formulas to quantify some of the dependent variables. In some instances, reported results appeared in descriptive statistical tables or as distribution percentages for the measured attributes (Arboretti et al., 2009; Bamezai et al., 2011; Chennappa, 2009; Fielding & Fielding, 2008). Scholars cited inferential methods such as analysis of variance, multiple regression, and nonparametric tests to compare the behaviors of sample populations (Allan & Kemp, 2011; Brady & Lee, 2014; Grycova,

2013; Kochetkov, 2012; Nara, 2010; Niebuhr, Granato, Haas & Hamann, 2012; Oliva-Moreno et al., 2010).

Reliability

Error corrections due to miscoded social security numbers (SSNs) resulted in revisions that affected 0.9% of all jobs reported, based upon a method developed in 2005 for California jobs data. The corrected SSNs influenced job flow statistics errors, job interruption reporting errors, and reported payroll errors, but did not modify total reported jobs data (Abowd et al., 2009, p. 157).

Imputations estimated missing or invalid values, and the process of imputation differed for individual files and records. Comparisons of reported employment for the first month of a quarter within the UI system to employment reported within the CEW system led to reconciliations of discrepancies. Unsuccessful reconciliations required corrective statistical model applications to the raw data ((Abowd et al., 2009, p. 160) or incomplete QWI reports.

In a test of errors in recording continuous job histories where personal identifiers did not appear, an edit of 60 million continuous jobs indicated an error rate of .53% in the unedited set (Abowd et al., 2009, p. 194). Corrected job interruptions appeared as 0.9 % of jobs, and the magnitude of the corrections only influenced the measurement of hires and recalls and not absolute job totals. Successor-predecessor transitions in SEINUNIT databases could increase bias within employment estimates upward by 0.4% (Abowd et al., 2009, p. 196). Bias from matching individuals with work establishments via imputation never exceeded a median of .005 for test data. This finding signaled that the

imputation of the place of work entailed an insignificant level of bias (Abowd et al., 2009, p. 197).

The QWI series reliably predicted national job flows and supplemented existing series with its availability of NAICS, gender, and age statistics (Abowd & Vilhuber, 2011). The publicly accessible QWI arose from the LEHD and covered 98% of private employment in the 47 participating states. Abowd and Vilhuber (2012) studied the post-recession relationship between the severity of the drop in housing prices, earnings, and job movement via an empirical study of reported data in the QWI and HPI published by the FHFA. Worker coding resulted in a bias of 2% and this error primarily affected the reporting of work interruptions (Bjelland et al., 2011, p. 497).

Evaluating the effects of disclosure masking upon the reliability of published QWI data (Abowd et al., 2009; Abowd et al., 2006), researchers found insignificant biases in the disclosure-masking processes. Areas with higher levels of establishments and employees displayed a tighter distribution of bias. Insignificant variances between imputed and actual values reflected the reliability of the imputation methodology for relationships between workers and establishments (Abowd et al., 2006). Within this study, a *t*-test compared the average change in employment for two different sets of randomly selected MSAs within the East North Central and South Atlantic divisions to establish reliability. The significance of the correlation between the two sets of results indicated reliability (Frankfort-Nachmias & Nachmias, 2008). A computation of Cronbach's alpha using the SPSS program provided a reliability estimate (Field, 2009; Trochim & Donnelly, 2007).

Face Validity

The QWI series as a measurement of employment is valid (Abowd & Vilhuber, 2011; Abowd et al., 2009) since it is an aggregation of firm by firm, state-level reporting of jobs during historical reporting period. Forty-nine states and the District of Columbia participate and cooperate with federal data sources to update the series on a current basis. As of the first quarter of 2014, most states' latest updates covered the first quarter of 2013. MSA and county geographic aggregations provided the basis for random sampling for regional comparisons. The links to individual data via the PIK furnished demographic descriptors with which to construct longitudinal analyses of workforce demographic changes while maintaining confidentiality.

Census data served as the basis for analyses of changes within regions and sectors before and after the recession. The unit of analysis was an MSA level aggregation of employment within the East North Central or South Atlantic divisions of the United States. Fabricated metals manufacturing, NAICS 332, employees appeared in these divisions during the period 2008 to 2012.

The sampling method and the size of the sample as a percentage of the total population supported the presence of content validity (Frankfort-Nachmias & Nachmias, 2008). Although a G-power analysis indicated that a sample of 35 MSAs would be sufficient to attain a power of 80%, the respective population sizes of MSAs in the East North Central and South Atlantic divisions were 162 and 144. For this reason, the required sample provided coverage of a large percentage of the population.

The U.S. Census data represented by the publicly accessible QWI and its source, the LEHD, formed the core of research that focused on United States employment changes and trends within recent works (Abowd et al., 2009; Abowd & Vilhuber, 2012; Abowd & Vilhuber, 2011; Andersson et al., 2012; Bjelland et al., 2011; Blau & Shvydko, 2011; Helper, & Wial, 2010; Hyatt & McEntarfer, 2012)

Empirical Validity

Empirical validity is the assurance that the design and inferential tests are measuring the topic of the research and that the results are an indication of an actual relationship or effect (Frankfort-Nachmias & Nachmias, 2008). Aggregated employment change data correlations with external economic growth variables, such as GDP growth, for specific MSAs, can establish the empirical validity of jobs as a measurement of economic resilience (Frankfort-Nachmias & Nachmias, 2008).

Regional economic clusters represent CAS and display resilient behavior expressed as strong employment patterns (Martin, 2012b; Simmie & Martin, 2010). Although resilience definitions depended upon the nature of the external shock under review, changes in employee levels and firm levels within regions over time operationalized resilience in several papers (Martin, 2012b; Pendall et al., 2009). In general, patterns of unemployment related to cyclical recessionary and recovery cycles and to innovation or creative destruction (Boianovsky & Trautwein, 2010, p, 241).

One aspect of adaptive behavior encompassed scalability and nonlinear interactions to increase flexibility among the inherent agents within an economic system. An entire industry benefited from the introduction of one new, innovative concept such

that larger firm sizes and a power law effect provided evidence of industry growth (Carbonara et al., 2010).

Construct Validity

The construct validity demonstration compared the conclusions of post-recession studies of regional resiliency using linear models to establish the relationship between employment and regional health with the research design that I used in this paper. Abowd and Vilhuber (2012) applied a mixed effect linear regression model to examine the relationship between employment effects and housing price changes within selected MSAs. Other papers compared population attributes before and after external economic events and in some instances, reported results using descriptive statistical tables in addition to distribution percentages for the measured attributes (Arboretti et al., 2009; Bamezai et al., 2011; Chennappa, 2009; Fielding & Fielding, 2008). Nonparametric designs, analysis of variance, and multiple regression designs modelled comparative behaviors of sample populations and identified relationships between economic status and external indicators (Allan & Kemp, 2011; Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Nara, 2010; Niebuhr, Granato, Haas & Hamann, 2012; Oliva-Moreno et al., 2010).

Recognizing that employment concentrations exist for given industry sectors within geographic regions, I considered an MSA-specific concentration of employees within the targeted industry of fabricated metal manufacturing as a CAS. The model assessed post-recession adaptive behavior. Sustained or increased employment levels operationalized resiliency. Demonstrations of adaptive ability included the changing

composition of the MSA's workforce demographic profile and firm makeup. Empirical test results confirmed that CAS theory is applicable to regional economies within the United States.

Operationalization and Data Analysis Plan

Four online data sources provided the primary data series needed to complete the independent samples *t* test and the multiple regression analyses. All of the series resided in an Excel worksheet format after completing the download. After a review and cleaning of the data, manipulation of the data created the requisite variable formats necessary to measure changes in MSA employment statistics after the recession. The SPSS software package routines performed the tests for Research Question 1 and Research Question 2. Table 6 presents the data sources.

Table 6

Data Sources

Attributes	**QCEW**	**QWI**
Sources	US Bureau of Labor Statistics	US Census Bureau
Frequency	Monthly and Quarterly	Quarterly
Sample Size/Source	99.7% of U.S. jobs	95% of U.S. private sector jobs
Attributes	Employment, Establishments, Wages MSA, NAICS	Employment, MSA, Gender, Education, Age, Firm Age, Size, Flow of Employment\NAICS
Geography	MSAs	MSAs

The BLS generated the QCEW and tabulated economic census employment, establishment, and wage data representing 99.7% of all governmental and private jobs in the United States. Access to UI program records drove the extensive coverage of jobs data within this series. Suppression protected disclosures where the publication of statistics for a given sector and region might compromise the privacy of the related firms. Data composition responded to changes in establishment business sectors, closures or reporting errors. Conversions from centralized reporting to location-based dispersed reporting on the part of large, multi-establishment organizations can also cause distortions.

The QCEW counted filled jobs at the time of UI reporting so that an individual holding multiple jobs appeared multiple times. A location quotient measured the relative concentration of designated industries within the QCEW. Although establishment level data formed the base unit of analysis, some firms displayed a preference for multi-establishment reporting and thus affected regional comparability for some sectors.

The QWI accessed the QCEW as one source during its compilation. Connecting job-level data to the employing firms allowed for a delineation of work force attributes within given sectors. Workforce age, ethnicity, gender, and educational attainment appeared for each region and sector on a quarterly basis, along with employment and wage data. The linked employer-employee database, LEHD, reported 95% of private sector jobs within the United States. The LED represented the product of Federal and state data sharing so that the LEHD and LED together produced the employment and demographic statistics (Abowd et al., 2009).

Combinations of publicly generated data, census data, and surveys combined to produce a usable, frequently updated database. Personal worker data collections came from state employment records, social security records, and federal tax records. Primary data sources encompassed: (a) UI earnings, (b) the QCEW, (c) business dynamics statistics, (d) the United States census, (e) SSA, and (f) tax return data linked to UI earnings using a PIK. Data that links employees with firms forms the basis of employment flow studies within regions and industries (Abowd et al., 2009).

Variables

Table 7 presents the variables in this research paper matched with the records contained in the QWI/QCEW database:

Table 7

Fundamental LEHD Concepts Underlying the QWI

Concept	Description	Variable
Dates	Quarterly data within calendar years designated as yyyy:q for the year and quarter	Time
Establishment	For each employer/location entity, an SEINUNIT serves as a unique identifier. A location and NAICS code is associated with each SEINUNIT.	Aggregated Private Sector Employment aggregated into MSA and/or NAICS code groupings
Employee	Social Security Number on the UI wage data; Identity is masked by assignment of a Protected Identification Key (PIK)	Gender
Employment at a Point in Time	Individual employment on the first day of a quarter when a valid UI wage record existed for a PIK/SEIN combination	Change in aggregated jobs for an NAICS sector, region from t_1 to t_2
Job	An association of a person (PIK) with an SEINUNIT in a yyyy:q based on year and quarter	Total change in Employment (Jobs) for a given MSA and/or NAICS code from t_1 to t_2

Note. Adapted from "The LEHD infrastructure files and the creation of the Quarterly Workforce Indicators " by J. M. Abowd, B. E. Stephens, L. Vilhuber, L., F Andersson, K. L. McKinney, M. Roemer, and S. Woodcock, 2009, *Producer dynamics: New evidence from micro data*, pp. 149-230.

Periodicity

The periods for which employment change observations applied encompassed the dates designated as the beginning of the recession in January 2008 (NBER, 2010), the start of the manufacturing recovery (U.S. Department of Labor – BLS, 2014), and the fourth quarter of 2012 as the cutoff for this research. The onset of the recession occurred in January 2008 as the Business Cycle Dating Committee marked peak economic activity in December 2007. The recession ended at the beginning of the third quarter of 2009 based on a sustained recovery as reflected in national economic indicator measurements (NBER, 2010). Published QWI and QCEW reports appear on a quarterly basis.

QWI Establishment Data

A federal-state governmental partnership managed the CEW or ES-202 reporting system under the auspices of the BLS and the Employment Security Agency. Unique establishment reporting of individual records included employment, NAICS code, and location for the QCEW database. The database is accessible for download to the public for the purposes of research (Abowd et al., 2009, p. 154). This study utilized the fields designated as employment, MSA, and NAICS codes for establishments. UI wage records provided quarterly employment data and extracted supplemental BLS county statistics to construct the QWI. MSA information originated from geographic coordinates while the BLS database and LEHD provided the relevant NAICS codes.

Employee Characteristics

The PCF captured the demographic attributes (Abowd et al., 2009, p. 154) of individuals with state unemployment insurance records (Abowd et al., 2009, p. 155). The

usage of SEIN identifiers for establishments precluded a need for a separate accounting for the work of one person for the same firm within several states. Work performed by one individual within several states counted as separate jobs within the QWI (Abowd et al., 2009, p. 156) based on matches between the SEIN and the FEIN to create a unique firm entity for a particular state.

Employment/Job Definition

The PIK-SEIN-SEINUNIT designated the essential components of a unique job identity within the QWI. This database incorporated the following: (a) employment, (b) earnings, (c) job creation, (d) turnover, (e) geography, (f) detailed industry, (g) worker gender, and (h) worker age (Abowd et al., 2009, p. 179-180). Weighting QWI data assured that the aggregation reconciled to quarterly state level private employment data and agreed with the QCEW published by the BLS. The two data sources only differed by .5% (Abowd et al., 2009, p. 182). Thus, the census- and UI-based QWI jobs data balanced to the BLS-based QCEW jobs data.

Research Questions and Hypotheses

An examination of economic system sustainability involved a comparison of the depth of employment losses among diverse regions within the fabricated metals manufacturing sector after the 2008 economic recession in the United States. Accepting regional industrial macroeconomic systems as entities conforming to the CAS theoretical framework, (Beinhocker, 2007; Buckley et al., 2008; Espinosa, & Porter, 2011; Foster, 2011; Kirman, 2010), this study evaulated internal reactions to external shocks by the fabricated metals manufacturing industry within diverse localized regional economies

within the United States. CAS theory maintained that, while reacting to external threats, open complex systems underwent evolutionary changes within a dynamic network of internal factors and inputs. Resiliency resulted from constituent linkages, optimization of technology, workforce evolution, and diversification of regional manufacturing sectors in the immediate aftermath of the recession. Employment levels reflected the presence of these factors (Beinhocker, 2007; Buckley et al., 2008; Foster, 2011; Kirman, 2010). An evaluation of the relative strengths of diverse subsystems revealed how regional industry clusters demonstrated uneven levels of resiliency.

The research questions compared regional subeconomies represented by the fabricated metals manufacturing sector firms for metropolitan statistical areas (MSA) within the East North Central and South Atlantic geographical divisions of the United States. The collection of employment, establishment, and demographic data transpires quarterly for each metropolitan and micropolitan statistical area for each division. The number of MSAs within the East North Central division that reported fabricated metals manufacturing employment in 1Q2008 was 162, and within the South Atlantic division, the number was 144.

Research Question 1

1. Were there regional differences in post-recession manufacturing sector unemployment rates within the United States?

$\mu 1 =$ Average rate of change in the fabricated metals manufacturing jobs held in the 50 randomly selected MSAs contained in the East North Central division of the

Midwest Region of the United States in the first quarter of 2010 versus the first quarter of 2008.

$\mu 2$ = Average rate of change in the fabricated metals manufacturing jobs held in the 50 randomly selected MSAs contained in the South Atlantic division of the Southern Region of the United States in the first quarter of 2010 versus the first quarter of 2008.

$H_0 1$: There is not a statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.

$H_0 1$: Null Hypothesis: $\mu 1 = \mu 2$

$H_1 1$: There is a statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.

$H_1 1$: Test Hypothesis: $\mu 1 \neq \mu 2$

Research Question 2

2. How did workforce gender and firm makeup affect post-recession regional manufacturing employment levels in the United States?

Dependent Variable: y_i = Percentage change in total employees in the fabricated metals manufacturing sector within the East North Central division of the Midwest region of the United States or the South Atlantic division of the Southern Region of the United States from the first quarter of 2008 to the fourth quarter of 2012 for MSA i.

Independent Variables: For the respective division:

x_{i1} = Percentage change in the male fabricated metals manufacturing workforce from the first quarter of 2008 to the fourth quarter of 2012 in MSA *i.*

x_{i2} = Percentage change in the female fabricated metals manufacturing workforce from the first quarter of 2008 to the fourth quarter of 2012 in MSA *i*.

x_{i3} = Percentage change in the number of fabricated metals manufacturing establishments from the first quarter of 2008 to the fourth quarter of 2012 in MSA *i.*

where:

$y_i = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2+} \beta_3 x_{i3}$

And $\beta_{j\ is}$ *the main effect of independent variable* $x_{ij.}$

$H_0$2: There is no statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels.

β_1 and/or β_2 and/or β_3 are not statistically significant predictors of changes in fabricated metals manufacturing employment within a region.

$H_1$2: There is a statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels.

β_1 and/or $\beta_{2,}$ and/or $\beta_{3,}$ are statistically significant predictors of changes in fabricated metals manufacturing employment within a region.

Threats to Validity

The design threat to validity (Trochim & Donnelly, 2007) was obviated by referencing the usage of regional comparisons to operationalize the concept of industrial clusters as representations of CAS (Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010). A threat to validity based on implementing a single method to measure

the concept of regional adaptability was overcome by measuring regional adaptive behavior by using firm proliferation, in parallel with the test of mean job growth. (Trochim & Donnelly, 2007).

Ethical Procedures: Data Protection and Storage

Disclosure-avoidance methods protected establishment level privacy within the QWI. Cross-referencing techniques that incorporated data from diverse sources corrected invalid codes or data within the ECF (Abowd et al., 2009, p. 167-168). Alternatively, data corrections arose from a multinomial predictive model where ratios found within the total population supported the imputation.

Social security numbers (SSN) drawn from state unemployment insurance databases based upon establishment reporting initially identified individuals. The LEHD process then replaced SSNs with a personal identifier to mask individuals' identities (PIK) (Abowd et al., 2009, p. 155). A random number assignment on a one-to-one basis to the SSN preserved the privacy of individual workers. The SSN/PIK database is physically located such that the commingling of the individuals records is prevented (Abowd et al., 2009, p. 157).

Summary

Employment rates in the fabricated metals manufacturing sector NAICS 332 did not fully recover from the effects of the economic recession that began in January 2008 (NBER, 2010). The adverse impact of the recession upon jobs employment appeared unevenly among demographic groups (Sum et al., 2010) and significantly affected the lucrative manufacturing sector. The recession influenced regional economies within the

United States in diverse ways. The ability to withstand adverse economic shocks and maintain economic viability are indicators of highly resilient sectors and regions and indicates the presence of CAS attributes. Intrinsic or extrinsic adaptability features could appear within the identified regional economic systems containing the fabricated metals manufacturing industry.

The research design for this study involved accessing secondary databases found on the websites of the United States Census Bureau and Bureau of Labor Statistics. For a selected sample of MSAs within the East North Central and South Atlantic divisions of the United States, the internet databases provided input for the variables for the independent means *t*-test in response to Research Question 1 and the dependent and independent variables appearing in multiple regression analyses for Research Question 2. This study measured differences in adaptive resiliency for the NAICS 332 fabricated metals manufacturing industrial code after the onset of the 2008 recession, for the two divisions. The independent variables operationalized adaptive behaviors while resiliency measurement as the dependent variable took the form of a percentage change in overall employment.

Chapter 4 will begin with a review of the purpose of this study and the method of data collection, followed by a description of the sampling procedure. Results will be reported in the form of descriptive statistics and the assumptions underlying all statistical tests will be summarized. The numeric, statistical results of all hypothesis testing will be conveyed with any applicable supplemental, post-hoc test results. Answers to the research questions posed in this study will appear in a summary format.

Chapter 4: Results

Introduction

This study identified a previously robust regional manufacturing sector and assessed its employment resiliency after the economic recession of 2008-2009. This study employed quantitative method in comparing changes in the workforce gender composition and firm population with indicators of resilience represented by sustained or increasing employment opportunities. Adaptive, responsive industries operating in a post-recession environment can contribute to the long-term viability of regional economies within the United States. The identification of effective input to optimal business formation models can be a favorable outcome of this study.

Research Question 1

1. Were there regional differences in post-recession manufacturing sector unemployment rates within the United States?

$H_0$1: There is not a statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.

$H_1$1: There is a statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.

Research Question 2

2. How did workforce gender and firm makeup affect post-recession regional manufacturing employment levels in the United States?

$H_0$2: There is no statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels.

$H_1$2: There is a statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels.

Chapter 4 will include an explanation of the data collection process and an exposition on the sample's composition and representative characteristics. Statistical analysis findings, descriptions of assumptions, and the outcome of supplemental hypothesis testing are reported in tables, and in a narrative format, as appropriate. Chapter 4 will conclude with a summary of the answers to the research questions and a transition to the prescriptive material contained in Chapter 5.

Data Collection

Data collection began on June 7, 2015, by accessing the websites that included the United States Census Bureau Longitudinal Employment and Household Dynamics database Quarterly Workforce Indicators (QWI), and the Bureau of Labor Statistics Quarterly Census of Employment and Wages (QCEW) database. Test data originated primarily from within these two databases. The periods for which data was downloaded included the first quarter of 2008 (1Q2008), the first quarter of 2010 (1Q2010) and the fourth quarter of 2012 (1Q2012). Sources and parameters for the sample data collected appear in Table 8.

Table 8

Data Collection Parameters

Variables	**QCEW**	**QWI**
Sources	US Bureau of Labor Statistics http://www.bls.gov/cew/datatoc.htm	US Census Bureau http://ledextract.ces.census.gov/
Time Period	1Q2008, 1Q2010, 4Q2012	1Q2008, 1Q2010, 4Q2012
Population	162 East North Central and 144 South Atlantic MSAs with NAICS 332 firm statistics	162 East North Central and 144 South Atlantic MSAs with NAICS 332 employees in 1Q2008
Sample Size	50 MSAs for each region	50 MSAs for each region
Variables	Establishment count for each unmasked MSA by quarter, for target NAICS 332	Employment level for each MSA by gender, by quarter, for target NAICS code 332
Variable Type	Independent = Change in Firm Level in MSA	Dependent = Employment Change Independent = Gender Workforce Characteristics

As described in Chapter 3, after accessing the applicable sites, a secure Dell laptop computer contained Microsoft Excel-formatted CSV file downloads from each source website. QWI database extractions required state-by-state queries. Pivot Table manipulations converted QWI state file aggregations to an NAICS 332 fundamental database that contained the elements a) regional MSA code b) MSA name c) total employees, male employees, and female employees for each of the test quarters.

QCEW database downloaded CSV formatted files required conversion to a Microsoft Excel format. Although limited to the NAICS 332 related industry code, the databases contained yearly data by quarter for each MSA within the United States. Due to the incongruent formats of location codes within the QWI and QCEW, two text functions (left, right, and concatenation) allowed for the conversion and harmonization of each QWI geographic MSA code into the associated QCEW code.

Achieving comparability with firm data retrieved from the BLS-based QCEW required the addition of employment data for the portions of interstate MSAs located outside of the targeted state/region combination to reported QWI employment data. As an example, the Youngstown-Warren-Boardman OH-PA MSA included employees residing in Pennsylvania and commuting within the MSA. In this instance, the Youngstown-Warren-Boardman OH-PA MSA employee level data for all test periods incorporated total employees reported for the Pennsylvania portion of that MSA in Region 3, East North Central.

On the other hand, the St. Louis MO-IL MSA resided within United States Census division 4, or outside of the test divisions, although a portion of the MSA's

employees resided in Illinois, or inside of the test divisions. In order to achieve comparability with QCEW conventions, this study excluded Illinois residents employed in St. Louis, MO in order to test patterns within the East North Central division only.

Within the QWI database, interstate MSAs that were located entirely within the region reported employment designated for each state separately. In order to harmonize data for comparability with QCEW MSA firm data, MSA transformations included all employees for that MSA. As an example, an adjustment to the Chicago-Elgin-Naperville IL-IN-WI MSA incorporated the employee count from each state (Illinois, Indiana, and Wisconsin) into the count for the single MSA with its principal city resided in Illinois. These three adjustments together changed the overall 2008 employment level totals by - 0.2% and 1.1% for the East North Central and South Atlantic divisions, respectively.

The sample excluded aggregations of employment data for non-MSAs within the region. The conceptual framework for this study contemplated a location-based collection of like firms forming a geographic economic cluster and acting as a complex adaptive system. Dispersed employment within rural areas of the regions would not fit within this conceptual framework definition.

A “VLOOKUP" function then accomplished an accurate extraction of the requisite MSA specific firm level data from the QCEW database for the test quarters for the East North Central and South Atlantic MSAs in their entirety, and appeared within the fundamental database.

After creating the fundamental database consisting of employment data for 162 MSAs in the East North Central division and 144 MSAs in the South Atlantic region,

sorting of each region's MSA records in descending order based on the total employment level in 1Q2008 created the target population for sampling. The top 40 MSAs in this list formed the first part of the sample. A selection of the remaining ten MSAs for the sample arose from a choice of every second name within the alphabetically sorted remaining names. This sampling process necessitated one substitution for each region during the selection of the final ten MSAs to avoid the potential effects of zero values in one or more variable. The data set of 50 MSAs for each region produced from this method is Sample 1.

Two factors contributed to the decision to abandon Sample 1 and to derive an alternate for testing Research Question 1 and Research Question 2. QCEW masked the majority of MSA firm levels to protect the identity of the firms within the designated population of MSAs. This practice appeared for large and small MSAs. Consequently, the number of records from which to populate independent variable y_3 declined from earlier expectations and the list of MSAs from which to draw a sample became smaller. The group of NAICS 332 MSAs fell from 162 to 56 in the East North Central division and from 144 to 71 in the South Atlantic Region. Within the new datasets, applying the same method of selecting the sample resulted in a sample size of 50 for each region. Of the original top 40 data points, 34 remained for the East North Central division and 33 remained for the South Atlantic region in the reworking of the sample. Sample 2 then became the second selection of 50 MSAs for each division, as described.

Abandonment of Sample 1 also followed from a test of the normality of the related sample distribution. The independent means *t*-test required a normal distribution

for the two samples subject to the comparison. The parametric test required a normally distributed sample of the changes in employment between the first quarter of 2008 and the first quarter of 2010 for the East North Central and South Atlantic divisions. Neither of the datasets met the test for Shapiro-Wilk test of normality and did not qualify for the stated test in response to Research Question 1. Both series were transformed using a natural logarithmic function and still did not meet the requirement of normality based on the Shapiro-Wilk test. Sample 2 data met the tests for normality.

Table 9 presents Descriptive Statistics on the Sample 2 data set used for hypothesis testing.

Table 9

Sample 2 – NAICS 332 – Fabricated Metals Manufacturing – 1Q2008

Region	**East North Central**	**South Atlantic**
Number of MSAs (Population)[a]	162	144
Employment (000)		
Total	441	179
Male	342	138
Female	99	41
% of US Employment [b]	28.5%	11.6%
Sample Employment vs. Region		
% of Total Regional	79.2%	73.7%
% of Male Employment	79.5%	74.3%
% of Total Female Employment	78.1%	71.6%
MSAs	30.9%	34.7%

a – After adjusting for interstate definitions
b – National data derived from QCEW database; QWI is available only on a state-by-state basis

Results

Synopsis

The purpose of this study entailed determining if geographic areas of the United States exhibited different responses to the Great Recession by examining the recession's effects on employment. In response to Research Question 1, test results indicated a rejection of the null hypothesis, as a statistically significant difference existed between employment changes in the NAICS 332 manufacturing sector for the East North Central division and the South Atlantic division of the United States during the period 1Q2008 and 1Q2010. To gain additional insight on divisional patterns, supplemental tests followed for the periods 1Q2010 to 4Q2012 and 1Q2008 to 4Q2012.

Research Question 2 addressed the adaptability of United States regions in the aftermath of the recession by employing a multiple regression analysis to examine the relationship between employment changes as the dependent variable, and workforce gender makeup and firm numbers as the independent variables. Focusing on the designated East North Central and South Atlantic divisional activity in the major manufacturing grouping of NAICS 332 fabricated metals manufacturing, male employment changes significantly affected employment changes, while changes in the female employee levels had a significant, but lesser effect. Supplemental tests cast additional insight on the interaction between male employment gains and the falling proportion of female employees during the recovery. The following table summarizes

the research results of the planned tests and the supplemental tests. Detailed descriptions of the test results will then follow.

Table 10

Synopsis of Results

Research Question	Null Hypothesis	Period	Result
1. Were there regional differences in post-recession manufacturing sector unemployment rates within the United States?	$H_0$1: There is not a statistically significant difference in employment effects of the Great Recession upon MSAs within the East North Central division and MSAs within the South Atlantic division.	1Q2008-1Q2010	Reject
		1Q2010-4Q2012	Reject
		1Q2008-4Q2012	Accept
2. How did workforce gender and firm makeup affect post-recession regional manufacturing employment levels in the United States?	$H_0$2: There is no statistically significant relationship between the change in employment levels and the gender makeup of the workforce and firm levels. β_1 and/or β_2 and/or β_3 are not statistically significant predictors of changes in fabricated metals manufacturing employment within a region.	1Q2008-4Q2012	Reject – Gender Makeup ($\beta_{1,}\beta_2$) Accept-Firm Level (β_3)

Research Question 1

Results of the independent means *t*-test application to employment data for the NAICS 332 fabricated metals manufacturing sector employment after the recession pointed to a rejection of the null hypothesis. There was a statistically significant difference between employment losses in the East North Central and South Atlantic divisions after the 2008 recession. The answer to the Research Question 1: "Were there

regional differences in post-recession manufacturing sector unemployment rates within the United States?" is affirmative.

After developing Sample 2, the test of the first hypothesis involved applying an independent means *t*-test to the sample. The sample consisted of changes in NAICS 332 employment after the Great Recession within 50 MSAs in the two test regions. A determination of normality with the sample statistics required the "*Analyze-Descriptive Statistics-Explore*" sequence of commands within the Statistical Package for the Social Sciences (SPSS) software application. In addition to the test statistics, the output included graphic representations in the form of Q-Q Plots, Histograms, and Box Plots.

A determination that the normality assumption applied to the distribution of percentage change in the sample of NAICS 332 employment levels for MSAs in the East North Central division from the first quarter of 2008 (1Q2008) to the first quarter of 2010 (1Q2010) affirmed that the assumption was met. Skewness (.645, *SE* =.337), kurtosis (1.385, *SE* =.662) and the Shapiro-Wilk test of Normality (W =.991, df = 50, p = .093) suggested that the normality assumption was met. A review of the Q-Q Plot, Histogram and Box Plot of this data yielded the same conclusion. An examination of the natural logarithmic transformation of this sample indicated normality also with indicators of skewness (.239, *SE* = .337), kurtosis (.996, *SE* = .662) and the Shapiro-Wilk test of normality statistics (W = .976, df = 50, p = .389).

Tests of the sample of the percentage change in NAICS employment levels for the selected MSAs within the South Atlantic region between 1Q2008 and 1Q2010 indicated evidence of normality. Skewness (.628, *SE* =.337), kurtosis (.572, *SE* =.662) and the

Shapiro-Wilk test of Normality (W =.969, df = 50, p = .210) strongly indicated that the normality assumption was met. Confirmation of this finding appeared in a review of the Q-Q Plot, Histogram and Box Plot of this data. Findings for the natural logarithmic transformation of this sample yielded similar results on the finding of normality as indicators were skewness (.291, SE = .337), kurtosis (.194, SE = .662) and the Shapiro-Wilk test of normality statistics (W = .985, df = 50, p = .778).

Given the confirmation of normality, the two independent samples were subjected the independent means *t*-test within SPSS by using the commands "*Analyze-Compare Mean- Independent –Samples T Test*". The sample data from the two regions met the tests of normality, were measured on a continuous scale (meets interval minimum), and were independent as data originated from independent MSAs (Field, 2009, p. 326). Groups were defined as 0 = East North Central and 1 = South Atlantic. Results of Levene's test of homogeneity of variance appeared within the report of the test results.

On average, the percentage loss in employment levels for all NAICS 332 employees in the East North Central division were worse (M = -.22, SE = .011) than those in the South Atlantic region (M = -.18, SE = .013) for the period 1Q2008 to 1Q2010. The difference was significant $t(98) = -2.347$, $p < .05$ and represented an effect of r = .23. Levene's test was not significant (F = 1.654, $p > .05$) so that the homogeneity of variances assumption was not violated. Subjecting the logarithmically transformed data to the independent means t-test yielded the same results as the East North Central division employment level loss for NAICS 332 was worse (M = -.26, SE = .014) than the average loss in the South Atlantic (M = -.21, SE = .016). The difference was significant

$t(98) = -.2.331$, $p < .05$ and the effect was .23. Levene's Test for the Equality of Variances ($F = 1.035$, $p > .05$) indicated that the assumption of homogeneity of variances was met.

Research Question 2

A multiple regression model wherein the dependent variable was the percentage change in employment for a given division and the independent variables were gender participation and number firms engaged in the NAICS 332 sector sought to answer the second research question. The question was: "How did workforce gender and firm makeup affect post-recession regional manufacturing employment levels in the United States?" The null hypothesis stated that the independent variables did not have a statistically significant relationship to the employment levels experienced in the post-recession environment of each of the test divisions. The independent variables operationalized adaptive measures taken by regional economies operating as complex adaptive systems in response to external shocks. The 2008 recession represented an external shock to the economies of the MSAs selected as the sample for this study.

Test results indicated that the null hypothesis could not be rejected for the variable number of establishments, as there was not a statistically significant relationship between percentage employment changes within the sample MSAs and percentage changes in the number of NAICS 332 establishments for the test period of 1Q2008 to 4Q2012 for both divisions. The null hypothesis could be rejected when considering the effect of changes in the gender makeup of the workforce. Males as a percentage of the workforce were statistically significant as a predictor of percentage changes in the

workforce. The percentage change in the female proportion of the workforce also demonstrated a significant relationship to the dependent variable, but the coefficient was smaller than the male component.

Discussions of entrenched long-term unemployment patterns appeared for low-income, less-educatedworkers (Sum, Khatiwada, McLaughlin, & Palma, 2010) in earlier studies while due to the recession, blue-collar occupations suffered disproportionately (Fraser & Freeman, 2011). At the same time, regional manufacturing clusters could demonstrate CAS attributes wherein member agents displayed evolutionary responses to external shocks to maintain the system's viability (Beinhocker, 2007; Carbonara, Giannoccaro, & McKelvey, 2010; Felton, Gibson, Flew, Graham, & Daniel, 2010; Foster, 2011; Kirman, 2010; Navarro-Espigares, Martin-Segura, & Hernandez-Torres, 2011).

Manufacturing jobs rebounded during the period January 2010 to April 2012 (Langdon and Lehrman, 2012) and the upturn represented a potential indicator of a positive outlook for that sector. Manufacturing led in innovation, compensation, and workers' educational levels. The importance of this sector stemmed from the link between an increasingly well-educated manufacturing workforce and an intrinsic wage and employee benefits premium (Langdon & Lehrman, 2012).

In light of the theoretical foundation and conceptual framework of this study, a hierarchal multiple regression model entailed three blocks of data in order to understand the relationship between employment changes and potential CAS agent adaptations such as workforce diversification and firm consolidation. Hierarchal multiple regression

models measured the applicability of certain external and internal variables to the changes in employment from the period marking the Great Recession's beginning (1Q2008) and a period that occurred considerably after the recession officially ended and employment rebounded (1Q2012). In addition, in light of the impact of manufacturing contractions upon lucrative, bluc-collar employment, independent variables included changes in the number of males and females employed, as well as changes in the relative share of the workforce occupied by each gender. The model measured these relationships for each of the two regions. Appendix B lists the definitions of the variables in this study.

The selected variables embodied measurable data for MSAs as economic systems, or clusters for the target industry, NAICS 332, fabricated metals manufacturing. Given the impact of the recession on male employment, based on the literature, three independent variables in the model measured changes in the employment level for each gender. The percentage change in male employment demonstrated collinearity with its female-based counterpart but low collinearity with other variables. Multicollinearity indicators related to the absolute and percentage changes in the fractions of employment by gender for both regions forced the inclusion of only one gender specific variable for each gender. The primary hierarchal model included the environmental variable in the first block, and the workforce profile variables in the next two blocks. The tests were conducted for each region using the "*analyze-regression-linear*" command in the SPSS software application.

An additional independent variable included the annual percentage change in the number of firms engaged in the NAICS 332 industry within a given MSA for the test period. Table 11 presents the multiple regression results for the East North Central division and Table 12 presents the results for the South Atlantic model.

Table 11

Predictors of Employment Level Changes – East North Central

			Change in Employment Patterns		
			Model 3		
Variable	Model 1 *B*	Model 2 *B*	*B*		95% CI
Constant	-.02	-.02	0.0		[-0.00, 0.00]
ChgFirms	0.42	0.05	0.02		[-0.02, 0.05]
EmpChgMale		0.99**	0.99**		[0.97, 1.00]
PCtChgFemFrac			0.25**		[0.22, 0.27]
R^2	.04	.98		1.00	
F	1.01	713.27		5001.27**	
ΔR^2		.94		.02	
ΔF		2015.08**		397.86**	

Note. N= 50. CI = confidence interval.
*p<.05. **p<.01

Table 12

Predictors of Employment Level Changes – South Atlantic Region

			Change in Employment Patterns		
			Model 3		
Variable	Model 1 *B*	Model 2 *B*	*B*		95% CI
Constant	-0.09**	-0.02**	-0.01*		[-0.01, 0.00]
ChgFirms	0.35	0.03	0.02		[-0.01, 0.04]
EmpChgMale		0.95**	.98**		[0.97, 1.00]
PctChgFemFrac			0.26**		[0.24, 0.28]
R^2	0.06	0.97		1.00	
F	3.31	743.28**		5575.17**	
ΔR^2		.91		.03	
ΔF		1387.74		468.01	

Note. N= 50. CI = confidence interval.
*p<.05. **p<.01

The percentage change in the number of firms operating within the NAICS 332 code for each MSA was not significant for either region. Given the majority percentage of NAICS male employees before and after the recession for each region, this variable reported the highest β for each sector. The model predicting the percentage change in the employment level in the East North Central division from 1Q2008 to 4Q2012 was significant ($F(3,46) = 5001.27$, $p < .001$), with an R^2 of 1.00. The predicted rate of total employment change is .99 (Percentage change in male employment) + .25 (Percentage change in fractional female employment). The percentage change in employment was .99% for each 1% increase in male employment and .25% for each 1% increase in the fractional percentage increase of female employees.

The model predicting the percentage change in the employment level in the South Atlantic Region from 1Q2008 to 4Q2012 was significant ($F(3,46) = 5575.17$, $p < .001$), with an R^2 of 1.00. The predicted rate of total employment change is .98 (Percentage change in male employment) + .26 (Percentage change in fractional female employment). The percentage change in employment was .98% for each 1% increase in male employment and .26% for each 1% increase in the fractional percentage increase of female employees.

The only other significant independent variable was the percentage change in the fraction of females or males in the workforce. An examination of the workforce makeup before and after the recession indicated that as total employment fell, employment of females fell disproportionately. Although male and female employment percentage changes in absolute terms demonstrated direct correlations, the percentage of men

occupying jobs in the target sector increased while the proportion of jobs held by women decreased and an inverse relationship appears. Table 13 presents descriptive statistics outlining the change in the relative fractions of males and females in the NAICS 332 workforce before and after the recession.

Table 13

Pre- and Post- Recession Change in Workforce Composition %

	East North Central	**South Atlantic**
Male – 1Q2010 v 1Q2008		
Population	+0.39%	+0.49%
Sample	+0.35%	+0.47%
Male – 4Q2012 v 1Q2010		
Population	+0.95%	+1.28%
Sample	+0.88%	+1.13%

Supplemental Tests

Research Question 1: Considering the broader period of 1Q2008 to 4Q2012, the null hypothesis could not be rejected, and differences in the average percentage change in employment for the two divisional MSA samples were not statistically significant. The supplemental tests indicated divergent employment loss patterns in the first two years of the recession while the divisional employment patterns converged as the economic recovery emerged during the period 1Q2010 to 4Q2012. Differences in the mean employment loss percentages were statistically significant for the period 1Q2008 to

1Q2010 and 1Q2010 to 4Q2012. The following table summarizes the differences in the job recovery trajectory for the test divisions and sector, compared to national statistics and the overall manufacturing sector.

Table 14

Comparison of Job Recovery Trajectory – Change in Employment

	National		**NAICS 332 – Divisions[a]**	
Period	All Mfg	NAICS332	ENC	SA
1Q2010-1Q2008	-16.1%	-19.1%	-22.2%	-18.2%
1Q2010-4Q2012	4.4%	12.6%	21.0%	10.3%
1Q2008-4Q2012	-12.9%	-9.0%	-4.5%	-10.1%

Source: United States Department of Commerce – Bureau of Labor Statistics; United States Census Bureau;
[a]Supplemental Tests of sample MSAs

The percentage change in employment was normally distributed for the period 1Q2008 to 4Q2012 for the East North Central division with indicators of skewness (.132, *SE* = .337), kurtosis (-.303, *SE* = .662) and the Shapiro-Wilk test of normality statistics (*W* = .991, *df* = 50, *p* = .970). The variable was also normally distributed for the South Atlantic division during this period, with indicators of skewness (.705, *SE* = .337), kurtosis .615, *SE* = .662) and the Shapiro-Wilk test of normality statistics (*W* = .964, *df* = 50, *p* = .132).

For the period of 1Q2008 to 4Q2012, the average percentage change in employment within NAICS 332 MSAs did not differ significantly between the two divisions for the continuous data of comparative statistics on employment change but did differ based on the logarithmically transformed data set. On average, the percentage loss

in employment levels for all NAICS 332 employees in the East North Central division during this period was less (M = -.04, SE = .019) than the degree of loss in the South Atlantic region (M = -.10, SE = .022). The difference was not significant, $t(98) = 1.858$, $p > .05$ and represented an effect of r = .18. The homogeneity of variances assumption was not violated as Levene's test was not significant (F = .173, $p > .05$).

The independent sample *t*-test performed on the logarithmically transformed data for the two regions between the periods 1Q2008 and 4Q2012 produced a slightly different outcome as the East North Central division employment level loss for NAICS 332 exhibited less severity (M = -.06, SE = .021) than the average loss in the South Atlantic (M = -.12, SE = .025) during this broader test period. The difference was significant $t(98) = -1.993$, $p < .05$ and the effect was .20. Levene's Test for the Equality of Variances (F = .617, $p > .05$) indicated that the assumption of homogeneity of variances was met. The value of the p statistic for this test was .049.

An examination of the distribution of percentage employment change between 1Q2010 and 4Q2012 indicated normality for the East North Central division with indicators of skewness (.284, SE = .343), kurtosis (.892, SE = .674) and the Shapiro-Wilk test of normality statistics (W = .975, df = 48, p = .387). The variable was normally distributed for the South Atlantic division, with indicators of skewness (.561, SE = .337), kurtosis 1.174, SE = .662) and the Shapiro-Wilk test of normality statistics (W = .969, df = 50, p = .213).

For the period of 1Q2010 to 4Q2012, the average change in employment within NAICS 332 MSAs differed significantly for the two divisions. On average, the

percentage gain in employment levels for all NAICS 332 employees in the East North Central division during this period was greater (M = .21, SE = .022) than the percentage employment gain in the South Atlantic region (M =.10, SE = .025). The difference was significant, $t(96) = 3.236$, $p < .05$ and represented an effect of r = .31. The homogeneity of variances assumption was not violated as Levene's test was not significant (F = .645, $p > .05$).

During the recovery period of 1Q2010 to 4Q2012, the percentage increase in employment in the East North Central division differed significantly from the increase in employment in the South Atlantic division. Statistically significant differences in the percentage loss of jobs from the beginning of the recession to its depths, and the pattern of the subsequent increase in jobs during the period of recovery existed for the two divisions. The pattern of job loss and recovery over the period of 1Q2008 to 4Q2012 differed for the two divisions.

Research Question 2: Table 13 presents the overall change in the makeup of the workforce for each region during the period 1Q2008 and 4Q2012. In addition to the models included in Tables 11 and Table 12, structured models designated female employment level changes as the dependent variable while the environmental indicators and percentage fractional changes in male employment remained as independent variables. Fractional changes in the workforce composition from female to male significantly affected female employment changes in the East North Central and the South Atlantic divisions. Table 15 and Table 16 present the results of the models

measuring the relationship of female employment changes with the environmental variable and percentage changes in fractions of male employment.

Table 15

Predictors of Female Employment Level Changes – East North Central

	Change in Employment Patterns		
		Model 2	
Variable	Model 1 *B*	*B*	95% CI
Constant	-0.08*	-0.02	[-0.08, 0.04]
ChgFirms	0.48	0.14	[-0.46, 0.75]
PctChgMaleFrac		-4.11**	[-5.77, -2.45]
R^2	.04	.37	
F	1.81	13.76**	
Δ R^2		.33	
Δ*F*		24.82	

Note. N= 50. CI = confidence interval.
*p<.05. **p<.01

Table 16

Predictors of Female Employment Level Changes – South Atlantic

	Change in Employment Patterns		
		Model 2	
Variable	Model 1 *B*	*B*	95% CI
Constant	-0.16**	-0.14**	[-0.21, -0.11]
ChgFirms	0.28	0.18	[-0.18, 0.55]
PctChgMaleFrac		-2.76**	[-4.03, -1.49]
R^2	.04	.31	
F	1.75	10.71**	
Δ R^2		.28	
Δ*F*		**19.00**	

Note. N= 50. CI = confidence interval.
*p<.05. **p<.01

The supplemental model predicting the percentage change in the female employment level in the East North Central division from 1Q2008 to 4Q2012 was significant ($F(2,47) = 13.76$, $p < .001$), with an R^2 of .37. The predicted rate of female

employment change is -.02 + -4.11 (Percentage change in fractional male employment). The percentage change in female employment was -4.11% for each 1% change in fractional male employment. The supplemental model predicting the percentage change in the female employment level in the South Atlantic Region from 1Q2008 to 4Q2012 was significant ($F(2,47) = 10.71$, $p < .001$), with an R^2 of .31. The predicted rate of total employment change is -.10 + -2.76 (Percentage change in fractional male employment). The percentage change in employment was -2.76% for each 1% change in fractional male employment. Therefore, in both regions, the percentage change in overall female employment for the test period demonstrated an inverse relationship with the percentage change in the male fraction of the workforce. The model demonstrated that a statistically significant inverse relationship existed between the change in female employment and the percentage change in the male fraction of the workforce.

An additional test of the relationship between the overall change in female employment and the percentage change in the male proportional employment for the period 1Q2010 to 4Q2012 yielded similar results. The supplemental multiple regression model predicting the percentage change in the female employment level in the East North Central division from 1Q2010 to 4Q2012 was significant ($F(1,47) = 13.69$, $p < .05$), with an R^2 of .22. The percentage change in employment was -6.51% for each 1% change in fractional male employment for the East North Central division. The model for the South Atlantic division during the same period indicated a significant effect of the change in the percentage of males, ($F(1,47) = 26.49$, $p < .001$), and R^2 of .36. For the South Atlantic division, the percentage change in overall female employment was

-4.89% for each 1% change in fractional male employment

Summary

Research Question 1 involved a determination of the equality of NAICS code 332 job losses between two regions of the United States during the Great Recession. An independent means *t*-test results indicated that job loss rates were not equal for the MSAs in East North Central division and the MSAs located within the South Atlantic Region during the period beginning 1Q2008 and 1Q2010. Therefore, the null hypothesis could be rejected as a statistically significant difference appeared between the employment level changes for the two divisions after the onset of the recession for the NAICS 332 sector. The test period encompassed the time between the maximum and minimum levels of manufacturing employment totals during the recession.

An additional independent samples *t*-test comparing the changes in employment levels for NAICS 332 for the East North Central and South Atlantic divisions during the period 1Q2008 to 4Q2012 produced inconclusive results as the difference was insignificant for the raw data but significant for logarithmically transformed data. However, the test of the equality of means for percentage changes for the two divisions for the period 1Q2010 to 4Q2012 was significant as the difference between the average percentage improvements was not zero. Therefore, the pattern of job recovery differed between the two divisions under examination.

Research Question 2 addressed adaptive changes in the MSAs in each region for the representative post recession period of 4Q2012. Changes in the gender makeup of the workforce and firm levels indicated that male and female percentage job level changes

indicated significant correlations (b = .82, p<.001 in ENC, b = .72, p<.001 in SA) and collinearity. For both regions. the relationship between female employment level changes and male proportional representation in the workforce was negative (b = -4.01, p < .001 in ENC, b = -2.76, p <.001 in SA). This relationship also held true for the period 1Q2010 to 4Q2012 as hiring of males outpaced that of females, and the difference was statistically significant.

Changes in the level of establishments did not display a statistically significant relationship with employment level changes in each of the test regions. Therefore, we could not reject the null hypothesis that there is no relationship between employment level changes and the firm level change independent variable. Adaptive behaviors appeared in a shift in the gender makeup of the workforce as females as a percentage of the workforce fell in a statistically significant manner after the recession. The null hypothesis was rejected in the case of the workforce gender makeup. Male employment gains demonstrated a significant effect upon employment changes and exhibited a significant negative relationship with the percentage change in the female percentage of each divisional workforce.

Chapter 5 will begin with a concise summary of the purpose of this study. A discussion of the findings of this research within the context of other recent work within this area of study will follow. The findings' implications in light of the foundation of CAS and the theoretical concept of industrial clusters will be addressed. Noted limitations and the reliability and validity of the study will then frame a narrative that focuses on recommendations for further research. Chapter 5 will conclude with an

examination and discourse covering positive social change implications and a summary statement encompassing the entire study.

Chapter 5: Discussion, Conclusions, and Recommendations

The emergence of adaptive traits within local CAS defined as industrial clusters suggested the presence of a resilient economic society. An important integrated manufacturing sector like NAICS 332 fabricated metals manufacturing could contribute to individual and societal economic well-being by displaying adaptive traits in the post-recession environment. This study addresses a gap in identifying and comparing resiliency and adaptive behaviors within local manufacturing clusters comprising diverse regions of the United States for the NAICS 332 sector.

Findings indicated that the recession's immediate impact on East North Central division MSAs employment levels was not equal to its effect on the South Atlantic division overall employment levels. The difference in the mean change in overall employment for the two divisions was statistically significant for the period 1Q2008 to 1Q2010. A test of the cross-regional difference in mean change in overall employment during the period 1Q2008 to 4Q2012 was somewhat inconclusive as continuous data indicated no difference and transformed data indicated that a difference in recovery remained. However, an independent means *t*-test of differences in employment recovery percentages for the two divisions during the period 1Q2010 to 4Q2012 revealed that overall employment recovered at different rates as the country emerged from the recession.

Although collinearity appeared between most of the variables measuring male and female employment changes, the employment of women fell in both regions as the proportion of men in the NAICS 332 workforce rose, and the gender makeup of the

workforce shifted after the recession (see Table 12). This finding held true for the period 1Q2008 to 4Q2012, and for the period 1Q2010 to 4Q2012 in both divisions. Tests indicaed that statistically significant relationships did not appear between changes in overall employment and changes in the number of firms for any period or region tested.

Interpretation of Findings

Findings and the Existing Literature

Regional resilience as the focus of this study demanded the selection of MSAs as the sampling frame and geographic partition on which to test post-recession employment growth, gender composition, and firm levels. Core-based economic structures with interrelated firms defined successful industrial clusters (Porter, 2008). Woodward's (n.d.) study of employment patterns among geographic units reported that 94% of the U.S. population resided in MSAs as defined in this study.

Business owners' responses to the recession included releasing employees (Dunkelberg et al., 2010; Sum et al., 2010) and optimizing capacity utilization rather than expanding or forming new businesses (Jolley & Mendoza, 2011). Surviving manufacturing firms adopted innovative management practices such as data collection to measure performance, and displaying and sharing performance metrics with employees (Bloom et al., 2013). As a prelude to the recession, some productivity gains and associated excess capacity precluded the need for new firm formations (Stiglitz, 2011). In summary, existing capacity allowed for internal adjustments only and eliminated the need for expansions. Findings of this study indicated that the percentage change in the number of establishments existing in NAICS 332 for the MSA sample during the period

1Q2008 to 4Q2012 did not have a significant relationship to percentage changes in the workforce for the East North Central or South Atlantic divisions.

After the Great Recession, a lower, less aggressive job recovery pattern appeared in comparison to past recessions (Bruyere et al., n.d.) and the construction and manufacturing sectors experienced the largest job losses while service sector employment sustained its prerecession levels (Stiglitz, 2011). In the presence of technological advances and new innovative industries, temporary unemployment ensued during recessionary cycles (Boianovsky & Trautwein, 2010; Diamond, 2009) while work patterns realigned geographically during the recovery process with disparate effects between regions (Boianovsky & Trautwein, 2010).

Findings of this study indicated that by 4Q2012, NAICS 332 employment rebounded but did not recover to pre-recession levels for MSAs in either of the two test regions. The average initial employment level reductions diverged for the two divisions for the period 1Q2008 to 1Q2010, and findings were inconclusive as to the mean differences in recovered employment during the period 1Q2008 to 4Q2012 for the two divisions. However, a significant difference between the average employment changes for the test divisions emerged based on a test conducted for the period 1Q2010 to 4Q2012. Langdon and Lehrman (2012) also reported a rebound in manufacturing jobs as of April 2012 as indicative of a positive outlook for the manufacturing sector in general.

Manufacturing wages and benefits per employee exceeded levels found in other industries. Colocation of research facilities with manufacturing plants stimulated innovation, and science and technology workers represented a larger than average

fraction of the manufacturing workforce (Helper & Wial, 2010; Langdon & Lehrman, 2012).

Entrenched, long-term unemployment patterns prevailed among less educated, low income, workers in industrial occupations (Sum et al., 2010), as blue-collar occupations experienced disproportionate adverse effects from the impact of the recession (Fraser & Freeman, 2011). The findings that the rate of decline in female employment was higher than that observed for male employment and that relative employment percentages changed after the recession in a statistically significant manner provided insight into this observation. Test results generated questions regarding effects of the recession on workforce demographics within other manufacturing sectors. At the start of the recession, males dominated the NAICS 322 fabricated metals manufacturing workforce, and this dominance continued through the recovery period as of 4Q2012. In a two-state study covering pre-recession activity, Abowd (2009) stated that females were more likely to be hired into new positions during a job creation cycle, than to be rehired or called back to previously existing positions. On the other hand, Blau and Shvydko (2011) found that the presence of higher fractions of younger females within the workforce indicated the presence of workplace flexibility and related to lower separation rates among older, mostly male workers (p. 481). An analysis of additional data regarding employment gains and losses by age and gender could be of assistance in understanding this phenomenon.

Researchers applied various probabilistic methods to the LEHD program data series and the publicly accessible QWI to understand the recession's impact upon

employment patterns. An MSA level comparison of housing price inflation and employment uncovered a significant relationship (Abowd & Vilhuber, 2012) while studies of job flows and wage inequality revealed labor rationalization inefficiencies and widening, skill-based wage discrepancies (Hyatt & McEntarfer, 2012). Bjelland et al., (2011) attributed labor adjustments that occurred in response to external economic shocks to worker exits from and entries to markets but also recognized that unidentified or residual factors contributed to worker movements. Andersson et al. (2012) supported a model in which, during the period 1992-2003, surviving higher-paying, capital-intensive, technologically advanced firms attracted higher wage, highly educated workers. At the same time, rates of earnings growth within the 10^{th} percentile of manufacturing employees lagged growth rates of the 90^{th} percentile, as less-sophisticated firms closed and the demand for lower-wage workers fell (Andersson et al, 2012).

Wages were excluded from the models in this paper, and no evidence appeared in the data that labor flows occurred between the test regions as both areas experienced losses in overall employment. The model excluded measurements of movements within regions and among MSAs and omitted any data and relationships between pre- and post-recession wage rates within employed worker groups.

This paper conformed to practices in existing literature wherein population comparisons employed national and international public and private secondary data sources for empirical analysis. The application of inferential methods ascertained the existence of statistically significant relationships. Descriptive statistical analyses extended the comprehension of trends in global and regional economies (Chennappa,

2009). Congruent with the approach used in this paper, existing literature incorporated the use of public database repositories of economic indicators and firm characteristics as the basis of several studies of relationships between unemployment and spending with the major cluster-related drivers. Univariate correlations, multiple regression, and analysis of variance techniques tested accessible secondary data to complete the comparative studies (Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012).

Findings and the Theoretical Foundation

The selected sample for each region consisted of MSAs in which an employee base existed at the onset of the recession. Given the research outcome for Research Question 1, the MSAs as CAS within the East North Central and South Atlantic divisions experienced reverberations from the shock of the Great Recession as employment levels fell dramatically for each region and gender in the NAICS 332 manufacturing sector. On a percentage basis, employment in the East North Central declined dramatically in the initial period but recovered rapidly during the upturn, in comparison to the South Atlantic division. Research Question 2 addressed the ability of the agents within these systems to diversify and interact via feedback and to move toward change for survival (Avery, 2010; Buckley et al., 2008; Ellis & Herbert, 2011; Espinosa, & Porter, 2011; Foster, 2010).

Pre-existing internal rules created system stability and resilience (Foster, 2010). CAS entailed spatial, non-linear relationships (Buckley et al., 2008; Carbonara et al., 2010; Ellis & Herbert, 2011; Espinosa, & Porter, 2011), and the system structure displayed fractal qualities (Carbonara et al., 2010). Employment data for Research

Question 1 and Research Question 2 originated in geographically diverse regions of the United States and entailed MSAs of diverse sizes, dispersed within each division, due to the sampling method and the size of the sample relative to the population of MSAs for each region.

Self-organized interactions among diverse agents to reform the overall structure for survival after external shocks led to change (Avery, 2010; Buckley et al., 2008; Carbonara et al., 2010; Ellis & Herbert, 2011; Espinosa, & Porter, 2011). The research design applied to Research Question 2 incorporated measurements of changes in the gender makeup of the workforce, and changes in the number of firms operating as NAICS 332 businesses for each sample MSA for the East North Central and South Atlantic divisions. The selected parameters operationalized adaptive measures in terms of changes in workforce makeup and firm levels. Statistically significant changes within each CAS, operationalized as an MSA, only appeared in changes in the workforce composition where males' share of the labor force between 1Q2008 and 4Q2012, and between 1Q2010 and 4Q2012, demonstrated an inverse relationship to changes in overall female employment.

While resilient systems demonstrated diversity within the initial system's composition, related industries arose from the base entities or agents to ensure survival (Martin & Sunley, 2007). System collaboration and interaction encompassed knowledge and resource sharing to develop suitable and efficient solutions (Maitland & van Gorp, 2009). The unknown factor reflected in the residuals of the model of female unemployment change and its inverse relationship to the increased male proportion

appeared uniformly for each region, and the reason for this statistically significant phenomenon is unknown.

The ability to recover and demonstrate flexibility after the occurrence of an external shock defined resilience within economic systems (Pendall et al., 2009; Tonts, 2011). An added dimension to resiliency involved a post-shock return to the initial state, and/or an improved condition and new equilibrium (Pendall et al., 2009; Simmie & Martin, 2010). Observed adaptability involved interscalar agents operating over time and distance through a multistage process that involved stages of resistance and recovery after an external event (Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010). Within this study, data collected as of 4Q2012 indicated the appearance of the start of an employment level recovery to pre-recession levels, and additional study encompassing current data would determine if this recovery persisted beyond the 4Q2012 period.

A comparison of two regions over the period of several recessions (Martin, 2012b; Simmie & Martin, 2010) indicated that superior global technological developments, stagnant workforce skills, and sluggish local business and industrial activity deterred and stymied system growth. Improved workforce education levels, movement into high growth industries, entrepreneurship, and innovation, stimulated growth within local economies (Martin, 2012b; Simmie & Martin, 2010). Similar to this model, resilience indicators included employee and firm levels within regions during the test periods (Martin, 2012b; Pendall et al., 2009).

Resiliency attributes in national economies included local economic agility (Montiel, 2011), stabilizing policies, minimal debt, workforce education (Briguglio,

Cordina, Farrugia, & Vella, 2009), and locational agility (Felton et al, 2010). Navarro-Espigares et al., (2011) defined resilience in terms of higher value-add and higher employment. Practical indicators of regional economic resiliency involved the emergence of diverse new high-growth industries, new employee skills, business formations and sustained job growth (Martin, 2012b). Incorporating employment levels and firm levels for each MSA within the model paralleled these concepts from the literature on regional resilience measurement. The model indicated a gender-specific effect of workforce composition changes but no effect of firm level changes within the localities in connection with overall employment level changes.

Findings and the Conceptual Framework

Cluster definitions and sustainability incorporated the presence of networks and collaboration (Porter, 2008). Solidly performing industrial cores or dominant firms attracted similar companies and instigated growth. Innovation initiated economic growth and stimulated the formation of economic groupings. Launching original technologies into low cost dispersed production sites demonstrated sector adaptation and resilience (Brenner & Muhlig, 2013; Mizuki, 2014; Randelli & Boschma, 2012; Ter Wal & Boschma, 2011; Zheng & Jin, 2014). The derivation of Sample 2 of MSAs within the East North Central and South Atlantic divisions as of 1Q2008 captured the largest MSAs within each region and a sample of smaller MSAs. Descriptive statistics indicated that the sample reflected population statistics and the adjusted R^2 pointed to the applicability of the findings to the respective populations.

During the recession, agents demonstrated rigidity before and after an economic shock within a structure that displayed system characteristics in the presence of undue and uncontrolled financial risk (Kirman, 2010; Marien, 2009). Internal failings and rigidity within the macroeconomic scheme appeared within the context of the CAS model. Within the literature, sustained or higher employment levels exemplified resilience in the aftermath of an economic shock (Martin, 2012b; Navarro-Espigares et al., 2011; Simmie & Martin, 2010).

Several labor-related concepts arose within the literature that addressed non-traditional approaches to understanding the recession's causes. Stagnant consumer wages and increasing income inequality (Lambert, 2011; Stiglitz, 2011) led to the use of higher consumer debt (Dore & Singh, 2012; Lambert, 2011; Stiglitz, 2011) as a funding source for consumer spending. As productivity increased, the demand for labor fell (Dugger & Peach, 2013) and consumer income declined (Dore & Singh, 2012; Stiglitz, 2011; Sumner, 2013). Unemployment accelerated and persisted (Love & Mattern, 2011; Sumner, 2013), while available capital contracted and constrained investment (Dore & Singh, 2012; Florio, 2011; Stiglitz, 2011; Sumner, 2013).

Wage and employment growth within the higher and lower-skilled levels of the workforce persisted after the recession while wages deteriorated in mid-skill level employment (Autor & Dorn, 2013; Canon & Liu, 2014; Hyatt & McEntarfer, 2012). Technology-related job destruction led to the geographical realignment of employment either offshore or domestically and increased demand for highly skilled, educated workers in certain models (Boianovsky & Trautwein, 2010; Diamond, 2009; Porter,

2008). The results of Research Question 1 indicated that employment levels fell for both regions at different average rates. The relationship between firm levels and employment changes was not statistically significant in either of the test regions. Test results indicated that the rate of job loss for males within the NAICS 332 sector was less severe that than for females in both regions so that the gender-specific workforce composition changed after the recession.

Limitations of the Study

The sample data described as Sample 2 met the requisite parametric test assumptions necessary to answer Research Question 1 and Research Question 2. The Durbin-Watson statistic confirmed the independence of all residuals for all multiple regression tests. The final selection of independent variables for the models eliminated noted instances of collinearity among gender-specific measures. All Tolerance values exceeded 0.10 and VIF values were at or very slightly above 1.0. Associated histograms appeared to be normal distributions for all models. P-P plots of the expected cumulative outcomes versus the cumulative observed outcomes were straight lines and indicated linear relationships. No evidence of heteroscedasticity emerged within either of the reported models upon examination of the scatter plots of the regression standardized residual vs. the regression standardized predicted value for the models. Partial plots of independent variables and casewise diagnostics revealed a minimal number of outliers given the sample size.

Variables that defined percentage employment changes for the East North Central division and the South Atlantic division during the period 1Q2008 to 1Q2012 reported

high reliability indicators as Cronbach's α = .85 and .82, respectively. For the period 1Q2010 to 4Q2012, the independent variables reported for the East North Central and South Atlantic divisions also reported high reliability indicators as Cronbach's α = .83 and .80, respectively.

Imputation methods addressed missing or invalid data elements within the LEHD. Database cross-references and probability models sufficed to impute missing fields, where necessary (Abowd et al., 2009). No adverse affects of data imputation methods appeared with the data. Limitations to the study stemmed from firm-level data masking for privacy purposes on the MSA level from the QCEW. This practice lowered the number of available MSA records with complete data fields and slightly altered the sampling process. The model adhered to the sample size of 50 cases per region described in the research strategy in Chapter 3. The supplemental independent means *t*-test of the East North Central division during the period 1Q2010 to 4Q2012 required the removal of two outliers to achieve normality in the distribution.

Face validity stemmed from the generation of demographic workforce descriptors from underlying pairings of masked individual identifiers and personal census data (Abowd & Vilhuber, 2011; Abowd et al., 2009). Content validity arose from data availability for all MSAs for gender-specific statistics while limitations arose from the masking of firm level data for some MSAs within the targeted regions. The sample size exceeded the required target necessary to obtain a power of 80%. This study follows recent analyses of United States employment trends within the United States accessed based on the publicly-available QWI database and the privately accessible LEHD

database (Abowd et al., 2009; Abowd & Vilhuber, 2012; Abowd & Vilhuber, 2011; Andersson et al., 2012; Bjelland et al., 2011; Blau & Shvydko, 2011; Helper, & Wial, 2010; Hyatt & McEntarfer, 2012). To affirm the empirical validity of this research, reference is made to the place of job growth in operationalizing economic resilience in several papers (Boianovsky & Trautwein, 2010; Martin, 2012b; Pendall et al., 2009; Simmie & Martin, 2010).

Linear regression models measured the relationship between regional employment and external resiliency indicators in recent literature (Abowd & Vilhuber, 2012; Brady & Lee, 2014; Grycova, 2013; Kochetkov, 2012; Niebuhr, Granato, Haas & Hamann, 2012). Construct validity was established in this study as it employs a methodology to measure the relationship between employment and market changes that is consistent with methodologies found in recent literature.

Consideration of confounding variables within this research design contemplated the regional impact of oil prices, utility prices, wages, and interest rates upon employment gains. However, the availability of relevant data for each of the MSA-level sampling units precluded the incorporation of these potential confounding variables.

Based on the test statistics and tests of assumptions described earlier, and discussions of validity and reliability, the results of this study are trustworthy, reliable and valid. Limitations to generalizability stem from the geographic comparison of only two regions within the United States. Other limits involve the unknown residual effects on the decline in relative female workforce participation for this sector after the recession.

Recommendations

Literature Review

The body of knowledge addressing the subject of labor changes and CAS as regional clusters would benefit from updated studies of wage differentials, re-employment rates, and demographic shifts in the workforce makeup. In addition to gender and employment interactions, further studies can measure the effect of educational differentials upon wage disparities within diverse business sectors. Targeted studies directed to locating industries with increasing value-add and gauging their impact on wages among diverse segments of the workforce can be of benefit.

Although comparative studies of regional resilience appear in the literature for European countries and Australia, specifically targeted studies of interregional differences within the United States are not as prevalent. The body of work characterizing regional economies as Complex Adaptive Systems is in a growth stage. Studies of effective responses to the recession's adverse conditions can supplement emerging theories explaining the causes of the recession.

Firm level practices and adaptive behaviors based on size and location, as well as industry classification could provide insight into the hiring approach on an aggregated basis and rationales for patterns of hiring observed within the data. Additional granularity and detail on 3-digit level hiring patterns within the larger 2-digit NAICS hiring code scheme could reveal anomalies such as that observed for gender-related workforce participation for the selected NAICS 332 sector in this study. Matches of

compensation and balanced workforce participation can inform and direct personal, enterprise-level and regional decision-making.

Current Study

An application of the research design to current, updated 2014 data would determine if observed patterns in the study persisted beyond 4Q2012. Regional statistically significant differences appeared in the level of adverse effects of the recession during the periods 1Q2008 to 1Q2010, and 1Q2010 to 4Q2012. Inconclusive findings followed an independent means *t*-test of the period 1Q2008 to 4Q2012. This observation would imply that an approach to equilibrium between the regions with respect to job loss rates might have begun during the period between 1Q2010 and 4Q2012, and manufacturing jobs began to approach pre-recession levels. An updated analysis would provide clarity on this issue.

Firm formation and closure effects were not significant, and improved access to data for this variable would assist in identifying adaptive enterprise behaviors. In addition, a comparison of the strength of the surrounding economy to employment patterns could provide a measurement of adaptive spatial activities within local economies among all resident agents.

An attempt to identify intervening variables could lead to comparisons among subgroups of the sampling units. A comparison of gender-related employment patterns among micropolitan statistical areas, metropolitan statistical areas, and non-MSAs within regions can provide insight as to pre- and post-recession workforce dynamics among age-related and educationally defined demographic groups. Efforts to discover the residual

effects could involve contrasts between the skill sets of those rehired or retained and those remaining unemployed, for the NAICS 332 industry, among employees at the beginning of the recession.

Finally, the incorporation of comparative regions from the west and southwest might provide additional insight as to changing labor patterns and potential effects of proximity to the Pacific Rim economies in the western United States in contrast to proximity to the Atlantic Basin for eastern economic systems. Differentials from the impact of imports or exports on employment patterns can be isolated with tests of selected, appropriate parameters.

Implications

Introduction

In the aftermath of the economic recession that began in January 2008, United States employment levels remained below pre-recession totals. Post-recession economic conditions unfavorably affected young, blue-collar labor force participation. Economic resiliency within business sectors and regions encompassed the ability to survive adverse economic shocks while retaining viability. Certain adaptations emerged after applying empirical methods of analysis to published economic indicators for given areas within the United States. Isolating the characteristics of adaptive industrial sectors and regions contributed to a comprehension of approaches to private sector growth initiative planning within the context of regional economic development. In general, as residents gain sustained, lucrative employment after an economic downturn due to adaptive resiliency

displayed in certain employing sectors and geographic areas, economic well-being can proliferate.

Implications for Individuals

National employment fell by 16.1% within the manufacturing sector and by 19.1% in the NAICS 332 sector beginning in the first quarter of 2008 until the first quarter of 2010. By the end of 2012, the job recovery progression within manufacturing was uneven. The NAICS 332 sector outperformed overall manufacturing losses such that net losses from the recession totaled 9.0% versus 12.9% for overall manufacturing. Individuals located within a region with access to this resilient sector benefited from adaptive behaviors and regained employment within an environment of overall economic decline. The East North Central division outperformed the national average of job recovery on a percentage basis for the target sector. The focus of employment recovery initiatives and job training to an adaptive sector manifests a positive social benefit for individuals through guidance to meaningful, sustainable employment.

The observed differences in the employment recovery of men and women can direct investigations into the underlying causes of the growing differential as the recovery emerged. Post-recession male hiring in the fabricated metals manufacturing sector and regions in this study outpaced the levels of female hiring. Investigations into the underlying causes and a determination of the source of this phenomenon as employee-based vs. intrinsic to society will benefit the formation of structured, directed career planning and training for all individuals.

Implications for Organizations

The results of this study provide the genesis of background data on the sources of differences in resilience within industry groups and between regions. This examination of recovering regions and industries within a context of macroeconomic stress can provide a basis for identifying adaptive system traits that will serve as templates for replication within external organizations and diverse industries. The divergence in the rate of job deterioration and recovery between the East North Central and South Atlantic division points to differences in adaptive behaviors. An isolation of the specific bases for the differences can inform constituent organizations within the NAICS 332 sector and contribute to future sustainability.

Implications for Society

Societal benefits stem from the understanding that regions experienced dissimilar patterns of job loss and recovery, and different adaptive behavioral systems can be identified as contributors to variable economic success. This study increased the body of knowledge regarding regional differences in economic recovery by examining a recent economic shock and its effect on two distinct regions of the country. Reactive patterns included changes in the workforce makeup without evidence of an increase or decrease in actual establishment levels for both regions in the study. Adaptive measures identified via additional study can be applied the country at large and to other manufacturing sectors.

The availability of longitudinal, public databases containing demographic and statistical records for basic economic units and industrial concentrations within the

United States allows for the conduct of future research to determine if the regional differences and gender effects remained aligned with overall economic recovery and progress. Study outcomes pointed to the presence of varying adaptive behaviors within regions in the presence of economic shocks, and encouraged the application of CAS theory to regional economies and the entire country to engender economic growth for the benefit of society. The outcome of this study can stimulate the initiation of additional research on the consistency of the pattern of relative female employment losses within the post-recession manufacturing sector given the significant wage premium inherent in that industry.

The application of the CAS model to regional economic behavior yielded an initial stage of understanding the activity of underlying constituents when districts regained or surpassed their pre-recession viability. The availability of quarterly employment records on publicly accessible databases facilitated the measurement of statistically significant changes in employment between the two separate workforce groups within two regions and measured the effect of changes in workforce gender makeup. These findings can be expanded upon and updated as databases are continually supplemented with current statistics, and new formats of data are developed and released.

Conclusions

This paper addressed the nature of regional employment pattern differences that appeared in the United States after the 2008 recession. The research design included tests of the effects of location, workforce demographics, and industry firm levels upon employment changes in the environment during and after the Great Recession. The

present study extended the body of knowledge concerning patterns of the post-recession employment recovery by comparing the resiliency of manufacturing employment in two regions of the United States. Specifically, this study analyzed the differences in employment patterns within the largest manufacturing segment, NAICS 332, fabricated metals manufacturing for the East North Central and South Atlantic divisions of the United States during the period of 1Q2008 to 4Q2012.

Within a post-recession environment, gainful employment can provide economic stability for workers residing in the United States. Wage and benefit premiums within the manufacturing sector are additional incentives to understanding the changing contribution of this sector to the overall economic well-being of the country and its citizens. In addition to discovering changes in the composition of the workforce of fabricated metals manufacturing employees in the East North Central division and the South Atlantic division, future research can continue to isolate and identify characteristics of regions demonstrating positive trajectories of employment level changes while operating in a post-recession environment.

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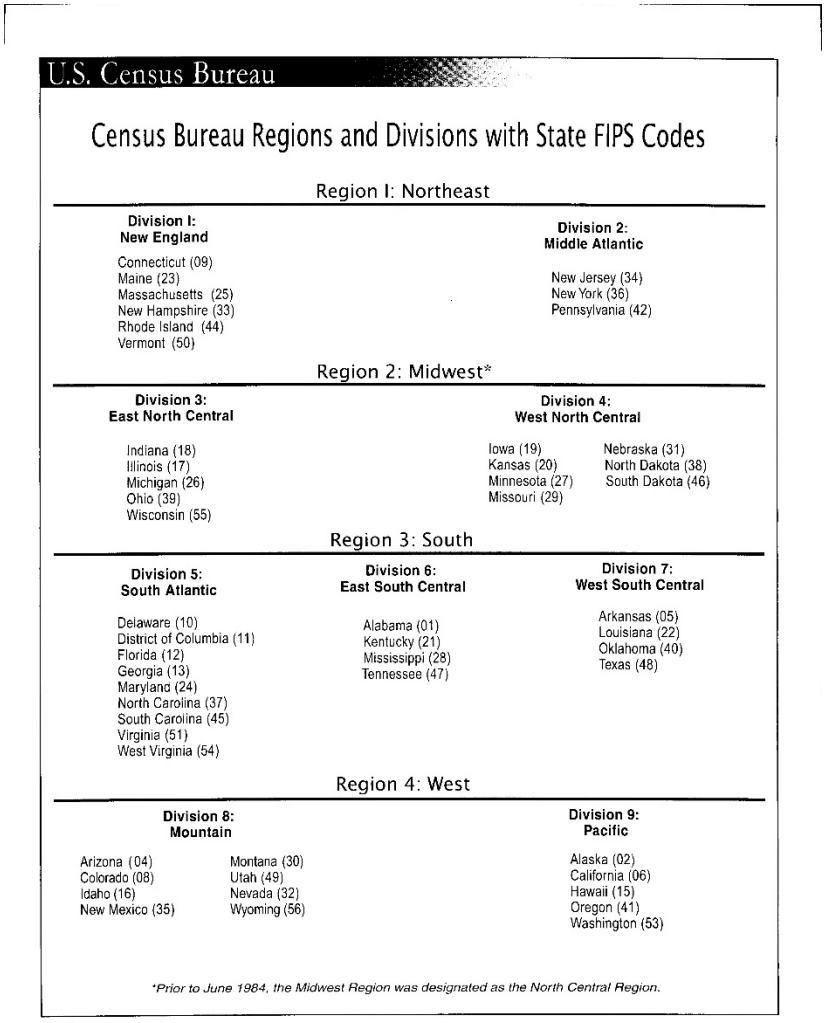
Appendix A: U.S. Census Regions



U.S. Census Bureau

Census Bureau Regions and Divisions with State FIPS Codes

Region 1: Northeast

Division 1: New England

Connecticut (09)
Maine (23)
Massachusetts (25)
New Hampshire (33)
Rhode Island (44)
Vermont (50)

Division 2: Middle Atlantic

New Jersey (34)
New York (36)
Pennsylvania (42)

Region 2: Midwest*

Division 3: East North Central

Indiana (18)
Illinois (17)
Michigan (26)
Ohio (39)
Wisconsin (55)

Division 4: West North Central

Iowa (19)
Kansas (20)
Minnesota (27)
Missouri (29)
Nebraska (31)
North Dakota (38)
South Dakota (46)

Region 3: South

Division 5: South Atlantic

Delaware (10)
District of Columbia (11)
Florida (12)
Georgia (13)
Maryland (24)
North Carolina (37)
South Carolina (45)
Virginia (51)
West Virginia (54)

Division 6: East South Central

Alabama (01)
Kentucky (21)
Mississippi (28)
Tennessee (47)

Division 7: West South Central

Arkansas (05)
Louisiana (22)
Oklahoma (40)
Texas (48)

Region 4: West

Division 8: Mountain

Arizona (04)
Colorado (08)
Idaho (16)
New Mexico (35)
Montana (30)
Utah (49)
Nevada (32)
Wyoming (56)

Division 9: Pacific

Alaska (02)
California (06)
Hawaii (15)
Oregon (41)
Washington (53)

**Prior to June 1984, the Midwest Region was designated as the North Central Region.*

Appendix B: Definitions

Variable	Definition
zzzEmpChgxxvyy	Percentage change in total NAICS 332 employment between period xx and yy within Region z.
EmpChgMale	Percentage change in male employment levels during the period xx to yy for Region z.
EmpChgFem	Percentage change in female employment levels during the period xx to yy for Region z.
ChgMaleFrac	Absolute change in the fraction of males in the NAICS332 workforce for a specific MSA during the period xx to yy.
ChgFemFrac	Absolute change in the fraction of females in the NAICS332 workforce for a specific MSA during the period xx to yy.
PctChgMaleFrac	Percentage change in the fraction of males in the NAICS332 workforce for a specific MSA during the period xx to yy for region z.
PctChgFemFrac	Percentage change in the fraction of females in the NAICS332 workforce for a specific MSA during the period xx to yy for region z.
ChgFirms	Percentage change in the number of firms operating in NAICS 332 for a given MSA between periods xx and yy for region z.