5-2011

Geographies of Competitive Advantage: An Examination of the US Farm Machinery Industry

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To the Graduate Council:

I am submitting herewith a dissertation written by Dawn M. Drake entitled "Geographies of Competitive Advantage: An Examination of the US Farm Machinery Industry." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Geography.

Ronald V. Kalafsky, Major Professor

We have read this dissertation and recommend its acceptance:

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A Dissertation Presented for the
Doctorate of Philosophy
Degree
The University of Tennessee, Knoxville

Dawn M. Drake
May 2011

DEDICATION

This dissertation is dedicated to the most important person in my academic career; my mentor and my friend, John Benhart, Jr. Without you, I never would have even gone to graduate school, much less finished my Masters and PhD. I cannot imagine what would have happened if I would have never met you. Thank you for all the years of support and encouragement and I look forward to the years to come.

In Memory of Dr. John Rehder

ACKNOWLEDGEMENTS

There are numerous people to thank for their help in the completion of this research project. First and foremost, I must thank my committee, led by advisor, Dr. Ron Kalafsky. Assisted by Dr. Tom Bell, Dr. Bruce Ralston, and Dr. Anne Smith, Dr. Kalafsky was a guiding force in the completion of this project. I also must thank the rest of the faculty and staff in the Geography Department at the University of Tennessee and Dr. Peggy Gripshover of Western Kentucky University for their guidance and support.

In addition to the support I received from faculty, I must also thank Linda Skolarus at the Benson Ford Research Center, Simone Munson and Lee Grady with the McCormick-International Harvester Archives at the Wisconsin Historical Society, and the staff of the Wellington Reading Room at the University of Guelph Libraries for their assistance in locating materials in the various archives. Also instrumental in this research were my tour guides at various Case New Holland plants – Ron Kleinsasser in Saskatoon, Saskatchewan and John Daniels in Dublin, Georgia. I would be remiss not to thank Cynthia Nelson at Case New Holland in Saskatoon for her help in setting up several tours for me. Also indispensible were the various employees from Case New Holland and AGCO, present at trade shows, who were always willing to talk to me and answer my questions.

This research was funded through a grant from the Government of Canada and the Stewart K. McCroskey Memorial Fund at the University of Tennessee. I am also grateful to the financial and moral support I received from Gary and Melissa Fehnel, Stephen Fehnel, and Rich Shirey.

Finally, I must thank my parents and family for their continuing support and encouragement. None of this would be possible without you.

ABSTRACT

Many explanations of competitive advantage view place as a secondary factor. Organizational studies models tend to be considered aspatially, yet most are inherently geographic. It is important to consider the impact that geography has on the success or failure of an individual firm or a sector. This dissertation examines how location impacts the US farm machinery industry through an empirical analysis of Porter's Theory of Competitive Advantage. Contributing to this empirical test are other bodies of literature including models for headquarters and research and development siting, product life cycle theory, industry life cycle theory, and green technologies as a driver of competitive advantage.

The US farm machinery industry is composed of three firms: Deere and Company, Case New Holland, and the Allis-Gleaner Corporation. Theory-elaborating case study methodology, informed by archival data, publically available documents, trade show reconnaissance, and plant tours, coupled with map and content analysis allows for a deeper understanding of how geography impacts competitive advantage in the sector.

Comparing findings from these geographic case studies to Porter's results led to a new understanding of competitive advantage for mature manufacturing in a globalized economy. Previous analysis found Porter's single diamond, which focuses on local conditions for competitive advantage, most appropriate for explaining mature industries in advanced market economies. This study found, however, that as mature industries increasingly pursue a global focus, a double diamond model, which takes into account both local and global conditions for competitive advantage, is more appropriate, even in an advanced economy.

This research also found that, much like second-tier cities are desirable for headquarters and research and development siting, second-tier countries (that can provide high-skill labor at

lower prices) are increasingly attractive for manufacturing operations. The need for modifications to product life cycle theory that take into account the impact of these countries as well as the effects of nationalism on manufacturing decisions in mature economies were also uncovered by this dissertation.

This research demonstrates the continued importance of place to understanding competitive advantage, not only in the US farm machinery industry, but generally for mature manufacturing as a whole.

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CHAPTER I
INTRODUCTION

1.1 Themes and Relevance

Amber waves of grain are a distinct and pervasive part of the common vision of America (Lopez 1989). The only way the United States (US) can prolong grain production at a prolific enough rate to maintain this imagery, given the continued decrease in the number of people working in agriculture full-time, is to employ the use of tractors, combination harvester-threshers (commonly referred to as combines), and other farm machinery that manage more land at a faster rate and allow for increasing yields on the same amount of acreage. While accounting for less than one percent of annual US gross domestic product (GDP), the US manufacturers of farm machinery generated over 3.2 trillion dollars of revenue from over 500,000 units produced in 2009. Seventy-five percent of this production was purchased by US farmers (IBISWorld 2009). Understanding the US farm machinery industry is critical not only to US manufacturing economics, but also to the maintenance of the American image. To comprehend the dynamics of competitive advantage between these firms, the importance of place must be studied more so than it has been in the past. This dissertation examines the geography of the US farm machinery industry, going beyond traditional analyses that use aspatial organizational studies models, to a new level of understanding based on the role that location plays in each firm's relative competitive advantage in the industry.

Three major companies dominate the US market in the production of farm machinery: Deere and Company (also known as John Deere [JD]) (Figure 1.1), Allis-Gleaner Corporation (AGCO) (Figure 1.2) and Case New Holland (CNH) (Figure 1.3). The farm machinery industry

Figure 1.1: John Deere equipment on display at the 2010 Ag Connect Expo in Orlando, FL (picture taken by author).

Figure 1.2: Various AGCO products, including (clockwise from top left) a Gleaner combine, Fendt tractor, Massey Ferguson combine, and Challenger tractors on display at 2010 Farm Progress in Boone, IA (pictures taken by author).

Figure 1.3: Equipment from the two divisions of CNH. On the left, Case International (Case IH) equipment on display at 2010 Ag Connect Expo in Orlando, FL. On the right, New Holland equipment on display at 2010 Farm Progress in Boone, IA (pictures taken by author).

can be defined in a variety of ways. For the purposes of this research, I will delimit the industry using the North American Industry Classification System's definition, which comprises establishments primarily engaged in manufacturing agricultural and farm machinery and equipment, and other turf and grounds care equipment, including planting, harvesting, and grass mowing equipment (except lawn and garden-type) (NAICS 2009). This definition allows for a broad interpretation of which firms should be included in the farm machinery industry: from those that produce a full-line of products to those that only produce small numbers of a single piece of machinery commonly used on the farm. To narrow the focus of the research, I will examine a single strategic group within the farm machinery industry. Schroeder et al. (1995) defines a strategic group as a cluster of competitors with similar strategy and production capabilities. Firms within the same strategic group typically compete with one another more so than firms in other strategic groups. For the purposes of this research the single strategic group I will examine is the one that has the most economic impact – the full-line manufacturers. As A.A.

Thornburgh, President of Massey-Ferguson Limited, noted in a 1958 speech to the Chemical Institute of Canada, “The full-line companies necessarily shape the pattern of the industry. Their operations reflect the basic economic changes that affect the industry as a whole…” (Archival and Special Collections, University of Guelph Library, X41 RHC A0433).

The three aforementioned US manufacturers (JD, CNH, and AGCO) not only produce the majority of high-horsepower tractors and combines, but also the bulk of other self-propelled farm machinery like sprayers, windrowers, forage harvesters, sugarcane harvesters, and cotton pickers as well as many other farm implements like plows, discs, harrows, hay balers, and planters. Deere, CNH, and AGCO represent the only farm machinery firms in the US that can deliver a full-line of farm machinery including high-horsepower tractors and self-propelled combines. Fewer farmers managing more acres with higher yields have necessitated the use of larger implements, pulled in tandem to reduce trips across the field (Wehrspann 2010a). Additionally, genetic modifications of crops like corn and soybeans have increased both the thickness and total amount of biomass to be harvested and plowed under (Wehrspann 2010b). Both of these conditions require tractors and combines with more horsepower and torque (Marquardt 2008).

The US farm machinery industry is an under-researched sector of the mature manufacturing economy that deserves further attention. It can serve as a superior case study to examine geographic interpretations of common organizational studies models. Case studies at the individual firm-level are excellent for validating and expanding existing theories as well as generating new conjecture (Roth and Kostova 2003). In many cases, organizational studies models are treated aspatially when, in fact, common sense tells us that location matters. The purpose of this dissertation is to demonstrate that location matters to these heretofore aspatial theories and models through an empirical case study of the US farm machinery industry.

Research on the US farm machinery industry is salient to economic geography for a number of reasons. First and foremost, examining the agricultural machinery industry is critical to the understanding of the location of mature manufacturing in the US. US agriculture has an advantage in that well-established firms that build the machines that are necessary to the production of high crop yields and efficient harvests are primarily located within the borders of the US. The Big Three[1], due to their proximity to the customer and changing trends in agriculture (such as increasing farm sizes), can be far more responsive to the ever-shifting technology in agriculture than can foreign competitors. In addition, the Big Three have developed a worldwide reputation for high quality and durability when compared with the products of international firms (Aeppel 2006), which allows them to differentiate themselves from international competitors (IBISWorld 2009). For these reasons, the US farm machinery sector is in a unique position compared to other mature sectors of the US economy. The typical farm machinery consumer in the US is more likely to identify one of the Big Three as their first choice when purchasing equipment (AG Poll 2010). This is somewhat different than other mature sectors like automobiles or machine tools where international firms often dominate the domestic market (e.g. Finegold et al. 1994; Dyer 1996a; Dyer 1996b). Questions about why this sector, which is as old as automobiles and machine tools, has not followed the same spatial trajectory based on its product life cycle have not been comprehensively addressed. Further research is necessary to understand why the farm machinery sector, a building block of the US agriculture sector, has deviated from the typical path of mature industry in the US and to discover what it can tell us about the future of US manufacturing. Also, by comprehending the

[1] Throughout the paper, the term Big Three will refer to the three main US farm machinery manufacturers (JD, CNH, and AGCO) that produce combines and tractors greater than 100 horsepower (75 kilowatts) as well as a full-line of other farm machinery.

Big Three's location decisions, agriculture, which is one of America's largest economic sectors by value, will be better understood.

More generally than the importance of research related to the economic geography of US farm machinery, is the importance of studying mature manufacturing as a whole. This research is a timely study of mature manufacturing in the US. For many years, the fortunes of the US farm machinery industry tracked closely those of the US automakers ("General Impressions of Brazil" ca. 1964, Archival and Special Collections, University of Guelph Library, X41 RHC A0434). Bankruptcy fears by Chrysler in the 1970s were followed closely by the demise of International Harvester (today part of CNH) and the Allis-Chalmers Corporation (today part of AGCO). In the 1980s, due to closures and consolidations, the US farm machinery industry saw its manufacturing capacity cut by half and employment fall by almost 60 percent (Feder 1994b). This pattern did not continue, however. As the three main US automakers struggled with global recession and, in some cases, sought bailout funds from the US government during the 2008 economic downturn, US farm machinery manufacturers reaped the benefits of record-high crop prices (Mullins 2008; D'Amica 2009) and incentives for farmers to buy new machinery that comply with government standards for clean emissions in tractors and other self-propelled farm machinery (Grooms 2010a). Understanding the history of the farm machinery industry, its geography, and why it has strayed from its traditional pattern of closely following the fortunes of the automobile industry, to its newfound success and growth, is crucial to understanding the future of mature manufacturing in the US as a whole.

It is not only as a study of the farm machinery industry or mature manufacturing in general that makes this research salient. Perhaps one of the most compelling reasons for this study is found in the debates surrounding "new economic geography." Krugman (1998) demonstrated the need for micro-scale empirical studies to test the models developed by "new economic geographers." This dissertation fills this niche, empirically testing Porter's Theory of Competitive Advantage (1990) at a micro-scale by studying a single industry in a single country. In a critical response to Krugman and other "new economic geographers," Martin (1999) called for studies of real places. By studying US farm machinery manufacturers this research is applying a model from "new economic geography" to a real place and a real industry in an attempt to assess the model. While economists and geographers have debated at length over methodologies in evolutionary economic geography, both parties agree that additional empirical studies are in order.

Finally, this research is relevant because it will expand the existing literature in several areas. Despite the inherently geographic nature of Porter's Theory of Competitive Advantage (1990) and numerous other models within the organizational studies literature, few geographers have employed the models in their studies (Porter 1998a). This is despite the fact that Porter (1994; 2000b) has repeatedly emphasized the importance of location in his research. Also, researchers have neglected the US farm machinery industry as an economic sector and, in fact, little case research has been conducted since the rash of bankruptcies in the late 1970s and early 1980s (Chandler 1977; Porter 1980). Given the rapid changes in the industry, contracting from numerous US firms to just three, it is important to update the case literature through an in-depth analysis. Geographic implications for organizational studies models can be demonstrated in the US farm machinery industry. Using a theory-elaborating case study methodology (Eisenhardt 1989), I evaluate these models in an attempt to expand them to include geography as an explanatory vehicle for mature manufacturing as observed in the US farm machinery industry.

This in-depth study of the US farm machinery industry is informed by a variety of commonly employed organizational studies models. It tests empirically Porter's Theory of Competitive Advantage (1990) while examining other aspects of the organizational studies literature that can contribute to a broader understanding of Porter's model and explain the relationship of the Big Three to one another and within the global economy.

There are many models in the organizational studies literature that can contribute to a better understanding of the competitive position of the Big Three. In most cases it is assumed that the processes that underlie these models occur regardless of location. Actual business decisions and manufacturing processes, on the other hand, occur in a space and a place. It is important to recognize that fact and attempt to tease out the ways in which location contributes to success or failure for a firm, industry, or economy.

Certain aspects of the literature do make room for the importance of place. Research into headquarters locations (e.g. Klier and Testa 2002; Gong and Wheeler 2007) and research and development (R&D) sites (e.g. Nobel and Birkinshaw 1998) take into account the infrastructure and labor pool necessary to make these functions successful. Contributing to this understanding of what makes locations desirable for functions such as command and control and R&D is work by Richard Florida (2002) on the creative class. When one looks at the locations in which R&D occurs for the US farm machinery industry, one must wonder how difficult it is to draw highly-educated scientists and engineers to places like Moline, Illinois; Fargo, North Dakota; or even New Holland, Pennsylvania. Does this have an impact on any one of the three firm's ability to maintain competitiveness in the farm machinery industry? Has AGCO led the charge in research into meeting new emissions standards because its R&D facility, located in Atlanta, Georgia, has connections with automobile manufacturers, like BMW and Volvo Trucks, along the I-75/I-85 corridor? Would it have those connections if it was not located in one of Florida's creative class cities? It is important to look at these aspects of the organizational studies literature from a geographic perspective to understand how they influence competitive advantage for the US farm machinery industry.

Another body of research in organizational studies that is crucially important to understanding the geographic aspects of competitive advantage comes from product life cycle and industry life cycle theory. Vernon (1966) proposed that the amount of capital or manpower put into the production of a product depended on where it was in its life cycle. Goods that are new need higher levels of research and marketing and are produced in small batches, all of which drive up costs per unit. As the good matures, innovations diminish, and production becomes standardized, the product runs become longer, automation of production increases, and cost per unit declines. There is a geography to this life cycle as well (e.g. Vernon 1979). When goods are in their infancy, they are closely guarded; new technology is proprietary and they are likely to be produced in industrialized nations where there is easy access to high-skill R&D and marketing functions. As the good matures and cost is more of a competitive concern, production may be moved to less expensive areas. This is what one would expect in the farm machinery industry, but with the exception of AGCO that produces the majority of its tractors in South America, the trend to move mature production overseas has been limited for the Big Three. As the farm machinery industry has matured and innovations have become incremental at best (United States Patent and Trademark Office 2009; United States Patent and Trademark Office 201a, b) one would expect the industry to move to cheaper production areas more distant from the negative externalities in developed economies and cities, yet the majority of production remains in highly unionized cities of the Upper Midwest. It is an important aspect of competitive advantage for the US farm machinery industry to determine why the sector has defied the accepted organizational studies models regarding its place in the product life cycle.

Industry life cycle theory similarly contributes to an understanding of the US farm machinery sector (Audretsch and Feldman 1996). Industry life cycle theory states that industries will cluster at the beginning and end of their life cycles. At the beginning, this is to allow for sharing of resources, knowledge spillovers, and the development of economies of scale. At the end of the life cycle, the clustering occurs again to promote creative destruction (Schumpeter 1950) whereby the twilight industry may find a way to reinvent itself. The farm machinery industry follows this pattern, with the early cluster being centered in the Upper Midwest of the US – in the heart of the traditional corn and wheat areas of the country. Today, as the farm machinery industry moves into the mature phase of its life cycle (IBISWorld 2009), a new cluster is emerging, centering on AGCO and the Atlanta Metropolitan Statistical Area (MSA).

A final area of literature that is ever increasing in importance when explaining performance and competitive advantage in the farm machinery industry is the impact of green technologies. Friedman (2008) has suggested that the US can regain competitive advantage in the global economy by becoming the leader in the design and development of technologies that reduce carbon footprints. For the US farm machinery industry, this has meant increasing fuel efficiency and reducing emissions in accordance with Environmental Protection Agency (EPA) regulations (Mowitz 2010b). The leaders in developing this technology can gain additional competitive advantage in the industry, while the followers may lose market share depending on the adoption rates of the technology by farmers (IBISWorld 2009). It is an important area to consider when evaluating empirically Porter's model in relation to the US farm machinery industry.

All of these bodies of literature and models in organizational studies, whether they are related to location, product and industry life cycles, or technology, are important in developing the themes and objectives of this research. This examination of the farm machinery industry will help develop the importance of place to competitive advantage as well as other models commonly used in the organizational studies literature.

1.2 Research Objectives and Questions

Over the years, JD has outperformed other firms in common indicators of market value – sales and stock prices – experiencing revenue growth as much as three times greater than AGCO and four times greater than CNH (Market Watch 2009). Deere has managed to keep its headquarters in Moline, Illinois, while CNH and AGCO have suffered through market volatility, merged with other companies, and shifted their operations around the country and the world. In recent years, however, AGCO has experienced rapid growth in market share and is currently developing into a major competitor for JD. This research examines why this is the case and if market performance has its roots in the geographic aspects of organizational studies models.

Following from the themes presented above I address three main research questions:

1). Does location play a role in the operations, competitive issues, performance, and competitive advantage of US farm machinery firms?

Each of the organizational studies models, mentioned as part of the themes of this research, contribute to the understanding of Porter's Theory of Competitive Advantage (1990) and have geographic aspects that get buried within industry case studies. It is the goal of this research to determine if location matters to competitive advantage. One must account for the power of location to truly understand the operations, competitive issues, performance, and competitive advantage of the Big Three and their place in the global economy.

2). Do the performance and competitive issues of the US farm machinery industry conform or contradict the assumptions of Porter's Theory of Competitive Advantage (1990)? What potential modifications could be made to Porter's Theory of Competitive Advantage based on the findings of the case studies in this research?

Once the situation within the US farm machinery industry has been elucidated, it should be possible to use it to empirically test Porter's Theory of Competitive Advantage (1990) and determine if the case studies conform or contradict prior findings. Do other strains of research and other organizational studies models need to be incorporated to explain more accurately competitive advantage in the farm machinery industry? Are green technologies a driver to shift market share in the industry? Can Porter adequately explain the farm machinery industry or are modifications necessary?

3). Are there under-researched or undiscovered geographical characteristics of the organizational studies literature that pertain to the US farm machinery industry?

Given the variety of organizational studies models that contribute to an understanding of competitive advantage in the US farm machinery industry and given the number of these models that do not adequately consider the importance of place, it seems likely that there are undiscovered geographical aspects of these models that will be uncovered through case studies in the US farm machinery industry.

1.3 Operationalization of Research

The previously outlined research questions and themes are examined through a variety of methods, both quantitative and qualitative to tease out relationships and discover the geographic aspects of commonly used organizational studies models as they relate to the US farm machinery industry. While each research question will have its own accompanying methods, the entirety of the research will occur within a framework of theory-elaborating case study methodology (Eisenhardt 1989) to discover how geography permeates the US farm machinery industry, an industrial sector that has traditionally been approached using aspatial organizational studies models. Porter's Theory of Competitive Advantage will provide a background for these empirical case studies. Reciprocity between Porter (1990) and the case studies will allow the empirical data to inform the model and the improved model, in turn, to shape the research findings. The result, it is hoped, will be a better understanding of the US farm machinery industry and an empirical evaluation of Porter's Theory of Competitive Advantage (1990).

1.3.1 The role of locations in the operations, competitive issues, performance, and competitive advantage of US farm machinery firms

Case studies of individual firms are a desirable means to evaluate more complex processes within organizational studies (Roth and Kostova 2003). Theory-elaborating case study methodology, as employed in this dissertation, requires large amounts of process data to construct profiles of the firms (Langley 1999). Eisenhardt (1989) recommends using multiple sources to gather data to analyze each of the cases. Porter (1980) outlines a number of data sources that can be parsed for information about operations, performance, and competitive advantage of firms. Following these two examples, I have identified several data sources that will be employed to construct individual cases.

One of the key aspects of case study methodology is an in-depth examination of documents either provided by the corporations themselves or those that are publically available. This included such items as the content of corporate websites, annual reports, newspaper and trade journal articles, and brochures distributed by the company. Ribisi et al. (2003) demonstrated the use of content analysis on websites as a way to gather data. The websites of the Big Three provided a wealth of knowledge about operations strategies, performance over time, and even competitive advantage. This was supplemented with other publically available documents including literature collected at trade shows. All of these data were employed to construct case studies following the example of Eisenhardt (1989).

Because the history of the firms in my study stretch over many decades and the firms have been subject to mergers and acquisitions, archival research was necessary and is recommended when employing a theory-elaborating case methodology (Eisenhardt 1989; Eisenhardt and Graebner 2007). Archival data are available in abundance for these firms and the companies they have purchased over the years.

In addition to data gathered from archives and publically available documents, I collected information from the firms themselves through the use of trade show reconnaissance as advocated by Bathelt and Schuldt (2008). Critical participant observation (Goss 1999) at farm machinery trade shows allowed me to survey the marketing strategies of the Big Three and collect data on the firms. By attending a variety of different trade shows, I was able to observe the behavior of the Big Three as they catered to various audiences (Power and Jansson 2008). While conducting trade show reconnaissance, I also captured images of each of the Big Three's display areas, which were utilized in photographic content analysis (e.g. Low and Sherrard 1999; Ribisi et al. 2003; Fahmy 2004) to find further evidence of each firm's operational, performance, and competitive strategies.

One more source of data about the Big Three can come through publically offered plant tours. Each of the Big Three has at least one plant to which it offers public tours. Others may be available by contacting the company. Plant tours are a commonly used research tactic in organizational studies (Upton and Macadem 1997), but have been less widely used in economic geography. The information that is offered on these tours, as well as observations made on dealership visits, when viewed through the critical eyes of a researcher (Goss 1999; Kruse 2005) familiar with the farm machinery industry adds to the case study methodology and provides more data for use in evaluating Porter's Theory of Competitive Advantage (1990).

Adding to the data employed in the theory-elaborating case study methodology (Eisenhardt 1989), I also examined location decisions through exploratory map analysis of the spaces that the Big Three occupy in the US. By looking at these locations in terms of the points in Porter's quadripartite model, I could better hypothesize what makes a location desirable for the various functions (headquarters, R&D, manufacturing) of the Big Three.

1.3.2 Modifying Porter's Theory of Competitive Advantage based on the findings of the case studies

Once the data were collected through archives and publically available documents, trade show reconnaissance, and plant tours, I evaluated the data to look for patterns and keywords that indicate the use of prevailing models in the organizational studies literature. I qualitatively compared strategies to Porter's Theory of Competitive Advantage (1990) and other models in the organizational studies literature, using a continuation of Eisenhardt's (1989) theory-elaborating case study method. Using content and tabular analysis, I looked for keywords in the data that indicate theories in practice. By informing the model with empirical evidence and using the model to drive an understanding of competitive advantage, the location decisions for the Big Three of the US farm machinery industry, it is hoped, will be realized.

1.3.3 Identifying under-researched or undiscovered geographical characteristics of the organizational studies literature

Through the theory-elaborating case study methodology (Eisenhardt 1989) and the empirical test of Porter's Theory of Competitive Advantage (1990), gaps in the existing organizational studies models should become evident. Eisenhardt's (1989) case study method is designed to expose these gaps and allow researchers to expand existing theories or develop new theory to fill them. Given the type of data collected and synthesized, I expect to expand existing theories to reintroduce place into organizational studies models based on the examinations of the US farm machinery industry.

1.4 Organization

Chapter II and **Chapter III** will look at the existing knowledge in the field. **Chapter II** will trace the history of the Big Three from hundreds of separate small companies to the three mega-firms we see today. It will look at their place relative to one another and in relation to the US and global economy. This chapter will also examine, in brief, international firms that could become larger players in the farm machinery industry in coming years and how their market share relates to that of the Big Three. **Chapter III** will include an explanation of Porter's construct, an examination of other pertinent organizational studies models that can play into an understanding of the US farm machinery industry, and finally a description of the gaps in the existing literature.

Chapter IV will review the data and methods employed in the research and how the data and research bolstered my arguments. It will include an explanation of theory-elaborating case study methodology, trade show reconnaissance, and content analysis that employs QDA Miner. **Chapter V** will discuss the outcomes of my research and how the US farm machinery industry and the organizational studies literature interact spatially using a variety of methods including content analysis, trade show reconnaissance, exploratory map analysis, and plant tours. In **Chapter VI**, I will synthesize the research findings to assess the ability of organizational studies literature to explain competitive advantage and the geography of the US farm machinery industry. Finally in **Chapter VII**, I will make conclusions, answer the research questions, outline the limitations of the research, as well as propose suggestions for future study and the future of the US farm machinery industry.

CHAPTER II
THE FARM MACHINERY INDUSTRY

2.1 The Big Three

> Tractor manufacturing was also an industry that just like its customers the farming community, was to go through profound and painful change in the three decades from the 1970s through the 1990s, and will most probably continue to do so into the new millennium (Frielander quoted in Gibbard 1999: 9).

This quote by Bob Frielander, Commercial Operations Director of New Holland from 1992 to 1996, perhaps best captures the history of the Big Three. Deere, AGCO, and CNH each have very different manufacturing trajectories involving varying degrees of interaction with other farm machinery manufacturers in the US and abroad. While JD has existed only under the name of Deere and Company, AGCO and CNH have undergone myriad name changes throughout the years. Currently each has a number of brands under which it markets its goods, none more than AGCO, which manufactures almost 20 separate brands, while JD and CNH produce fewer than ten. At present, the farm machinery industry is riding an economic upswing, due largely to the very high commodity prices in the US and world. Emerging demand in international locations, such as South America and China, as well as the constant pressure to innovate and develop new technologies that are more efficient and easier for the farmer to use greatly shape the competitive climate for not only the Big Three, but also the international competitors that seek to take a portion of their market share (IBIS World 2009). By looking at the history of each company, it is easier to understand the trajectory that led them to their current positions in the US agricultural machinery sector.

2.2 Allis-Gleaner Corporation

No company in the farm machinery industry has a more storied and complicated history than AGCO. The original parent company of AGCO was the Allis-Chalmers Corporation, begun in Milwaukee, Wisconsin in 1901 from a merger of several small foundries and manufacturing firms (Mills 1986). From the earliest days as the E.P. Allis Company, the firm subscribed to a philosophy of eliminating competitors by purchasing them and developing new technology by acquiring companies that developed it (Petersen 1978). "[Edward P. Allis] had built his Reliance Works and E.P. Allis Company on a philosophy of constant expansion financed by borrowed money" (Petersen 1978: 67). To become known as a cutting-edge innovator in the farm machinery industry, Allis-Chalmers purchased many tractor and implement manufacturing firms including Advance-Rumely in 1931, and Gleaner Harvester Corporation in 1955. Allis-Chalmers was the first to offer rubber tires, power steering, and factory-installed turbochargers on tractors (Gaines 2010a). Mergers and acquisitions gave Allis-Chalmers a unique advantage over other producers in terms of innovative technology, but put it at risk because of the difficulty of managing a company of that large size (Petersen 1978).

In 1985, Allis-Chalmers went bankrupt after years of struggling to compete with the sleeker International Harvester, Ford Tractor Operations, and JD. It was purchased by Klochner-Humboldt-Deutz Ag (KHD) of Cologne, Germany and Allis-Chalmers became Deutz-Allis dominated by a North American Headquarters in Norcross, Georgia and a worldwide base of operations in Germany (Mills 1986). By 1990, however, members of the original Allis-Chalmers Corporation had managed to leverage enough capital to purchase the company back from KHD; a company that was struggling to understand the needs of the American farmer (AGCO Corporate 2010). Klochner-Humboldt-Deutz Ag decided to refocus its priorities on the new markets opened by the fall of the Berlin Wall (Freiberg 1995). Deutz-Allis re-formed as the Allis-Gleaner Corporation, moving from Norcross, Georgia, where KHD maintained its facilities for its engine division, to Duluth, Georgia and began to amass a larger market share of the industry by buying more than 24 different companies, continuing the pattern of mergers and acquisitions that was begun by E.P. Allis (Fischer 2010).

The re-formation of Deutz-Allis into AGCO transformed the company from a 200 million dollar firm to an industry leader worth two billion dollars, most of which occurred under the leadership of charismatic chief executive officer (CEO), Robert Ratliff (*US Industry Profile* 2009). The process of amassing new companies began almost immediately with the purchase of White Farm Equipment in 1991, which had been formed in 1969 through a merger of Oliver Farm Equipment Company, the Minneapolis-Moline Company, and Cockshutt Farm Equipment, Ltd. This introduced into AGCO another set of companies with long histories of farming innovation, including predecessor to Oliver, Hart-Parr Tractor Company, which was not only the first firm in the US devoted to strictly building tractors, but also was the first to use the term "tractor" to refer to its self-propelled gasoline traction engine (Gaines 2010a). When White Farm Equipment went bankrupt in 1985, its combine technology was sold to Massey-Ferguson and its New Idea line of planting equipment was renamed as White-New Idea, which AGCO purchased in 1991. Acquisitions continued for AGCO, including Massey-Ferguson in 1994, Hesston in 2000, and Caterpillar's agricultural division in 2002 (AGCO Corporate 2010) (Figure 2.1).

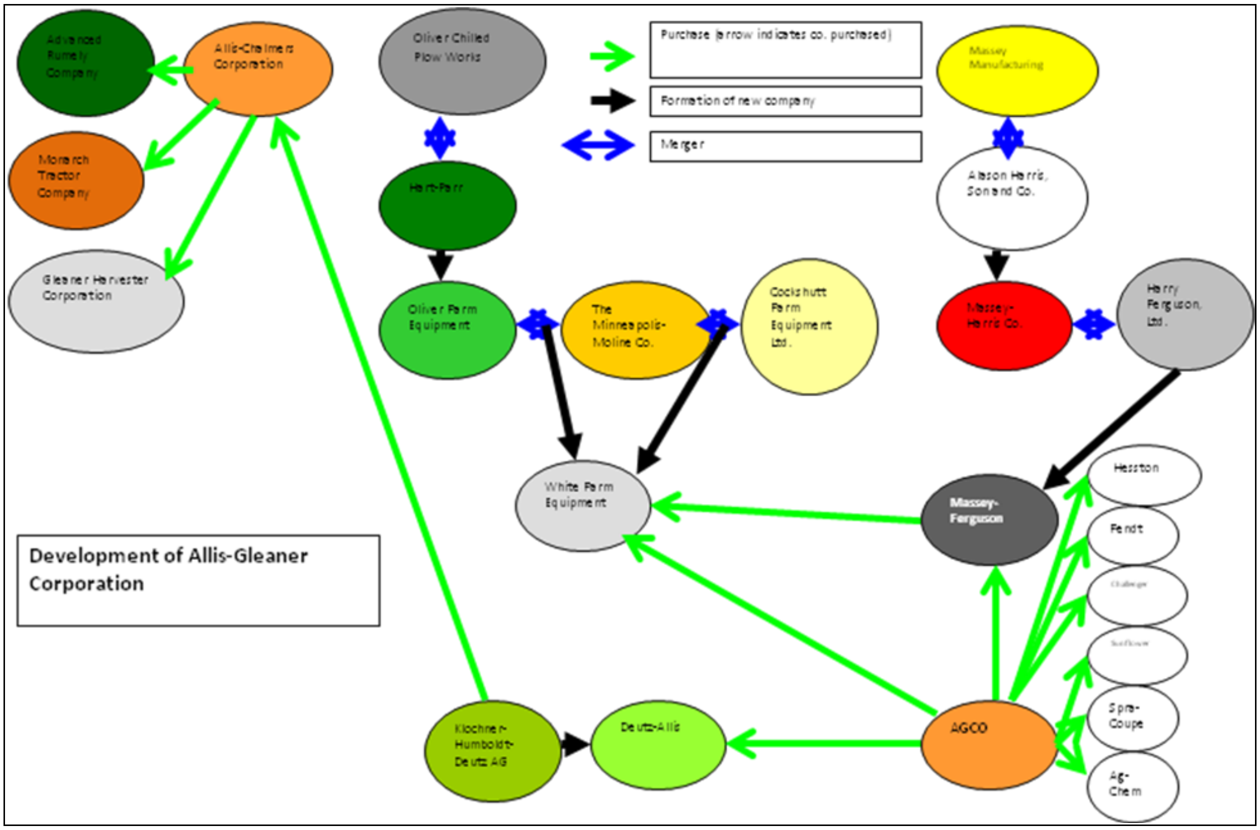

Figure 2.1: The development of AGCO from its roots in the Allis-Chalmers Corporation. The colors of the ellipses are representative of the primary paint color used by each company on its machines. Arrows that begin along another arrow indicate the formation of a new company from the merger or purchase indicated by the arrow that the new company is emitting from.

The purchase of Massey-Ferguson in 1994 has had the most profound long-term impact on AGCO. From 1962 to 1997, Massey-Ferguson had been the largest tractor producer in the world (Feder 1994b). By acquiring Massey-Ferguson, AGCO suddenly was the largest producer in Europe (Freiburg 1995). Massey-Ferguson became one of the core brands of AGCO along with Challenger[2], Valtra, and AGCO tractors. In 2010, AGCO announced that it would no longer sell the distinctive Persian orange AGCO tractor brand that was a nod to the company's roots as the Allis-Chalmers Corporation (Fischer 2010). The company decided to instead focus limited R&D dollars on fewer core brands, selling tractors in the US under only the Massey-

[2] Challenger is the brand name that AGCO acquired from Caterpillar as a part of the sale of the agricultural division in 2002.

Ferguson or Challenger names – brands that the company felt had the most national and international brand loyalty (Fischer 2010; Gaines 2010c). Many loyal customers of AGCO have expressed distress at this decision and competitors often question the lack of heritage that AGCO has in its line when compared to JD or CNH's core brands (Gaines 2010b; Gaines 2010d). AGCO points out, however, that Massey-Ferguson, when traced from its very beginnings in Canada has a legacy that stretches to 1847 – older than even the Allis-Chalmers Corporation (Gaines 2010b). The AGCO brand name is well-known, as is the distinctive orange paint, only in the Upper Midwest (R. Hamre, pers. comm.; Gaines 2010c), but it is Massey-Ferguson, with its history of leadership in Europe (Van Zandt Schreiber 1966), that will have the most sustained familiarity in the future. That is the legacy that AGCO continues to capitalize on in its marketing strategies as it moves into the future.

Today, AGCO maintains the third largest share of the world and North American market, behind JD and CNH, but is rapidly growing and attempting to cash in on complacency by JD. According to recent estimates, AGCO controls approximately nine percent of global market share and ten percent of North American market share (IBISWorld 2009; Kanicki 2011). In the last few years, AGCO has closed the gap in market share globally with CNH. AGCO, unlike JD or CNH, focuses its production and sales more globally, with only 20 percent of its products being sold in the US. Over 50 percent of AGCO's products are sold in Europe, with another 25 percent going to South America, making it the market leader in both regions (AGCO Corporate 2010; *Trachbel Magazine* 2010). It is the largest producer in Brazil, controlling over 60 percent of the market for tractors in that country (Shinkle and Marquardt 2008; AGCO Corporate 2010). In 2006, the company was among the top 20 performing stocks on the New York Stock Exchange, sharing that distinction with such firms as GameStop and Comcast. In that single year, AGCO gained an outstanding 87 percent increase in portfolio value (Benner et al. 2009). In 2009, it was listed as 306 on the Fortune 1,000 with annual revenue of a little more than 8.4 billion dollars (*Fortune* 2010a). In 2008, AGCO was named by *Forbes* as one of the most trustworthy companies in the US based largely on its responsible accounting practices and environmental stewardship (Murdock and Ray 2008). It was the first firm in the state of Georgia to routinely certify its accounting reports and monitor its bookkeeping practices (AGCO Corporate 2009).

In recent years AGCO has changed its focus from acquisition to innovation (McMahon 2010a). This has been an ongoing process since 2004, when the company purchased Valtra of Finland and was informed by the US Justice Department that any further major acquisitions by AGCO would trigger anti-trust investigations (McMahon 2010a). Prior to this, AGCO's strategy had been to acquire and overhaul small farm machinery companies to diversify its line and create an image for itself (Feder 1994c). After the priority shift, budgets were refocused to increase R&D funding and generate an appreciable enhancement in the number of patents the firm applied for in a year (McMahon 2010a). Until recently, AGCO applied for fewer than 15 patents in a year, compared to more prolific rates for JD and CNH (United States Patent and Trademark Office 2009; United States Patent and Trademark Office 2010a, b) as Table 2.1 indicates. While JD and CNH still apply for far more patents in any year, AGCO is leading the charge in green innovations. In 2009, AGCO became the first farm machinery producer to comply with EPA emissions standards, utilizing selective catalytic reduction (SCR) technology in their E_3 Sisu engines (Figure 2.2) to turn diesel exhaust into clean water vapor (AGCO 2009; Gaines 2010a). This was followed by continuously variable transmission (CVT) technology to make tractors and combines more fuel efficient (McMahon 2010a). Fendt, one of the divisions of AGCO, is the only tractor line in the world to provide a full range of tractors from 70 to 360 horsepower (52 to 268 kilowatts) with CVT (Neunaber 2010). Recent interviews with AGCO CEO, Martin Richenhagen, have pointed to a new technology focus for the company (*Trachbel Magazine* 2010). Industry analysts have repeatedly pointed to the ability of AGCO to focus R&D activities on the development of specialized technologies that meet the needs of farmers around the world (Marquardt 2008). This new focus is what has made AGCO the company to watch among the Big Three.

Figure 2.2: An AGCO E_3 Sisu low emission diesel engine, employing SCR technology, on display at Ag Connect Expo in Orlando, FL in 2010 (picture taken by author).

Table 2.1: Patents granted, by year, for each of the Big Three (United States Patent and Trademark Office 2009; McMahon 2010a; United States Patent and Trademark Office 2010a, b)

Year	AGCO	CNH	JD
1995	8	Case Corporation = 21 New Holland = 32	67
1996	2	Case Corporation = 26 New Holland = 35	64
1997	1	Case Corporation = 23 New Holland = 27	55
1998	3	Case Corporation = 37 New Holland = 36	70
1999	13	Case Corporation = 67 New Holland = 44	84
2000	12	Case Corporation = 78 New Holland = 39	69
2001	8	Case Corporation = 69 New Holland = 46	122
2002	10	Case Corporation = 51 New Holland = 40	119
2003	9	Case Corporation = 73 New Holland = 52	154
2004	9	Case Corporation = 45 New Holland = 35	158
2005	3	87	141
2006	6	93	142
2007	2	106	151
2008	13	81	138
2009	50	103	143

2.3 Case New Holland

Perhaps less complicated, although no less storied is CNH, which has two main components: Case International (Case IH) and New Holland Farm Machinery (Figure 2.3). Corporate headquarters have been located in Chicago; Racine, Wisconsin; Troy, Michigan; New Holland, Pennsylvania; and most recently Amsterdam, The Netherlands. Case IH is a consolidation of two companies: J.I. Case Threshing Machine Company and International Harvester Farm Equipment Division (Case IH 2010a). Case was purchased by Tenneco Incorporated in 1967 (Stonehouse and Brumbaugh 1996), which then purchased International

Harvester to create Case IH in 1985 (Case IH 2010a). Tenneco sold Case IH to FiatAgri in the 1999. FiatAgri merged it with New Holland, which it already owned, to form CNH (I&T Staff Writers 1999). In addition to CNH, FiatAgri also owns Fiatallis and Fiat-Hitachi, both construction equipment firms (*Implement & Tractor* 1999).

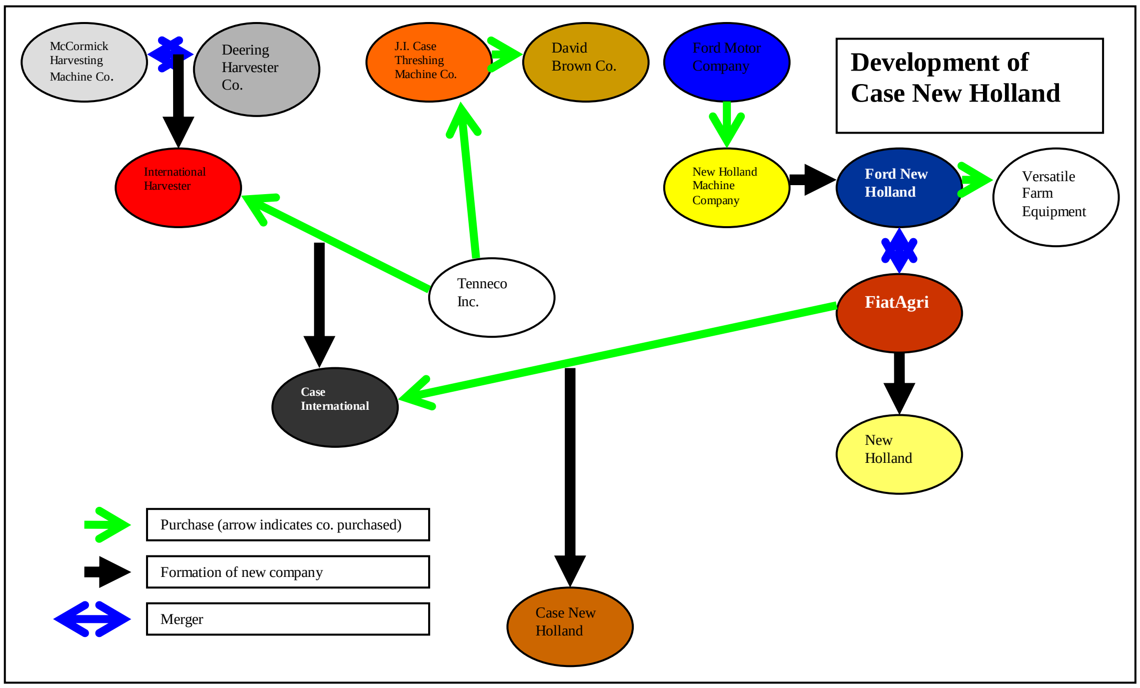

Figure 2.3: The development of CNH from its roots in multiple companies. The colors of the ellipses are representative of the primary paint color used by each company on its machines. Arrows that begin along another arrow indicate the formation of a new company from the merger or purchase indicated by the arrow that the new company is emitting from.

New Holland is a combination of Ford Tractor Operations and New Holland Machine Company. In 1987, Ford purchased New Holland from the Sperry Corporation and formed Ford New Holland Incorporated (Pripps 1997). The Tractor and Implement Division of the Ford Motor Company has a long legacy in the mechanization of agriculture. While the Hart-Parr Tractor Company may have built the first factory dedicated to the production of farm machinery and coined the term "tractor," it was Henry Ford's assembly line system and the Fordson tractor that allowed the average farmer to mechanize his operations. In 1917, Ford introduced the Fordson tractor, selling it for around 400 dollars – far less than any of the competitors could sell a tractor for at the time (*US Industry Profile* 2009). In 1990, Ford Motor Company decided that American-built farm machinery was no longer profitable on its own (Gibbard 1999). It merged with FiatAgri, which continued to produce the distinctive blue tractors using the New Holland nameplate (Gibbard 1999; *Implement & Tractor* 1999). By 1993, FiatAgri acquired all of Ford Tractor Operations, which it would later add to its purchase of Case IH to form CNH (Gibbard 1999).

Fiat is listed as 64 among the Global Fortune 500 companies with annual revenues of almost 87 billion dollars (*Fortune* 2010b). Case New Holland accounts for 20 percent of those profits, or approximately 17.4 billion dollars annually (Bertacche and Cinelli 2009). The company maintains 26 global factories and has distribution in 160 countries (Marquardt 2008; *US Industry Profile* 2009). The two brands of CNH command a large loyalty in North America, controlling approximately 37 percent of market share (Kanicki 2011), despite only controlling about 11 percent globally (IBISWorld 2009). Today New Holland and Case IH tractors roll off the same assembly lines, identical machines in two different colors, preserving market share for both loyal Ford and International Harvester users, but raising serious concerns about the efficiency of duplicated effort.

2.3 Deere and Company

Deere is the least complicated of the Big Three. Starting in 1843, from humble roots as a plow works, JD has built itself into a global empire, all the while maintaining its headquarters in

Moline, Illinois (Mills 1986). It has remained isolated in terms of partnership, resisting the urge to purchase more and more companies (Figure 2.4). Beyond JD's early history, which was marked with a series of purchases to expand from a single product line of plows to a full-line manufacturer, it has remained rather isolated, not merging with numerous companies like CNH and AGCO. Early purchases included Waterloo Gasoline Engine Company in 1918 and the Wagner-Langemo Company in 1929 to add two important items to its line – the tractor and the thresher (Mills 1986). In 1936, JD expanded its line again to include combines by purchasing technology from Caterpillar (Mills 1986). One other major acquisition, in 1946, of the Lindeman Power Equipment Company, that JD had been partnering with for over ten years to produce agricultural crawlers, spawned the beginning of JD's construction division and the end of JD producing crawlers for farm use (Gerstner 2000). After the initial series of purchases and the acquirement of Lindeman, JD has been largely independent, growing organically rather than through merger and acquisitions, unlike AGCO or CNH (Mills 1986; Gerstner 2000).

Perhaps because of this stability and insularity, JD represents the largest share of the global market in agricultural machinery today with just over 21 percent (IBISWorld 2009). It captured this position from International Harvester in 1958 and has held it ever since (Mills 1986). It does not control the market share in North America, however, holding only 25 percent compared to CNH's combined 37 percent (Kanicki 2011). It is the brand with the most loyalty and brand recognition among large US farmers, however, with over 66 percent of a recent survey of farmers[3] stating that the primary brand of combine and tractor on their farms was JD. Of that group of JD farmers, 77 percent stated that they were brand-loyal to JD green (Kanicki 2011). This has translated into huge revenues for the company. In 2009, JD was 87 on the Fortune 500

[3] The surveyed group of farmers were among all US farmers who earn more than 500,000 dollars per year

(*Fortune* 2010a) and 307 among the Global Fortune 500 with annual revenues of a little more than 28.4 billion dollars (*Fortune* 2010b), over half of which come from the Agricultural Division (IBISWorld 2009). Deere maintains factories in nine countries and has a distribution network that stretches to 120 countries around the globe (*US Industry Profile* 2009). In 2010, JD was named one of the "World's Most Admired Companies" by *Fortune* (2011) and also a top-100 Best Corporate Citizen by *Corporate Responsibility Magazine* (2011). It maintains both an important economic and philanthropic role in the Quad Cities[4] (Marsh 1985) without attempting to acquire all the other firms within the industry. This, however, raises serious concerns about its level of complacency and ability to adjust to foreign rivals and even domestic competitors, such as AGCO.

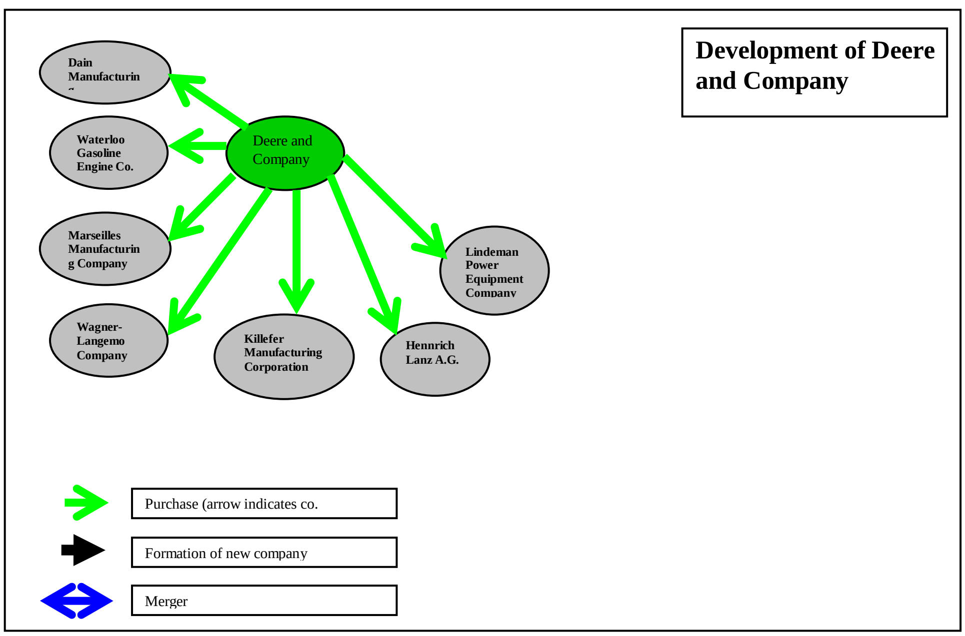

Figure 2.4: The development of JD. The colors of the ellipses are representative of the primary paint color used by each company on its machines.

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[4] The Quad Cities is the colloquial name used to designate the urban amalgam composed of Davenport and Bettendorf, Iowa, and Moline, East Moline and Rock Island, Illinois. In fact, there are five cities in the "Quad Cities".

Deere has not always focused on its core industry of farm machinery manufacturing as a way to generate profits, despite the fact that it makes up 90 percent of sales (Kingsbury 2010). Other ventures, such as a health insurance company, crop insurance company, fertilizer manufacturing plant, and financial services have also helped to build JD's fortune (Eichenwald 1990; Gerstner 2000). Today JD is made up of not only its Agricultural Division, but also a financial services division, construction and forestry division, and commercial and consumer equipment division (Deere and Company 2006). Deere continues to generate profits outside its core competencies even now. One example of this was John Deere Wind Energy, was a wholly-owned subsidiary that provided consumers, interested in generating wind power, a one-stop company for wind farm design, financing, installation, and management (Deere and Company 2010b). Recently, however, this division was sold to a subsidiary company of Exelon Corporation for 900 million dollars (*Diesel Progress* 2011a), leaving JD with fewer companies outside its core competencies. Another one of JD's largest money makers, outside its core competencies, is its managed healthcare plan, which serves not only the company's employees, but other businesses in the Midwest of the US (Feder 1994a; Barboza 1999). Deere also uses its brand image to its advantage, marketing a line of clothing and toys to more than just farmers (Barboza 1999).

Generating profits outside a company's core competencies is not usual among the Big Three. It is a method of insulating company profits from the cyclical demand fluctuations in the farm machinery industry (Barboza 1999). Predecessor companies of AGCO and CNH both had significant investments outside of farm machinery. In addition to agricultural machinery, CNH also builds construction equipment (CNH 2010). Allis-Chalmers engaged in a wide variety of investments including manufacturing refrigerators and freezers, snowmobiles, all-terrain vehicles, and construction equipment (Petersen 1978). International Harvester also manufactured heavy-duty trucks and refrigerators (Marsh 1985). All of the Big Three have invested outside of their core competencies as they felt appropriate. Today, however, JD demonstrates the most wide focus and diversity in investments, while AGCO markets itself, based on its focus on one core competency (agricultural equipment), as the "… largest pure play, full-line agricultural equipment manufacturer…" in the world (AGCO 2011c).

2.4 Other Farm Machinery Firms

While the Big Three dominate the farm machinery industry both within the US and abroad, this is not to say that they are the only firms that have a role in the sector. In general, farm machinery exports exceed imports in any given year (*US Industry Profile* 2009). The farm machinery industry, however, is seeing new entrants, mostly companies from abroad that are increasing the number of imports into the US. Most of these firms are not, however, able to compete across the full line of products the way the Big Three can. Their dealership networks are limited in the US. On the whole, the farm machinery sector, even beyond the Big Three, is highly concentrated (*Business Wire* 2006). While the Big Three control 43 percent of the global market for farm machinery, the remaining members of the top 20 firms in the world control another 37 percent, meaning that 80 percent of the sector is controlled by just 20 companies (*Business Wire* 2006).

Geographically, the nearest competitor to the Big Three is Buhler Versatile, a firm based in Winnipeg, Manitoba (Figure 2.5). Versatile was once a wholly-owned subsidiary of the Ford New Holland Corporation, specializing in the production of four-wheel drive articulated tractors (Buhler Versatile 2010). As a part of the merger of Ford New Holland with FiatAgri, the companies were required, under US anti-trust laws, to sell off Versatile (*Implement & Tractor* 2000). The company and the design of the New Holland Genesis tractors (Wehrspann 2010f) were purchased by Buhler Industries of Winnipeg, another Canadian farm machinery company that specialized in implements such as loaders, augers and conveyors (Buhler Industries 2010). Until 2004, Buhler Versatile produced the highest horsepower tractors sold in North America (Buhler Versatile 2010). In 2006, 80 percent of Buhler Versatile was acquired by Rostselmash Limited, a Russian combine manufacturer. Through this partnership, the company has increased its global distribution to match that of the Big Three. Versatile cannot compete with the Big Three on product variety (Buhler Versatile 2010). The firm has recently been shifting strategies, however, hoping to diversify its product line, in an attempt to become a full-line manufacturer. The company's new CEO, Dmitry Lyubimov, who was installed after Rostselmash acquired Versatile, has refocused the company on the production of both the large articulated tractors that the company is known for, as well as smaller fixed-frame row crop tractors and will begin importing Rostselmash combines to North America in the near future. Rostselmash has a virtual monopoly on the combine market in Russia already (Wehrspann 2010f). All of this growth and diversification is part of a strategy to become a lower cost alternative to the Big Three for North American farmers (Wehrspann 2010f).

Figure 2.5: Buhler Versatile's display area at 2010 Western Canada Farm Progress in Regina, Saskatchewan (picture taken by author).

Most European competitors are not full-line manufacturers either. The exception to this, among large firms, is the Italian company SAME Deutz-Fahr. This firm, that acquired KHD in 1995, five years after KHD sold off the North American portion of the company that became AGCO, produces tractors (Figure 2.6) in a wide range of horsepower ratings, including a number over 100 horsepower (75 kilowatts) for sale in Europe, Asia, and the US (Cousins 2008). Many of these tractors, however, were distributed, until recently, through a partnership with AGCO (*PR Newswire* 2000). Additionally, while SAME Deutz-Fahr is the fifth-largest farm machinery producer in the world, its operations are much smaller than that of any of the Big Three and are dependent on profits from its subsidiary, Deutz Ag, in which SAME Deutz-Fahr is the largest shareholder (*Diesel Progress* 2011a). Deutz Ag produces diesel engines for off-road applications (Cousins 2008). In 2008, while AGCO, as the smallest of the Big Three, manufactured well over 1,000 combines, SAME Deutz-Fahr manufactured less than 300

(Tsoneva 2008). The European company simply does not have the means to compete globally with the Big Three.

Figure 2.6: A SAME Deutz-Fahr Agcostar tractor on display at the 2011 National Farm Machinery Show in Louisville, KY (picture taken by author).

Other European firms do not offer a full line of farm machinery. CLAAS, one of Europe's largest agricultural equipment manufacturers, concentrates almost entirely on harvesting machinery, including combines (Figure 2.7). CLAAS focuses only marginally on tractors, usually through joint marketing ventures with other manufacturers including Renault and Caterpillar, prior to Caterpillar's sale of its Challenger line to AGCO (*PR Newswire* 2002; *Farmer's Guardian* 2003). Another European firm, Zetor, of the Czech Republic, which has only recently recovered from a series of financial setbacks and plant shutdowns, focuses solely on tractors and engines (Figure 2.8). The company does not offer a full-line of implements and other machinery to its customers (*Global News Wire* 2006).

Figure 2.7: A CLAAS Lexion combine on display at 2010 Farm Progress in Boone, IA (picture taken by author).

Figure 2.8: A Zetor tractor on display at the 2011 National Farm Machinery Show in Louisville, KY (picture taken by author).

A final European firm, McCormick International, was at one time the British division of International Harvester. In 1999, when Fiat purchased Case IH to merge it with New Holland, European trade laws required Fiat to divest itself of the holdings of the British division. In 2000, those holdings, including land and buildings, were purchased by ARGO s.P.a of Italy and made into the Worldwide Headquarters for McCormick International, which produces McCormick and Landini tractors (Figure 2.9). The following year, the company opened a manufacturing plant in the US near Pella, Iowa (McCormick International 2010). The company produces tractors, including those over 100 horsepower (75 kilowatts), but does not manufacture combines or any other type of farm machinery. It cannot compete with the market share enjoyed by the Big Three or even SAME Deutz-Fahr. On the whole, among the European farm machinery manufacturers, none can approach the product-line or volume of sales of the Big Three.

Figure 2.9: McCormick and Landini tractors (from left to right) on display at the 2010 Western Canada Farm Progress show in Regina, Saskatchewan (pictures taken by author).

Perhaps the largest threat to the market dominance of the Big Three comes from Asia. The fourth largest farm machinery company in the world is Mahindra and Mahindra, an Indian firm (Figure 2.10), which produces a limited full-line of farm machinery, tractors, and combines for sale in Asia, Europe, and North America (*ENP Newswire* 2009). The company has recently broken an important barrier to entering new markets by introducing a line of tractors that produce over 100 horsepower (75 kilowatts), which other Asian firms have not been able or wished to do (*ENP Newswire* 2009). Mahindra and Mahindra has won a number of highly coveted engineering awards including a Japan Quality Medal and the Deming Prize, as well as being recently awarded an Agricultural Leadership Award from New Delhi's *Agriculture Today* (*ENP Newswire* 2009). The company serves a niche type of market that the Big Three cannot by providing a cheap, but functional tractor to parts of the world that cannot afford the costs of innovation that come with American machines (Kingsbury 2010). Mahindra and Mahindra has strategic alliances in Japan, China, and South Korea as well as numerous manufacturing plants in the US and shows no signs of slowing down (*ENP Newswire* 2009). Currently, its combine sales are limited to Asia, which restricts it somewhat compared to the Big Three. As Mahindra and Mahindra continues to expand its product line and enter new markets, however, it will remain the largest threat to the Big Three's considerable US and international market share.

Other Asian firms do not provide the wide range of products or the global distribution that the Big Three and Mahindra and Mahindra do. Among Japanese firms, only Kubota produces a tractor with greater than 100 horsepower (75 kilowatts). Another Japanese firm, Yanmar focuses much of its attention on compact diesel tractors and construction equipment (*PR Newswire* 2007), while Kubota offers a wider line, including implements for its compact diesel tractors (Figure 2.11), construction equipment, and utility vehicles for traveling around the farmstead (*Business Wire* 2004). Another Asian firm, Tong Yang Moolsan (TYM) based in South Korea (Figure 2.12), has the potential to offer a full line of farm equipment, including combines and tractors over 100 horsepower (75 kilowatts), but currently does so through marketing agreements with Mahindra and Mahindra and does not have the capability to produce high horsepower tractors on its own (*India Business Insight* 2002; *The Weekly Times* 2008). It does, however, claim to be, "the fastest-growing tractor brand in North America" (TYM 2011: A1). None of these firms seem to have the potential in the short-run to challenge the position of the Big Three. Among Asian farm machinery manufacturers as a whole only Mahindra and Mahindra poses a real threat to the Big Three in the foreseeable future. At present, however, the Big Three possess the largest product lines with the widest global distribution networks of any farm machinery firm in the world and, therefore, will be the focus of this research.

Figure 2.10: Mahindra's display area at the 2010 National Farm Machinery Show in Louisville, KY (picture taken by author).

Figure 2.11: A Kubota tractor on display at the 2011 National Farm Machinery Show in Louisville, KY (picture taken by author).

Figure 2.12: A TYM tractor on display at the 2011 Ag Connect Expo in Atlanta, GA (picture taken by author).

CHAPTER III
ORGANIZATIONAL STUDIES MODELS

3.1 Introduction

This chapter will review the literature that informs this research. In addition to outlining the existing models in organizational studies and the trajectory of thought that led to my research questions, it will elucidate the gaps in the literature that make this dissertation salient to the study of economic geography.

3.2 Theoretical Framework

To understand how and why these three companies have operated in the locations they have, it is worth examining organizational studies models. More specifically, Michael Porter's Theory of Competitive Advantage (1990) informs this study and was evaluated throughout. By examining each of the four factors of Porter's model (Figure 3.1), one may be better able to understand why certain firms succeed and others fail within the same industry. According to Porter (1990) the model contains four elements: 1) ***factor conditions***; 2) ***demand conditions***; 3) ***related and supporting industries***; and 4) ***firm structure, strategy, and rivalry*** to build a competitive advantage in business. These four elements are additionally impacted by the outside factors of ***government*** and ***chance*** (Porter 1990). Competitive advantage in industry is fostered by strength in multiple dimensions of Porter's model, not just one or two of the elements (Porter and Stern 2001). The points in the diamond are mutually reinforcing feedbacks and in an advanced economy become difficult to separate (Porter 1994; 2000b).

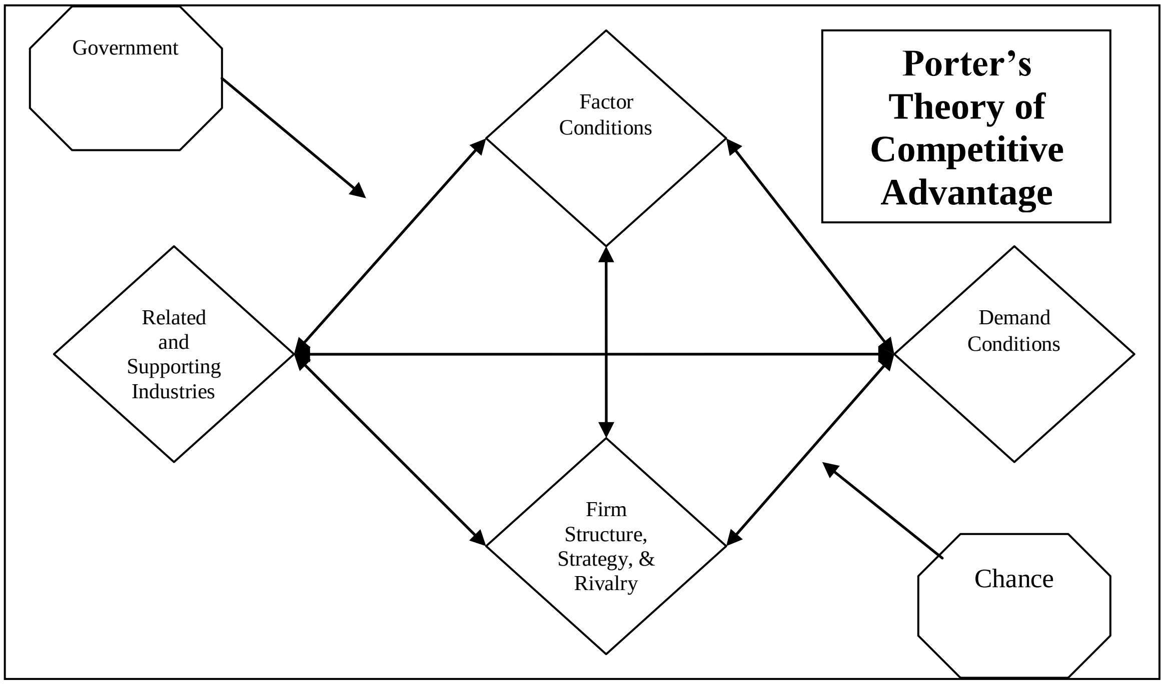

Figure 3.1: A schematic of Porter's diamond of competitive advantage (Adapted from Porter 1990).

In order to fully understand the implications of Porter's Theory of Competitive Advantage (1990) on the spatial decisions of the US farm machinery industry, each point should be first examined separately. ***Factor conditions*** are the factors of production necessary to the industry in question. These factors include such things as human and physical resources, necessary knowledge and capital, and infrastructure. They may exist in a hierarchical pattern (Porter 1990). In the steel making industry, for example, access to bulky commodities such as coal, iron ore and limestone would have more impact on location decisions than labor considerations might. In a more knowledge-based industry, however, human capital and connections to nearby research facilities and universities become more important factor conditions (Porter and Stern 2001). Certain factors of production can be created, such as infrastructure and access to capital, and factor disadvantages can be overcome by favorable conditions in one or more of the other points in the diamond. As technology continues to advance, weakness in local factor conditions can be overcome by global sourcing (Porter 1994). Nonetheless, industries are at their most efficient and competitive when the factor conditions of a selected site are strong (Porter and Stern 2001). Firms must be careful, however, not to choose a location that presents the cheapest source for the most factor conditions as the long-term consequences for productivity may not be obvious in the short-term (Porter 1998b). Incomplete knowledge of the future implies that a firm cannot assume that a site that maximizes profit today will do so in the future based solely on factor conditions. There is always an element of chance involved in site selection (Alchian 1950) and amassing multiple points within Porter's construct is a way of hedging one's bets in the future.

Porter (1990) also suggests that ***demand conditions*** are crucial to competitive advantage. The nature and complexity of an industry's domestic market can have a large influence on its success in the global economy. A highly sophisticated consumer base that demands much from its domestic industries can help to drive innovation and stimulate growth (Schroeder et al. 1995). Vernon (1979) recognized that management in companies tends to be rather myopic and requires the vision of consumers in the company's home market to drive innovation. The market segments in which the local consumers are most concerned are likely to be the ones in which a successful firm excels. For instance, because the Japanese construction industry buys more hydraulic excavators than any other type of construction equipment, this has become one of the only segments of the global construction machinery market where small Japanese firms out-compete Caterpillar (Porter 1990). A sophisticated consumer base can demand better and more differentiated products from its domestic firms and provide a window into the needs of potential customers both globally and locally (Porter 1998b; 2000b). Firms in a market with a sophisticated consumer base must constantly make decisions and attempt to predict the desires of a fickle consumer base (Hirsch 1967). This position many times leads firms to a perpetual cycle of innovation to meet customer needs. The lack of a well-developed and demanding consumer base can partially lead a firm or sector to develop low quality goods and services that are imitative of its competitors (Porter 2000a).

In addition to the importance of the sophistication of the consumers, Porter (1990) suggests that market size also has an impact on competitive advantage. He presents two sides to the argument, largely due to the fact that the consensus on the importance of the size of markets is mixed. Many believe that large markets lead to economies of scale. Others, however, see a large domestic market as a disincentive to export. In any case, it is the sophistication of the buyers that is crucial to competitive advantage. Domestic markets also become test pools for how well a good or service will be received on the world stage. Being able to anticipate the desires of international buyers because of experience in a challenging domestic market will reduce costs and increase competitive advantage (Porter 1990).

Related and supporting industries are also important to the competitive advantage of corporations and nations. The presence of a network of industries that supply the key sector as well as related industries that can stimulate innovation and drive competition can make an industry thrive where others fail. (Porter 1990) Local suppliers and partners can work together to spawn new innovations in products and production methods (Porter and Stern 2001). They also can exchange information and data cheaply and act as a system of checks and balances to prevent opportunistic behavior among certain members of the cluster that might limit competition or innovation (Porter 1994; 2000b). Sourcing parts and knowledge from local areas instead of distant suppliers can reduce transaction costs and stimulate partnerships and synergies between firms (Porter 2000b). When firms are closer to their suppliers, they can reduce the amount of parts inventory they must carry and move toward more efficient just-in-time (JIT) manufacturing systems. Complementarities between firms can enhance productivity, stimulate innovation, and provide opportunities for joint marketing at reduced costs (Porter 2000b).

The fourth point in Porter's Theory of Competitive Advantage (1990) is ***firm structure, strategy, and rivalry***. This covers many of the day-to-day decisions of management as they pertain to competitive advantage. This can be as simple as a decision to participate in the local community through the chamber of commerce or philanthropic activities, both of which can foster deeper connections with local related and supporting industries and competitors (Porter and Stern 2001). Competitive advantage can be greatly impacted, both positively and negatively by what may appear to be very minor decisions at the firm level (Hill and Brennan 2000). Firm structure, strategy and rivalry also include considerations related to the nature of domestic rivals and how they stimulate innovation and growth.

Management decisions and goals should match well with the sources of competitive advantage coming from other points on the diamond. Many managers do not think of their day-to-day decisions in this manner. They become preoccupied with what is best in the short-term and not the long run success and viability of the firm (usually due to a need to produce short-run dividends and please shareholders), missing the important connections between location and management decisions (Porter 2000b). In addition to the importance of the management decisions, consideration of rivalry can also impact competitive advantage. Domestic rivals stimulate not only local competition, but also status in the global market. Peer pressure and stress to distinguish oneself from one's competitors drive rivals to innovate and create new products and more efficient processes. Observation of the behavior of nearby domestic rivals can reveal their weaknesses and illuminate niche areas of the market where demand is not being filled (Porter 1980; Porter 2000b). Firms and industries that exhibit low productivity often lack strong local rivals (Porter 1998a; 2000b). "National champions" that are heavily subsidized to excel without domestic competitors often are not as competitive internationally as those firms that are forced to compete locally (Porter 1990).

In addition to the four points of the diamond that interact with one another, two additional outside factors, ***government*** and chance, influence the four points. The two exogenous forces impact the diamond as a whole so as to shape the nature of competitive advantage in an industry or nation. Government policy and incentives can stimulate or restrict an industry, often at a microeconomic level (Porter 2000b). This can occur on the local or national level to stimulate investment, enhance infrastructure, and/or improve opportunities for organic clusters (Porter 1990; Porter and Stern 2001). Local tax incentives and openness to trade and investment can promote construction of new manufacturing sites. Government encouragement of innovation capacity can increase competitive advantage for not just one industry, but the entire region or country (Porter and Stern 2001). Regulations on safety or environmental damage can add to the fixed costs of production causing firms to raise prices to the consumer.

Similar to the role of government, ***chance*** can impact the points of the diamond to shape competitive advantage in a nation or economic sector. Chance events are usually outside the control of individual firms and have little to do with day-to-day operations of the sector. They are idiosyncratic moments that are often disruptive to the industry as a whole. These may occur in the form of inventions, wars, advances in basic technology, or shifts in foreign demand (Porter 1990). At times, a moment of chance can create a shift in demand or in factor conditions (Porter 1998b). Pred (1972) discusses this chance phenomenon in terms of "shocks to the system" and found that they have profound effects on location decisions, even if the actual event seems to have little to do with the industry in question.

The role of chance in economics is not an idea that Porter (1990) revolutionized. Alchian (1950) discussed the role of uncertainty in evolutionary economic theory and the importance of accounting for it in any economic analysis. Human behavior is unpredictable as is life. Some amount of economic success for any firm comes as a result of sheer luck or pure chance as Porter (1990) would phrase it. Some firms will transition successfully through the changes that chance brings while others will not alter their course and instead fall by the wayside. For a complete understanding of competitive advantage at any unit of analysis, one must account for the possibility of chance.

Porter's Theory of Competitive Advantage (1990) can and has been utilized at multiple scales. In addition to its most common application to understand countries and regions, it can be used to study smaller units such as industry sectors and individual firms (e.g. Schroeder et al. 1995). Porter's diamond has been widely applied to understand competitive advantage in other countries. Ozlem (1999) found that the construct was applicable to an analysis of the economy of Turkey. He made extensive policy recommendations for the country based on Porter's work. Driffield and Munday (2000) cite the construct as a best practice method for economic development of a nation. With a few exceptions, the application of Porter's diamond has been largely ignored, however, for use in understanding individual industries. Boasson and MacPherson (2001) and MacPherson and Boasson (2004), however, have used the construct to understand the US pharmaceutical industry. Additionally, Bowen and Leinbach (2006) applied Porter's model to examine the airfreight and electronics industries in Southeast Asia. There is a continued need to employ Porter's construct to individual industries in order to evaluate the model's robustness and applicability.

Porter's research has faced serious criticism from others in the field (for a summary see Davis and Ellis 2000). Many have questioned its applicability to developing economies and countries that are largely influenced by foreign direct investment (FDI). Ozlem (1999) and Bowen and Leinbach (2006) were, however, able to use the construct effectively to understand Turkey and industries in Southeast Asia, respectively. Moon, et al. (1995) adapted Porter's model to a double diamond and applied it to understand countries with high levels of FDI, such as South Korea and Singapore (Moon et al. 1998). The double diamond model uses the same anchor points, but accounts for the fact that many small and developing economies employ not only a diamond related to local advantages, but also a second diamond that sources advantage from global locations as well (Moon et al. 1998).

Despite the criticisms of Porter, Yetton et al. (1992) found that the model was useful for understanding developed economies and mature industries. Given that the Big Three fit into both of these categories, it is assumed that the problems in Porter's research that have been identified by other scholars will not impact this study. I do believe, however, that some modifications to the model will result from my empirical testing using the US farm machinery industry as a case study.

In addition to discussions of the suitability of Porter's Theory of Competitive Advantage (1990) for varying types of economic systems, there has been a prolonged discussion among economic geographers about the theory itself. Many mainstream geographers dismiss Porter's work as not being geographic (Martin 1999). They believe that because Porter has not subjected his research to empirical tests in real places that it has no position in the economic geographic literature (Martin 1999). Porter (1994) has recognized that many dismiss his work because they feel that location is becoming less important in a global economy. Through this dissertation, I hope to prove that not only are distance and location important, but also to conduct an empirical test of Porter's Theory of Competitive Advantage (1990) in a real place to refine the theory and improve the model.

Porter's construct is useful for examining the Big Three in the US farm machinery industry and, as Martin (1999) and several economists have mentioned, is a location theory in need of empirical testing. Given the fact that Porter's Theory of Competitive Advantage (1990) is the foundation of many local economic development plans (World Bank 2010), it is crucial to evaluate the theory and determine its suitability for wider application to mature manufacturing. While there are numerous other location theories that could be tested through a case study of the US farm machinery industry, Porter's Theory of Competitive Advantage (1990) is well-suited and most in need of empirical evaluation and therefore was selected for this research.

3.3 Organizational Studies Models

To evaluate Porter's Theory of Competitive Advantage (1990) and place the Big Three into geographic space requires an understanding of numerous other organizational studies models. Each of the points in Porter's diamond can be better explained through certain other theories including the literature on location decisions for headquarter and R&D sites. This is supplemented by studies of the creative class, developed by Richard Florida (2002), which indicate that the types of environments that are most conducive to attracting the labor necessary for headquarters and intensive R&D are going to be those that offer a wide variety of amenities and an open-minded population. Also important to the empirical test of Porter's model, as it pertains to the US farm machinery industry, is product life cycle theory (Vernon 1966) and place-based product life cycle theory (Vernon 1979), which relate manufacturing location to how standardized the product has become (i.e. how far along the life cycle from innovation to maturity are the goods). Recent studies relating to industry growth through green technology also proved important, especially in light of AGCO's shift to market zero-emission tractors and other self-propelled farm machinery (Friedman 2008).

3.3.1 Headquarter Location Studies

One important area for a study of this type is the headquarters location literature, which speaks to factor conditions and firm structure, strategy and rivalry within Porter's model. Stability and success for JD has been identified as maintaining its Worldwide Headquarters in Moline, Illinois, while AGCO and CNH have moved around the country and the world. The headquarter literature provides a rich resource for location theory, both with respect to why companies select sites and why they choose to move from one site to another.

Klier and Testa (2002) studied the location trends of a number of large companies' headquarters throughout the 1990s. They found that many companies try to balance both positive and negative factor conditions in selecting a site. Many headquarters, located in large metropolitan areas, while benefiting from sizeable pools of skilled labor, highly specialized business services, and transportation and communication linkages, suffer from the negative externalities such as traffic, congestion, and high land rents. These headquarters move to new sites that lack the negative externalities, but have as many of the necessary factor conditions as possible. Gong and Wheeler (2007) believe that, for these reasons, many corporations are shifting to the southern US, choosing second-tier cities over traditional large metropolitan areas.

Aksoy and Marshall (1992) found similar patterns in England as companies searched for competitive advantage outside London. As the example of Bank of America in Charlotte, North Carolina has demonstrated, positive factor conditions can be generated more easily than negative ones can be expunged (Smith and Graves 2005), making second-tier cities fertile ground for headquarter locations.

While the headquarter location decision literature is useful for understanding what makes a site attractive to a corporation, in general, it does little to explain specifically the farm machinery industry's decisions. Shilton and Stanley (1999) and Goodwin (1965) found distinct clusters of management functions within the metropolitan US. Porter (2000a) believed that many companies located their headquarters within these clusters because there is greater access to capital and people who have appropriate knowledge and experience. There are fewer barriers to entry and more opportunities when a firm locates its headquarters in one of these existing clusters. Strauss-Kalm and Vives (2007) found that headquarters are less likely to locate at a great distance from other headquarters in their industry.

3.3.2 Research and Development Location Studies

Coupled with the literature on headquarter locations is that which discusses suitable locations for companies to pursue R&D activities. This body of research addresses all four points in Porter's diamond in one way or another whether through factor conditions related to labor, demand conditions related to developing a product that responds to the needs of sophisticated consumers, research synergies created by related and supporting industries, or executive decisions as a component of firm structure, strategy, and rivalry. Many of the studies on R&D functions for large corporations, such as the Big Three farm machinery manufacturers, find the majority of R&D in metropolitan areas, near the company's headquarters. Malecki (1979) found concentration of R&D functions to be even greater than that simple model, with most sites being in a handful of northeastern and Sunbelt cities. More recent studies have demonstrated the increasing globalization of R&D with many companies now conducting five to 25 percent of their innovation in international locations (Nobel and Birkinshaw 1998), likely due to the cost savings these locations provide (Hirsch 1967). Additionally, second-tier cities, both in the US and abroad are increasingly attractive as R&D sites, largely for the same reasons they are attractive for situating headquarters (Gong and Wheeler 2007). Porter and Stern (2001), however, stress that R&D location decisions should not be driven by cost considerations, but rather because the external environment is conducive to stimulating innovation.

3.3.3 Creative Class Cities

Within the study of the R&D and headquarter location decisions of the Big Three US farm machinery manufacturers, another branch of literature becomes important. Research into the geography of talent and creative class cities indicate that the type of labor necessary in both command and control and innovation would be most easily attracted to cities with above-average diversity and a dense network of high-technology jobs (Florida 2002). While most would say that the types of innovations that mature industry, like farm machinery, make do not require creative people, with the introduction of cutting-edge zero emissions technology and precision navigation in tractors, that may not necessarily be the case.

3.3.4 Product Life Cycle Theory

In addition to the studies on headquarter and R&D locations, other organizational studies models can contribute to the evaluation of Porter's Theory of Competitive Advantage (1990) as it pertains to the US farm machinery industry. Perhaps one of the most interesting in terms of its geographic implications is Vernon's product life cycle theory (1966), which was subsequently updated as place-based product life cycle theory (1979). Vernon states that as products progress from development and introduction to maturity and obsolescence, the manufacturing processes as well as the sites that companies chose to manufacture will shift to maintain competitive advantage. Early in the life cycle of a product, its production processes are unstandardized and require highly skilled labor and manufacturing flexibility, both conditions that are more likely to be found in advanced economies, such as the US (Vernon 1966; Schroeder et al. 1995). Expenditures in R&D will be highest during this period of the life cycle (Vernon 1966). As the product matures, however, manufacturing process become more mature and high-skilled labor can be substituted for capital investments in a standardized manufacturing process and production can be moved to lower cost areas such as the US south (Kalafsky 2006), or international locations (Vernon 1966). As manufacturing becomes increasing more technically advanced in the US, firms are more likely to see shorter product life cycles between introduction and standardization (Vernon 1979; Gaines 2010d).

In terms of Porter's framework, this can have impacts on factor and demand conditions as well as firm structure, strategy, and rivalry. Porter and Stern (2001) believed that advanced economies cannot maintain competitive advantage if they continue to produce standard products that are at the end of their product life cycle or if the firms continue to use standard production methods. Remaining at the forefront of the product life cycle and continuing to be innovative has lasting impacts on the economic development of not only the individual firm, but the region that the firm is located (Hill and Brennan 2000).

3.3.5 Industry Life Cycle Theory

Along with looking at the life cycles of the individual products in the farm machinery industry, it is also necessary to consider the impacts that the life cycle of the industry itself can have on location decisions. Audretsch and Feldman (1996) have found that industries tend to cluster both at the beginning and the end of their life cycles. At the early stages, when many new products are being developed, it is easiest to be densely clustered, where new ideas can freely flow and necessary parts and materials for new designs can be quickly accessed. Evidence of clustering at the birth of industries has been documented in industry studies, and is often cited as a contributing factor in an industry's success (Atwood 1928). At the end of an industry's life cycle, as the mature sector seeks its next new Schumpeterian reincarnation[5], it again needs this concentration to create synergistic brainstorming sessions and develop new products and manufacturing processes (Porter 2000b).

3.3.6 Green Technologies

One final area of research that is relevant to the evaluation of Porter's Theory of Competitive Advantage (1990), as it pertains to the US farm machinery industry, is the newly emerging studies on green industries. To remain on the forefront of the product life cycle, and therefore remain competitive, a firm must constantly be developing new technologies for its

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[5] Schumpeter (1950) proposed that in a healthy economy, there must be "creative destruction" whereby old industries deteriorate and disappear and new industries, which are better able to compete in a changing economic landscape, are created.

products. Technology and competitiveness are therefore very closely linked (Schroeder et al. 1995). Friedman (2008) believed that American corporations can gain market share in a global economy by developing cutting edge green technology, including tractors and other self-propelled machinery that use less fuel and/or produce less emissions. Porter and Stern (2001) believed that the firms with the greatest competitive advantage were those that keep advancing the technological frontier faster than their rivals can keep pace. For Friedman (2008) that new frontier is going to be in the area of green technologies. Reports by the Atlanta branch of the Federal Reserve Bank (2010) support this, indicating growth in manufacturing in the southeast for companies producing environmentally friendly goods and speculating that continued growth through 2011 will be in sectors producing green products. Porter and van der Linde (1999) agreed, stating that the way in which a company responds to environmental regulations is a proxy for overall competitiveness. The most competitive firms will innovate to meet regulations while less competitive firms will fight regulations. For the farm machinery, these regulations primarily deal with emissions standards. A recent report on the status of the US farm machinery industry further confirms that fact, stating that "… the ability of a manufacturer to produce energy efficient, low emission machinery gives firms an important competitive advantage over other firms" (IBISWorld 2009: 12).

Friedman (2008) is not the first to propose green technology development as a competitive advantage strategy. Porter and van der Linde (1999) discussed how becoming green could increase a company's efficiency in the long run and improve its position in the global economy. They believed that there is a prevailing myth in management that competitiveness and environmental regulations are not compatible. Instead there has to be a trade-off between the two. By constructing case studies in several industries that have dealt with increasing environmental regulation, they found little evidence, however, of this trade-off (Porter and van der Linde 1999). Instead companies often were driven to innovate and develop industrial processes to meet environmental standards. These innovations usually streamlined production processes, reduced wastes, and improved product quality. Schroeder et al. (1995) believed that one of the ways companies remain on the forefront of the product life cycle is by developing new and more innovative production processes. In fact, manufacturing technology and competitive advantage were very tightly linked. Porter and van der Linde (1999) found that, in most industries, the pollutants that regulations were trying to reduce were often wastes of an inefficient manufacturing process. Companies could meet environmental regulations while reducing bottom line costs and increasing competitiveness. First movers to the technology become pioneers with additional name recognition in the industry (Porter and van der Linde 1999). Additionally, once the new production process was in place, the firm could capitalize on the “greenness” of its product, commanding a higher price for it in the marketplace (Porter and van der Linde 1999).

Lash and Wellington (2007) made suggestions about how businesses can seize green opportunities to build competitive advantage by reducing a company’s global warming contribution and reframing its image to be more environmentally friendly. Examples of this can be seen in the construction industry, where, “a fleet which includes the newest Tier 4 generation machines would certainly give a contractor a competitive advantage in some projects and areas, particularly those in air quality non-attainment areas” (A. Schaeffer, quoted in Grooms 2010a: 11). Lash and Wellington (2007) believed that an awareness of a company’s green image could increase competitive advantage by reducing risk, improving marketing and efficiency, and providing opportunities for firms to innovate into new areas of the economy. They cited the example of Caterpillar that not only was a leader in meeting emissions standards in the construction industry, but also spun off a division of the business dedicated to the manufacturing of catalytic components that all diesel engine manufacturers would need in the future to meet emissions standards (Lash and Wellington 2007). Their primary contention in this research, however, was that much of the risk that a company faces in a greener economy is by not being on the leading edge of innovation. While they recognized the opportunities for financial gains through innovation, they were most concerned with impacts from litigation, regulations, and negative perception of image if a firm does not green its image as fast as competitors (Lash and Wellington 2007).

Freidman (2008) advocated for more than just reducing pollution in the manufacturing process and reshaping image. He believed that manufacturing firms in the US can regain competitive advantage by developing the next wave of green technologies. This is further backed by recent statements by venture capitalist, John Doerr, who believes that, along with biotechnology and information technology, green technologies could very well be the next money-making opportunity for the US economy (Lash and Wellington 2007). The member of the Big Three that can best capitalize on the opportunity may be in a different position in terms of competitive advantage in the future.

3.4 The Need for Further Geographic Analyses of Organizational Studies

While much has been written in the organizational studies literature about Porter, individual manufacturers, headquarters, R&D locations, geographies of the creative class, product life cycle theory, and the development of green industries, a gap exists where organizational studies and agriculture intersect. While Porter's construct has been applied to explain some industries, to this point the farm machinery sector has been largely ignored. Geography as a discipline has given little attention to Porter's theories despite their inherently geographical nature. Martin (1999) criticizes Porter's model, dismissing it from the realms of economic geography because the model has not been empirically tested using real places. This study can provide that requisite testing using case studies of real places and real firms to establish credibility for the model within mainstream economic geography.

There also has been little research into the farm machinery industry either in general, or more specifically by geographers. Case studies related to the sector (Chandler 1977; Porter 1980) have not been updated since the consolidation of the US farm machinery industry in the late 1970s and 1980s. Geographers have looked at the history of manufacturers in the Midwest (Leichtle 1995). Another geographer examined the early location decisions of US farm machinery firms in the nineteenth century (Pudup 1987). This economic geography study, while compelling and pertinent to my own research, is desperately in need of an update and expansion. Pudup (1987) examined the location dynamics of the industry when there were hundreds of small firms. How then did the US end up with just three large firms? Given the importance of farm machinery to agriculture and agriculture to the US economy, the lack of literature on the industry is a problem that deserves a resolution.

Specific cases of headquarter and R&D location decisions by different corporations have also received little attention. The literature on green industries remains a new avenue also in need of further study. It is the aim of this research to begin to fill the gaps where Porter, agriculture, and organizational studies models coalesce.

CHAPTER IV
DATA AND METHODOLOGY

4.1 Theory-Elaborating Case Study Methodology

The examination of geographic applications of the organizational studies literature through the lens of the Big Three US farm machinery firms requires a concerted effort to understand each company's history and corporate strategies – often known as process research (Langley 1999). Qualitative studies using process data are increasingly the choice for researchers studying problems at the industry or firm level who want to get beyond basic numbers to understand underlying processes (Markusen 1994). The use of multinational corporations, such as the Big Three, as the unit of analysis, in studies that seek to validate and/or expand existing theory has been verified by numerous researchers (for a review of articles see Roth and Kostova 2003). Given the complexity of multinational corporations, process research about them tends to lead to expansion and modifications of theories (Roth and Kostova 2003), which will be useful in an empirical study such as this.

There are a number of different strategies that can be employed to analyze and understand process data, each with its own strengths and weaknesses (Langley 1999). Given the desired outcomes to understand the US farm machinery industry in reference to spatial applications of theories in organizational studies, I will employ a case study methodology. Through content analysis I hope to understand each of the Big Three as they relate to prevailing models in organizational studies, including headquarters and R&D siting, product life cycle theory, and industry life cycle theory. The type of interpretation that is employed to understand the process data will impact the accuracy, simplicity, and generality of the results (Langley 1999).

One of the criticisms of many process data analysis methods is that they produce very shallow findings that cannot provide predictive power or theory (Langley 1999). Case studies, especially at the firm level, are most useful when they are carefully grounded in theory and have the ability to expand or create new conjecture (Roth and Kostova 2003). One process method that can provide predictive power and theory is synthetic strategies, where the researcher looks at the whole picture, and identifies regularities from multiple cases that can serve as evidence of theory (Langley 1999). Eisenhardt (1989) provides a case study methodology designed to build or expand theory that follows in the tradition of these types of synthetic strategies for analyzing process data. Examples of this methodology are abundant in management research (e.g. Eisenhardt and Bourgeois 1988; Bryson and Bromiley 1993; Schroeder et al. 1995). It is a less popular strategy in economic geography, but for the purposes of this research, it is appropriate because it should provide a clear picture of how existing models in the organizational studies literature fit with the case study and elucidate opportunities for the expansion of existing theory or the development of new theory. Following Eisenhardt's model closely, I can evaluate the suitability of Porter as an explanation of competitive advantage in the US farm machinery industry and also inductively elaborate on existing theories related to the impact that geography has on the US farm machinery industry. I also may be able to determine whether there are other theories in organizational studies in which geography plays a major role.

An effective industry study of this sort requires many different data sources that can provide high quality information, even if it is not available in large quantities (Markusen 1994). Eisenhardt (1989) recommends using multiple sources to gather data to analyze each of the cases. Porter (1980) outlines a number of data sources that can be parsed for information about operations, performance, and competitive advantage of firms. Following these examples, several data sources were identified and employed to construct the individual cases. Appendix A outlines the types of data that were employed to obtain the findings for each firm in the various analyses conducted in Chapter V. Markusen (1994) clearly states that a researcher cannot assume that all leading firms in an industry are "…peas in a pod" (481). Each company is different and displays its own idiosyncratic tendencies that may or may not fit expected patterns. For this reason, data for each case must be collected and analyzed separately using a variety of primary and secondary sources (Markusen 1994). This study of the US farm machinery industry includes: 1) an intense literature review of documents provided by the companies and obtained through archives and databases; 2) trade show reconnaissance (Bathelt and Schuldt 2008), where photographs from the display areas and field notes were parsed for meaning with content analysis software; and 3) publically available plant tours of the Big Three's facilities. O'Hara (1993), in studying the marketing behavior of firms within a specific industry, clearly states that one cannot only look to one source of data in drawing conclusions about individual firms. I supplemented content and tabular analysis of these data with exploratory map analysis, which highlights spatial factors in the location of the Big Three's US facilities. Incorporating the data into the case study methodology should improve the understanding of the location decisions of the US farm machinery industry and allow for a reflexive and empirical test of Porter's Theory of Competitive Advantage (1990).

4.2 Data Sources

4.2.1 Document Analysis

One of the key aspects of the case study methodology is an in-depth study of documents either provided by the corporations themselves or publically available. Documents can include the content of corporate websites, annual reports, newspaper and trade journal articles, and brochures published by the companies. Much information about the individual firms can be gathered from documents of this type.

Ribisi et al. (2003) demonstrated the use of websites as a way to gather data. They proposed a methodology whereby multiple pages of a website are analyzed for content and keywords. Following this model, I collected images from the main page of each of the Big Three's corporate websites[6] and every page that could be accessed one page from the main page. Depending on the navigation structure of the website, the number of pages analyzed varied widely from 78 for AGCO to only 38 for JD. CNH was comparable to AGCO, and 72 separate pages were analyzed. The websites of the Big Three provided a wealth of information about operations strategies, performance over time, and even competitive advantage.

The website analyses were supplemented with other publically available documents such as recent annual reports and Securities and Exchange Commission (SEC) filings from the firms, which are also available on the individual companies' websites. Minnick (1998) discussed the importance of SEC filings in historic business research. Additionally, literature and brochures from the firms were collected at trade shows, plant tours, and dealership visits. Finally newspaper clippings and articles in trade publications, such as *Successful Farming*, *Farm Industry News*, and *Farm Journal* were also collected to further expand the sources of data on the Big Three. All of these data were employed to construct case studies following the example of Eisenhardt (1989).

[6] CNH maintains a separate website for each Case IH Agriculture and New Holland Agriculture, so images were collected from both and merged into one file for analysis.

4.2.2 Archives

Because the history of the firms in this study stretch over many decades and the firms have been subject to mergers and acquisitions, archival research was also necessary and is recommended when employing a theory-elaborating case methodology (Eisenhardt 1989; Eisenhardt and Graebner 2007). Archival data allows researchers to expand cases longitudinally beyond a snapshot in time (Markusen 1994). Archival data are abundant for these firms and the companies they have purchased over the years (Appendix B). Throughout the research, I mined three major archives for information about the US farm machinery industry (Table 4.1).

Table 4.1: Archives mined for research

Archive	**Location**	**Companies Researched (Company it Belongs to Today)**
Benson Ford Research Center	Dearborn, MI	Tractor Division of Ford Motor Company (CNH); New Holland Equipment (CNH)
Wisconsin Historical Society	Madison, WI	International Harvester (CNH); J.I. Case Farm Machinery (CNH); McCormick-Deering (CNH); Allis-Chalmers Corporation (AGCO)
University of Guelph Libraries	Guelph, Ontario	Massey-Harris (AGCO); Massey-Ferguson (AGCO)

Archival research has been used in a number of economic geography studies (e.g. Black 1995; Black 2000). Archives of the US farm machinery industry have also been used in multiple projects. Domosh (2006) used the McCormick-Deering archives at the Wisconsin Historical Society in her study of American imperialism in advertising. Nevins and Hill (1976) constructed their seminal history of Ford Motor Company, including its Tractor and Implement Division, based largely on the archives at the Benson Ford Research Center. Each of these examples indicates the suitability of archives to contribute to a study of this type. Archives provide a rich source of information both based on what is included and what has been omitted over the years (Ogborn 2003). Looking into the historic legacy of companies that make up the Big Three US farm machinery manufacturers as they exist today, sheds light on their location decisions and how well those decisions fit into Porter's Theory of Competitive Advantage (1990).

4.2.3 Trade Show Reconnaissance

In addition to data gathered from archives and publically available documents, I collected information from the firms themselves through the use of trade show reconnaissance as advocated by Bathelt and Schuldt (2008). A trade show can be defined as "… events that bring together, in a single location, a group of suppliers who set up physical exhibits of their products and services from a given industry or discipline" (O' Hara 1993: 69). Trade shows can vary in size, geographic focus (regional, national, international), and market coverage (vertical, which appeals to a single industry, or horizontal, which appeals more broadly, such as a home and garden show), and whether the show focuses on consumer awareness or sales (O'Hara 1993).

Trade show reconnaissance is a system of participant observation that mimics the critical-participatory observation that Goss (1999) performed in his study of the Mall of America. Trade show attendance allows a researcher to examine both marketing strategy and cultural production as visitors interact with display areas (Penaloza 2001). By studying the display areas of farm machinery firms, capturing images, collecting brochures, attending workshops and seminars, and participating in the full trade show experience, I was able to collect data that painted a fuller picture of the industry.

Trade shows are becoming an increasingly large portion of marketing budgets for firms and expenditures continue to grow each year (Gopalakrishna et al. 1995; Power and Jansson 2008). Firms with an extensive export portfolio of goods and large market share, relative to other firms, are most likely to exhibit at international trade shows, while national and regional trade shows are more common for smaller firms or those more focused on domestic sales (Rice 1992). Firms with larger market share will typically participate in more trade shows per year (Herbig et al. 1996). Trade shows are opportunities for manufacturers to display their products and have direct access to large pools of potential consumers all in one location. Trade shows can be a good way for a firm to penetrate a market in which it has had less involvement throughout the firm's history (Rice 1992). The trade show is a large investment for both the firm marketing its goods and the potential customer attending to gather information and make informed buying decisions (Rice 1992).

Trade shows are not, however, always about potential sales. Many trade show displays are designed to also generate "buzz" about a firm and encourage word-of-mouth advertisement by visitors long after the trade show has ended (Havens 2003). Firms often worry about the image that is projected by its presence or absence at a particular trade show (Rice 1992; Gopalakrishna et al. 1995). Many North American firms have indicated that a large part of the motivation for displaying at a particular trade show is because their competitors are also present at the show (Herbig et al. 1996). Trade shows are an opportunity for firms to battle with their competitors head-to-head and develop awareness about their products among visitors (Gopalakrishna et al. 1995). In an industry, like farm machinery, where, on the surface, products appear to be very similar, trade shows are important venues for product differentiation and establishing brand identities (Havens 2003). Additionally, given the high price tag on many pieces of farm machinery, trade shows are an opportunity to demonstrate the machinery and allow potential consumers to interact with it, which will reduce the perceived risk of investment (Rice 1992). Research has indicated the increasing importance of trade shows to corporate marketing strategies (Munuera and Ruiz 1999) and has demonstrated that the function of the trade show is not always about direct sales as much as it is about informing the public about a firm's positive attributes (Havens 2003).

Bathlelt and Schuldt (2008) explored the benefits of trade show reconnaissance in researching networks and knowledge spillovers as they pertain to economic geography. A recent review article extolled trade fairs, conventions, and conferences as good sources of knowledge flow in an industry (Hughes 2007). Power and Jansson (2008) have also demonstrated the importance of studying multiple trade shows as a method of data collection because different trade shows cater to different types of audiences and provide different views of the strategies that the firms employ. Maskell et al. (2006) even mentioned agricultural trade shows as one of the many types of temporary clusters of activity that can be mined for useful economic geography data. Trade show reconnaissance has frequently been used in marketing and management studies (e.g. Munuera and Ruiz 1999; Godar and O'Connor 2001), but has also been gaining popularity in geography (e.g. Maskell et al. 2006; Bathelt and Schuldt 2008). Power and Jansson (2008) see trade fair reconnaissance as a research tool complementary to existing methods in economic geography. "Trade shows are an important component of the marketing mix for many industrial products…," (Dekimpe et al. 1997: 55) and therefore can be a good source of data for the US farm machinery industry.

There are a multiplicity of trade shows throughout the year for the US farm machinery industry that vary in size and geographic focus, including the regional, national, and international scales (Appendix C). Almost all farm machinery trade shows can be considered vertical in market coverage for the larger agricultural industry, providing vendors not only in the machinery industry, but also seed companies, fertilizer manufacturers, precision agriculture services, and livestock management firms. While this may appear to be more horizontal in terms of farm machinery, given the inseparable connections between machinery and other aspects of farming, it is best to view the farm machinery industry as part of the larger agriculture sector to which these trade shows cater. Farm machinery trade shows are almost universally what O'Hara (1993) terms *limited service* trade shows whereby the emphasis of displays is often less directed to onsite sales and more designed to disseminate information, create brand loyalty, and answer potential customers' questions about specific products.

In the course of the research, I attended five different farm machinery trade shows, some on multiple occasions. I followed the suggestions of Power and Jansson (2008) to select shows that cater to a variety of different audiences or purposes (Table 4.2). Godar and O'Connor (2001) outline various types of audiences that a show may be catering to and the types of visual cues that can be observed to confirm the target groups. Display areas at trade shows can have varying impacts and leave different impressions on customers and prospective customers (Gopalakrishna et al. 1995). By physically attending professional trade shows where the Big Three promote their products, I observed marketing behavior and collected publically available literature to incorporate into the content analysis.

Table 4.2: Trade shows attended as part of trade show reconnaissance

Show Name	**Location**	**Dates Attended**	**Description of Show**
National Farm Machinery Show (NFMS)	Louisville, KY	February 2009, 2010, & 2011	Largest indoor farm machinery show in the US. Caters directly to farmers and producers as well as experts in the farm machinery industry. ***US-focused***
Farm Progress	Boone, IA	September 2010	Largest outdoor farm machinery show in North America. Caters directly to farmers and producers as well as experts in the farm machinery industry. ***US-focused***
Canadian International Farm Show (CIFS)	Mississauga, Ontario	January 2011	Canadian equivalent of the National Farm Machinery Show. Indoor event that caters to farmers and producers with more focus on livestock. ***North American-focused***
Western Canada Farm Progress (WCFP)	Regina, Saskatchewan	June 2010	Largest farm machinery show in North America dedicated to dryland farming. A combination of indoor and outdoor displays catering directly to farmers and producers as well as industry experts. ***North America-focused***
Ag Connect Expo (ACE)	Orlando, FL and Atlanta, GA	January 2010 & 2011	The only international farm machinery show held in North America. An indoor show designed to cater to a more international audience of producers and suppliers. ***Internationally-focused***

While conducting trade show reconnaissance, I also captured images of each of the Big Three's display areas, which were utilized in photographic content analysis (e.g. Low and Sherrard 1999; Ribisi et al. 2003; Fahmy 2004) to find further evidence of each firm's operational, performance, and competitive strategies. This is a research technique that has not been utilized frequently in geography to this point. The number of photographs that were collected for analysis varied greatly from show to show and firm to firm, depending on the size of the display area, the amount of equipment on display, and signage used in the display area (Table 4.3). Display areas for CNH provided the most images. These areas often had similar floor space to AGCO when the space used by Case IH and New Holland are combined. Given the fact that the company sometimes only displays Case IH products, it is surprising it provided the most images. Because AGCO typically uses the most signage, has the most floor space, and displays the greatest variety of equipment, it is not surprising that the firm also provided many images. The fact that JD has consistently had smaller display areas, with less signage, and in some cases, no display at all means that there were fewer images to analyze. Hughes (2007) believed that ethnographic research, such as this type of participant observation and other visual strategies can greatly add to the construction of organizational case studies.

Table 4.3: Tally of images collected for each of the Big Three at various trade shows

Firm	**NFMS 2009**	**ACE 2010**	**NFMS 2010**	**WCFP 2010**	**Farm Progress 2010**	**ACE 2011**	**CIFS 2011**	**NFMS 2011**	**Total**
AGCO	13	30	43	14	49	86	13	74	322
CNH	Case: 9 NH: 4	Case: 12 NH: NP	Case: 19 NH: 18	Case: 11 NH: 15	Case: 61 NH: 39	Case: 70 NH: NP	Case: 33 NH: NP	Case: 49 NH: 30	Case: 264 NH: 106
JD	2	16	11	13	19	10	NP	32	103

NP = not present at show

Numerous articles in the organizational studies literature have attempted to create conceptual frameworks to help researchers gather data from trade shows (e.g. Dekimpe et al. 1997; Hansen 1999). Dekimpe et al. (1997) looked at trade shows in various countries and industries to measure their effectiveness related to the marketing strategies of the firms that participate. They suggested that researchers examine various aspects of the trade show at the scale of the individual firms, including the level of pre-show promotion investment, the size and orientation of the booth to foot traffic, the number of sales personnel available on the floor for potential customers to speak to, and the types and relative size of trade shows at which a firm chooses to display. Studying these aspects can help a researcher better understand the goals of the firms. Hansen (1999) similarly suggested several areas that should be considered when observing a firm's behavior at an industry trade show including selling and non-selling behaviors and the ability of a booth to attract visitors. Rice (1992) has indicated a positive correlation between success of a firm at a trade show and the investment that is put into the space both in dollars and personnel on the floor. Herbig et al. (1996) believe that, "The single most important factor affecting the ability to make contact is the number of personnel on duty" (102). Also important is the use of live-action demonstrations of goods to draw in foot traffic and increase "buzz" (Rice 1992). Rice (1992) suggests that the observer must take into account not only the exhibit, but also the actions of the personnel and other activities such as receptions and seminars. "…Trade show participation is too expensive to be left to the formal exhibit alone" (Rice 1992: 41). The observer should make note of strategies that a firm uses to keep potential customers in an area for as long as possible and evaluate the effectiveness of those strategies. All of these characteristics were taken into account and recorded in a field notebook as I attended the various farm machinery trade shows.

4.2.4 Publically Offered Plant Tours and Dealership Visits

Another source of data about the Big Three can come through publically offered plant tours that the firms give at some of their facilities. These tours are often a critical part of the companies' integrated marketing communications (Mitchell and Orwig 2002). Plant tours are designed to provide a multi-sensory experience that allows consumers and other tour participants to establish a connection with the brand while learning about the firm's operations, production process, and historical significance (Mitchell and Orwig 2002). Plant tours are often an overlooked source of data about a company (for an example of effective use of plant tours in research, see Schroeder et al. 1995). They are, however, commonly employed in business as a method to learn and assess operations for employees at all levels from management to production (Upton and Macadem 1997). Written reports about the inner workings of an individual plant are often outdated and do not present the same type of image of a firm's performance as can be obtained through an onsite visit to a manufacturing facility (Upton and Macadem 1997). Plant tours that are undertaken academically usually occur for one of three reasons: learning, assessment, or teaching (Upton and Macadem 1997). I followed the suggestions of Upton and Macadem (1997) on how to engage in a learning tour, including the development of a conceptual framework to organize the variety of ideas presented in the course of the tour. Such a conceptual framework allowed me to make sense of the operation as a whole after the tour was completed.

Each of the Big Three has at least one plant at which it offers public tours. Other special tours may be available by contacting the company. Appendix D lists the tours that are currently publically available among the Big Three. In addition to plant tours, I was also able to occasionally visit independent dealerships of the Big Three. Kruse (2005) discusses different types of observational fieldwork – organized tours and unsupervised observations. My plant tours were organized tours, led by employees or retirees of the company, while my dealership visitations were thoroughly unsupervised and allowed me to collect literature from the company and observe the advertising signage used by the various companies.

In the course of the research, I toured three of CNH's facilities (Table 4.4). While it would have been ideal to attend facilities from all of the Big Three, CNH has the most facilities open for tours and its facilities were the most accessible for research. The information that was offered on these tours allowed me to compare actual observations of the workings of the company with statements made by the company in written documents. While documents are often easier to access, Upton and Macadem (1997) pointed out that text is a poor substitute for seeing the actual operations of a company. They also recommended tours of multiple factories to gather as much data as possible and allow the researcher to acquire a "practiced eye and develop a richer base of comparison for subsequent tours" (Upton and Macadem 1997: 106). Each tour is unique and provides a different insight into the company and its operations (Kruse 2005). To get the most benefit from the tour and collect as much data as possible, the observer must be open-minded and not enter the tour with pre-conceived notions of what to listen and look for (Upton and Macadem 1997).

Table 4.4: Plant tours taken during research

Plant Name	Company	Location	Function
New Holland Operations	CNH	New Holland, PA	Hay tool manufacturing; North American HQ of New Holland Agriculture; R&D for hay and forage tools, combines, and cotton pickers
Dublin Works	CNH	Dublin, GA	Compact diesel tractor manufacturing and assembly
Saskatoon Works	CNH	Saskatoon, Saskatchewan	Planter and seeder manufacturing

Most plant tours are led by employees or recent retirees. These employees may demonstrate different interpretations of a company than corporate people and thereby offer another view on the inner workings of a firm (Markusen 1994). Upton and Macadem (1997) recommended engaging workers on the floor in discussions as well to get the most variety of information from as many differing perspectives as possible. Kruse (2005) and Mitchell and Orwig (1997) both pointed out that the dialogue that is presented during an organized tour often represents a manipulation of the actual discourse, carefully constructed based on the image the company wants to portray to the visitors. An experienced researcher, schooled in the inner workings of the industry, however, can parse these discourses for actual meaning, taking a critical look at the discourse with which he or she is being presented (Kruse 2003). Using a critical participatory method of observing culture (Goss 1999), similar to that used by Kruse (2005) to parse actual meaning from organized tours of sights important to the legacy of the Beatles in Liverpool, England, can provide good data. Employing the knowledge of the farm machinery industry, which I have developed through the course of this research, allowed me to gain many insights from the plant tours.

4.3 Content Analysis

Once the data were collected through archives and publically available documents, trade show reconnaissance, and plant tours, they were evaluated to look for patterns and keywords that would indicate the use of prevailing models in the organizational studies literature to make operational and location decisions. The dissertation qualitatively compared strategies to Porter's Theory of Competitive Advantage and other theories in the organizational studies literature. Porter's construct was evaluated using a continuation of Eisenhardt's (1989) theory-elaborating case study method. Using content and tabular analysis, I looked for keywords in the data that indicated theories in practice. Content analysis, which has been advocated as a good methodology in economic research by Holbrook (1977), is the process by which researchers identify a number of categories and then tally the number of instances of keywords within the research notes that fall into each category. The categories need to be specific enough to allow multiple researchers to arrive at similar categorization of the same material (Silverman 2000).

Content analysis was conducted within QDA Miner, using a researcher-generated code book, to look for theories in practice. Pictures taken at trade shows, archival documents, newspaper and trade publication articles, and documents provided by the company, as well as images of web pages, field notes from trade shows, archives, and plant tours were all imported into the software for visual inspection and manual coding. The results of the coding were then summarized by the software in a series of reports that I interpreted as I looked for evidence of various organizational studies models in practice in the operations of the Big Three.

Content analysis allowed me to categorize the large amount of data that was collected, including images captured at various trade shows in a search for detectable patterns (Creswell 2003). Coding the data permitted me to break them into more significant chunks that were parsed for meaning (Creswell 2003). As the categories of keywords began to take shape, negatives cases, which did not fit the model, presented themselves. It was then necessary to decide if the negative case was best explained as a category missing from coding or as data that did not fit the expected pattern (Ryan and Bernard 2000). Studies by Beaverstock et al. (2000) and Malloy (1998) have demonstrated the suitability of content analysis in studying problems in economic geography. The addition of tabular analysis, where lists of information for each company are systematically compared, were also of use as I analyzed the collected data (Eisenhardt 1989).

4.4 Exploratory Map Analysis

Adding to the data collected as part of the theory-elaborating case study methodology, I also examined location decisions through exploratory map analysis of the spaces that the Big Three occupy in the US. Appendix E and Figures 4.1 and 4.2 outline these locations. Notice that CNH's Worldwide Headquarters in Amsterdam has been proxied with its North American Headquarters in New Holland, Pennsylvania and Racine, Wisconsin largely because the majority of executive power resides in these facilities and not the Worldwide Headquarters in Amsterdam. By looking at these locations in terms of the points in Porter's model that can be mapped[7], I can better determine what makes a location desirable for the various functions (headquarters, R&D, manufacturing, assembly) of the Big Three.

Geographic information systems (GIS) are powerful tools for analysis of both spatial and non-spatial information. They allow for query and visualization of large data arrays. Not only can GIS handle spatial statistics, but they can integrate non-spatial variables and generate new data obtained from combination and overlay (Cheng et al. 2007). As Navalgund et al. (2006) discovered, GIS not only can process the data, but present it in a manner that is easily digestible for policy makers and the general public. "…GIS provide an environment in which to classify the differences between places in terms of a continuum of characteristics rather than dummy variables" (Srinivasan 2002). Robinson and Kapo (2004) chose GIS analysis over traditional linear regression models because of the software's ability to provide relationships that can be

[7] Factor conditions, demand conditions, related and supporting industries, firm structure, strategy, and rivalry, and government can all be mapped at some level. Chance, by its random nature, cannot be modeled in a map.

applied to other areas of study. Data-driven GIS models make fewer assumptions than linear regression equations, making them a more powerful analysis tool. Additionally, GIS models are very flexible and their models can be quickly adapted to accommodate changes in the study subject. Birkin et al. (1996) praised GIS tools for providing researchers with both the ability to proactively plan and retroactively adapt to factors impacting the phenomenon they are studying. For the purposes of site location research, they are proven and useful tools for analysis.

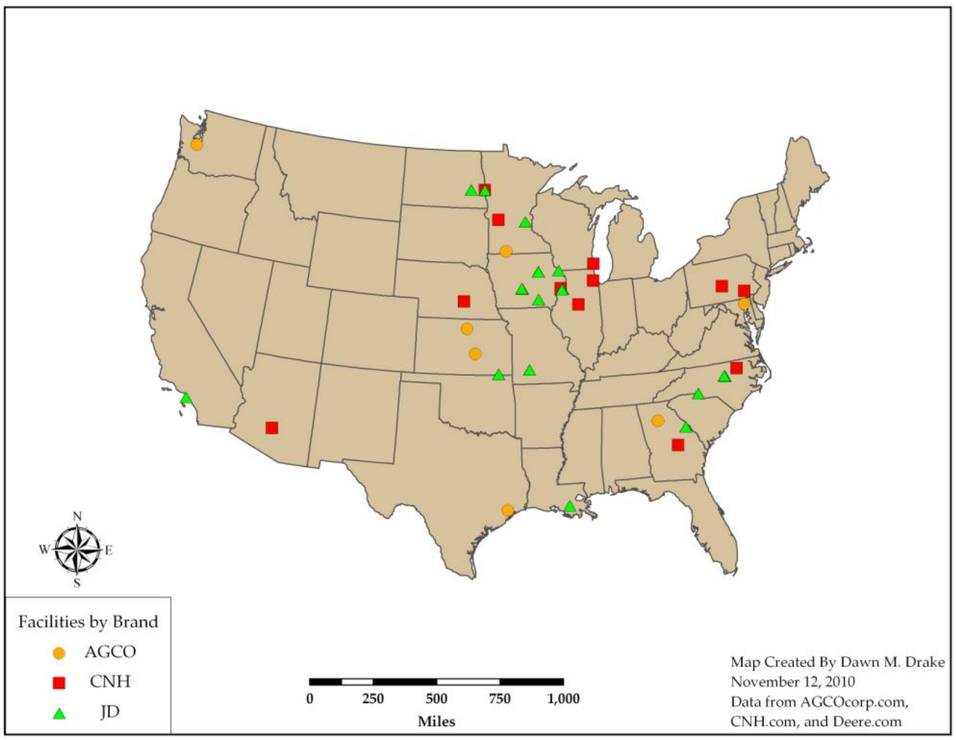

Figure 4.1: Locations of the US facilities of the Big Three, categorized by manufacturer.

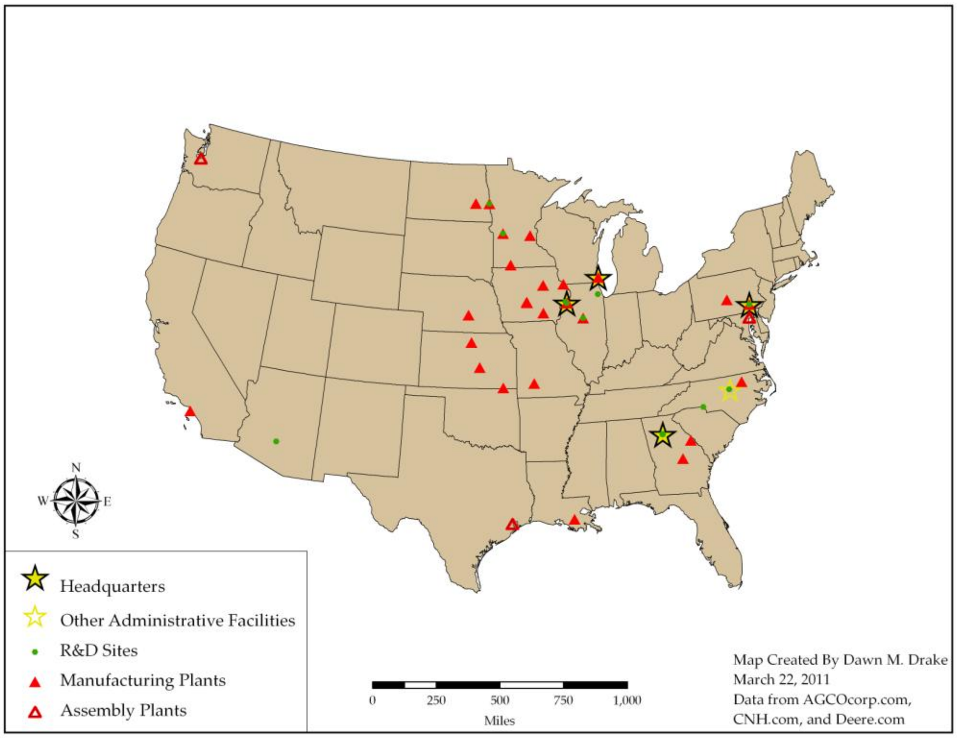

Figure 4.2: Locations of the US facilities of the Big Three, categorized by function.

Many different researchers have used the tools provided by GIS software packages to analyze a variety of location decisions. While the majority of the studies have been in the retail sector, Moeller-Jensen (1998) used GIS to help Danish government officials select the optimum site for a new school. The most popular applications of GIS, for retailers, have been situating new malls and store locations (Golley 1991; Cheng et al. 2007). Clarke (1998) dates the beginning of the GIS revolution in retail site selection to the mid-late 1980s, although site location research itself dates back to the 1960s (Birkin et al. 1996). Much research has been done in Europe on how to best use proprietary and custom-built GIS tools to select sites for big box stores (Webber 1996; Benoit and Clarke 1997). Foust and Botts (1990) used a simple GIS model to select the best site for a new bank branch in a Wisconsin city. All of these studies demonstrate noteworthy methods for determining ideal sites.

Another application for GIS is in industrial site selection. Industrial site selection is a complex process that involves both environmental and economic considerations. Navalgund et al. (2006) used GIS to develop an atlas of land suitable for industrial use based on environmental concerns in India. On the other hand, Buurman and Rietveld (1999), Wu (2000), and Holl (2004) used economic models, based largely on the work of Weber (1929), to parse out appropriate sites for industrial location in Thailand, Spain, and China, respectively. These studies focus on transportation links, labor pools, supplier networks, and consumer markets. Similar work has been done in the US by Singletary et al. (1995), who looked at a variety of locations in South Carolina for manufacturing sites and Robinson and Kapo (2004) who studied the construction aggregate industry in Virginia and Maryland. The use of GIS allowed these researchers to study multiple variables concerned with both factor and demand conditions to determine ideal situations for various industries. Each of these studies provided credence to the method used in examining the US farm machinery industry.

Good situation translates into transportation linkages, labor pools, and access to consumer markets (Fox and Murray 1990). Cheng et al. (2007) have suggested that GIS studies which examine distances and local labor conditions are critical to site analysis. By classifying places as attractive and unattractive for the US farm machinery industry, assumptions can be made about the probability that certain sites will connote better situation than others and therefore increase the Big Three's individual competitive advantage in the market. "Previous studies suggest that industrial firms are by no means randomly distributed. Generally firm location behaviour is attributed to a wide range of factors – for example, transport costs, input prices (wages and land prices) and agglomeration economies" (Wu 2000: 2443). While idiosyncrasies exist (Fox and Murray 1990), it is believed the data and methods explain a majority of the location decisions of the Big Three of the US farm machinery industry.

A variety of data sets were used in the GIS analyses. As proposed by Wu (2000), a number of site-specific variables, in a multimodal manner, can identify the drivers of place decisions. Locations of the majority of the Big Three's facilities were obtained from their websites (AGCO Corporate 2007; CNH 2007; Deere and Company 2007) and placed into a database to make them more manageable. The location database was address-matched at the ZIP code level using Environmental Systems Research Institute's (ESRI) ArcGIS 9.3's geocoding tools to develop a map of the Big Three's facilities.

Transportation infrastructure is critical to the success of any manufacturing facility, both to bring in raw materials and to ship out finished products (Fox and Murray 1990). Research on impacts that local government can have on siting decisions for industry have repeatedly demonstrated the importance of infrastructural investments, both in the short and long term (Fox and Murray 1990). Among the most important types of transportation infrastructure are highways and railroads (Fox and Murray 1990). A variety of researchers have indicated the importance of transportation infrastructure to industrial location, especially multi-modal infrastructure in the form of highways, major two-lane roads, and railroads (Buurman and Rietveld 1999; Singletary et al. 1995). Research by Strauss-Kalm and Vives (2007) found that highway connectivity and proximity to an airport were critical predicting variables for headquarters location. Port facilities, connected to manufacturing areas by highways, are also a crucial part of any connectivity assessment for industry (Valverde 1997). All of these types of infrastructure were considered when evaluating the locations that the Big Three occupy in the US.

Transportation data were gathered from the US Geological Survey's National Atlas (2007) and the Bureau of Transportation Statistics' National Transportation Atlas Database (2010). These data were used to evaluate the transportation connectivity of the Big Three's facilities applying a number of common GIS functions. Using ArcGIS's Spatial Analyst, straight-line distances (as the crow flies) were calculated for highways, major two-lane roads, railroads, port facilities, navigable waterways, and airports. This method has been employed by a number of researchers as part of the process of determining suitability of a site based on connectivity (Thorson 1994; Holl 2004; Arai et al. 2005). Once straight-line distances were compiled, a connectivity hierarchy for headquarters, other administrative offices, and R&D sites as a group (Table 4.5) and manufacturing assembly plants as another group (Table 4.6) was generated. Srinivasan (2002) stated that accessibility is measured by both distances between places and the functions of the places in question. The two hierarchies were created using the models of Singletary et al. (1995) for highways, major two-lane road, and railroad access, Valverde (2007) for ports, Lagneaux (2007) for navigable rivers, and Strauss-Kalm and Vives (2007) for airports. By selecting parcels that met the requirements for each tier of the hierarchies, the entire US was reduced to a series of small polygons that are suitable for various functions. This process parsed a large geographic area down to a much smaller chunk that can be easily understood in terms of its transportation factor conditions.

Table 4.5: Hierarchy of connectivity for administrative and R&D functions

Tier Number	Connectivity Criteria
One (Well-Connected for Administration/R&D)	Less than 25 miles (40 kilometers) to an airport and less than one mile (1.6 kilometers) to an interstate
Two (Semi-Well-Connected for Administration/R&D)	Less than 25 miles (40 kilometers) to an airport, less than one mile (1.6 kilometers) to a major two-lane highway, and less than 10 miles (16 kilometers) to an interstate OR Less than 50 miles (80.5 kilometers) to an airport and less than one mile (1.6 kilometers) to an interstate
Three (Connected for Administration/R&D)	Less than 25 miles (40 kilometers) to an airport, less than one mile (1.6 kilometers) to a major two-lane highway, and less than 25 miles (40 kilometers) to an interstate OR Less than 50 miles (80.5 kilometers) to an airport, less than one mile (1.6 kilometers) to a major two-lane highway and less than 10 miles (16 kilometers) to an interstate
Four (Poorly Connected for Administration/R&D)	Less than 50 miles (80.5 kilometers) to an airport, less than one mile (1.6 kilometers) to a major two-lane highway and less than 25 miles (40 kilometers) to interstate
Five (Not Connected for Administration/R&D)	Everything Else

In addition to connectivity, the available labor pool is another important factor condition for industry (Buurman and Rietveld 1999). Research by Fox and Murray (1990) has conclusively indicated the importance of human capital investments and the level of educational attainment as a factor in industrial siting. The function of the facility will greatly impact the necessary skill level of the labor at different sites. Highly skilled labor is needed at administrative and R&D sites, while more low-skilled and semi-skilled labor is need at manufacturing and assembly plants (Ouwersloot and Rietveld 2000). Following the model proposed by Holl (2004), educational attainment data for the US population, age 18 to 65, was

Table 4.6: Hierarchy of connectivity for manufacturing and assembly functions

Tier Number	Connectivity Criteria
One (Well-Connected for Manufacturing /Assembly)	Less than 25 miles (40 kilometers) to an airport, and **either** less than ½ mile (0.8 kilometers) to a railroad, or less than ½ mile (0.8 kilometers) to a navigable river, or less than one mile (1.6 kilometers) to an interstate
Two (Semi-Well-Connected for Manufacturing/Assembly)	Less than 25 miles (40 kilometers) to an airport, and **either** less than ½ mile (0.8 kilometers) to a railroad, or less than ½ mile (0.8 kilometers) to a navigable river, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 10 miles (16 kilometers) to an interstate, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 50 miles (80.5 kilometers) to a port facility OR Less than 50 miles (80.5 kilometers) to an airport, and **either** less than ½ mile (0.8 kilometers) to a railroad, or less than ½ mile (0.8 kilometers) to a navigable river, or less than one mile (1.6 kilometers) to an interstate
Three (Connected for Manufacturing/Assembly)	Less than 25 miles (40 kilometers) to an airport, and **either** less than ½ mile (0.8 kilometers) to a railroad, or less than ½ mile (0.8 kilometers) to a navigable river, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 25 miles (40 kilometers) to an interstate, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 100 miles (161 kilometers) to a port facility OR Less than 50 miles (80.5 kilometers) to an airport, and **either** less than ½ mile (0.8 kilometers) to a railroad, or less than ½ mile (0.8 kilometers) to a navigable river, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 10 miles (16 kilometers) to an interstate, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 50 miles (80.5 kilometers) to a port facility
Four (Poorly Connected for Manufacturing/Assembly)	Less than 50 miles (80.5 kilometers) to an airport, and **either** less than ½ mile (0.8 kilometers) to a railroad, or less than ½ mile (0.8 kilometers) to a navigable river, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 25 miles (40 kilometers) to interstate, or less than one mile (1.6 kilometers) to a major two-lane highway and less than 100 miles (161 kilometers) to a port facility
Five (Not Connected for Manufacturing/Assembly)	Everything Else

obtained from the 2000 Decennial Census[8] (2007). These data were compared to facility locations to determine whether a specific locale has good situation.

Educational attainment of the population, age 18 to 65, was mapped using ArcGIS's categorization, normalization, and symbology techniques. County-level data were aggregated into three categories, which defined the population as having a high school diploma or less education, some college education, but not a bachelor's degree, or a bachelor's degree or more education. These categories were then normalized by the total population of the county to obtain a percentage. The percentages were mapped and interpreted following the visual deduction methods proposed by Schnell et al. (1999). By overlaying the facility locations, based on their education needs, one can visually determine the suitability of the labor pool for the function of the site.

Another aspect of factor conditions to be considered is research connections. Porter (1990) has indicated that competitive advantage can be enhanced by connections between industry and institutions of higher education. For the farm machinery industry, the most important academic connections would be with schools that have departments of agriculture or agricultural engineering, many of which are land grant institutions (Longworth 2007). Data on the location of schools with departments of agriculture was obtained from the North American Colleges and Teachers of Agriculture's website (2010) and compared to the list of land grant universities and colleges provided by the US Department of Agriculture (USDA) (2010). Addresses for these schools were geocoded to the ZIP code level and mapped for comparison with locations of facilities of the Big Three.

[8] The decennial census is the only source of county-level educational attainment data for every county in the US. More recent data on educational attainment from the American Community Survey is only provided for selected counties.

Demand conditions, as they impact location decisions, also can be examined within the GIS environment. Geodemographics of the potential customer base give firms an indication of where their target markets are (Birkin et al. 1996). Data of this type, for the farming community, can be obtained from the USDA's 2007 Census of Agriculture (2010). Table 38 of the census outlines machinery and equipment inventory on operations (2010). By using data on the total number of tractors over 100 horsepower (75 kilowatts) and total number of combines, clusters of prime markets were derived. This loosely followed methods suggested by Birkin et al.'s (1996) study of the consumer market for the US automobile industry. Using ArcGIS 9.3's hot spot analysis (Getis-Ord GI*), which applies a polygon congruity function (only counties that touch each other impact the cluster analysis), a series of maps showing areas with above and below average numbers of tractors greater than 100 horsepower (75 kilowatts) and numbers of combines were generated. Average and above average areas can be assumed to be the main market for the US farm machinery industry. Overlaying the Big Three's tractor and combine manufacturing and R&D facilities can visually display how well each firm is meeting market needs while minimizing transport costs.

Related and supporting industries were analyzed by examining the locations of both firms closely related to the farm machinery industry and those that supply the Big Three. The major related sector to the US farm machinery industry is the construction machinery industry. The largest US construction machinery producer is Caterpillar, with CNH's construction division and Deere and Company Construction coming in second and third, respectively (SBI 2007). The locations of Caterpillar's facilities (Caterpillar 2008) were geocoded at the ZIP code level to be compared to the locations of the Big Three's facilities to look for networking opportunities. Similarly, the heavy truck industry has been a vital related industry as the farm machinery sector deals with EPA emissions regulations that have been standard on heavy-duty trucks for a longer period of time (Mowitz 2010b). Location data on manufacturing plants for the heavy-duty truck manufacturers in the US, including Navistar, Daimler, Volvo, and PACCAR (IBISWorld 2010) were also geocoded at the ZIP code level for comparison with the Big Three's locations.

Finding information about suppliers is much harder for the farm machinery industry because this information is often a carefully guarded industry secret. Engine and tire suppliers are two major areas that remain somewhat transparent to someone who studies the industry. Fewer and fewer engines from third-party suppliers are being used, given the emphasis on solutions to meet Tier IV EPA standards, but AGCO continues to source some engines from Caterpillar and Perkins, while CNH maintains a joint venture with Cummins. These engines also continue to be used for tractors and combines shipped to areas of the world without emissions standards. Manufacturing locations for these three firms were geocoded to the ZIP code level to be compared with locations of the Big Three to look for possible knowledge spillover opportunities. Similarly, the majority of equipment sold by the Big Three is outfitted with tires from Goodyear, Firestone, or Michelin. The locations of these firms' agricultural tire manufacturing plants were also geocoded to the ZIP code level for comparison with the farm machinery industry.

Firm structure, strategy, and rivalry were analyzed from two perspectives. First, considering day-to-day strategies, the presence of agglomeration and economies of scale were considered. Using visual interpretation, as suggested by Schnell et al. (1999), facilities were mapped by firm and by function (i.e. administrative, manufacturing, etc.) to look for obvious spatial clustering. "The formation of the cluster is considered to provide a vital competitive advantage…" (Arai et al. 2004: 484). Individual firms were then parsed out to study how its facilities interact with each other. Shen (2005) found that the use of minimum and maximum distances can help determine accessibility and connectivity. For the purposes of this study, minimum and maximum distances were measured from each firm's headquarters to the rest of its facilities using ArcGIS's multi-ring buffer tool. Rings were drawn at regular intervals to determine how near the majority of a company's facilities are from its central administrative functions. This provides a clear picture of agglomeration within the company.

Another key part of firm structure, strategy, and rivalry is the location of international competitors to the Big Three that maintain facilities in the US. Through an exhaustive internet search of the major international competitors (CLAAS, Kubota, LS Tractors, Mahindra and Mahindra, McCormick International, SAME-Deutz Fahr, TYM, Yanmar, and Zetor), the US locations for these firms were uncovered and geocoded to the ZIP code level for comparison to the facilities of the Big Three to look for industry clusters that can further provide economies of scale and knowledge spillovers.

Finally, while there are many areas of government intervention that may be relevant to location decisions for the Big Three (Fox and Murray 1990), many of those, such as tax rates, are hard to obtain. Additionally, quantitative tests have proven that local tax rates often make little difference in siting decisions (Fox and Murray 1990), especially given the increasing tendency for firms to negotiate preferential tax agreements with local and state governments as part of a competitive economic package to attract the firm to a specific location. There is one aspect of government intervention, however, that may prove useful to this analysis. Labor laws, specifically in the area of unionization, are a factor in competitive advantage as collective bargaining agreements and strikes have been a continuing struggle for all of the Big Three throughout their histories (Associated Press 1988; Deere and Company 2009). To that end, data were obtained from the National Right to Work Legal Defense Foundation (2010) on whether a state had right-to-work laws and mapped to compare to the data on the Big Three's locations.

GIS analysis of different variables related to the points in Porter's model (1990) elucidates the geographic nature of organizational studies models. By mapping these variables and comparing them to the locations of the Big Three's facilities, a clearer picture of what makes a site desirable and which sites do not seem to fit existing models.

4.5 Methodology and Data in Summary

When one looks at patent data for the Big Three (Table 2.1), JD excels in measures of innovation, seemingly trampling AGCO and CNH (US Office Of Patents and Trademarks 2009; US Office of Patents and Trademarks 2010a, b). Yet, the other members of the Big Three continue to experience success in their own right. If one only looked at the innovation data, he or she would assume that AGCO is the least successful of the Big Three. But market indicators and recent awards demonstrate that such is not the case. Clearly there are factors other than the sheer number of patents in play that must be uncovered.

While quantitative analyses of data such as measures of innovation and market share are important, they do not tell the entire story. A qualitative approach is needed to fully understand the scope of this complex problem. Qualitative analysis, as conducted in this research, allows for a more complete picture of the US farm machinery industry, as dominated by the Big Three.

CHAPTER V
ANALYSIS

5.1 Introduction

To empirically test Porter's Theory of Competitive Advantage (1990), using case studies from the farm machinery industry, I broke the model into its separate elements and examined specific examples related to each component. Each facility was evaluated to determine the level of competitiveness that it might expect to achieve based on elements of each separate point of Porter's model. One would not expect every facility of the Big Three to be competitive in every element of the model. Chapter 6 will summarize the findings of the individual analyses to assess overall competitiveness for each of the facilities. Appendix A outlines the type of data utilized to arrive at the conclusions for each firm in each analysis. Not all of the individual facilities of the Big Three will be competitive on their own, either. It is important to remember that individual facilities are part of a larger network for the firm and while an individual site is not necessarily competitive, it may serve a purpose to the larger strategic goals of the company. Some of the facilities also may have been historically better located and simple inertia has prevented the Big Three from closing older sites.

5.2 Factor Conditions

For the farm machinery industry, factor conditions encompass access to components, such as steel and glass, labor, connections to universities and extension offices to provide necessary knowledge resources for product development, capital, including land and manufacturing equipment, and appropriate transportation networks to ship supplies to the manufacturing sites and finished goods to market. The density of manufacturing and headquarter sites for the US farm machinery industry in the upper Midwest is likely partially due to a combination of favorable factor conditions such as raw materials, labor, and access to the extensive network of land grant institutions in the region (Porter 1990). Proximity to these types of resources is crucial to the US farm machinery industry and likely influences its location decisions, though perhaps less so than in the past.

5.2.1 Raw Materials and Manufacturing Inputs

While listed as one of Porter's factor conditions, with the increasing interconnectedness of the economy even Porter himself admitted that access to manufacturing inputs, such as steel and glass, and their related raw materials are becoming easier and therefore less important as a factor condition for manufacturers (Porter and van der Linde 1999). In looking at the archives of some of the predecessor companies of the Big Three, it is apparent that, at one time, access to raw materials was one of the most important factors in selecting a site (*International Division Scrapbook*, ca. 1930, Benson Ford Research Center, The Henry Ford, Accession 689). As late as 1969, Massey-Ferguson was estimating that raw materials and casting costs comprised up to 16 percent of the price of the tractor (MacDonald et al. 1969). As transportation systems have increased in number and speed, this is less of a factor today (Porter and van der Linde 1999).

A few critical concerns remain regarding raw materials access for the Big Three. While AGCO and CNH make no mention of concerns about raw material prices on their websites, JD does mention apprehension about rising prices on about five percent of the pages. Annual reports of all three firms make mention of unease about increasing raw material prices, but only JD appears profoundly concerned about it (Wall Street Journal Staff 2009). Raw materials are currently equivalent to 58 to 68 percent of the Big Three's yearly revenues, depending on the price of materials in the marketplace (IBISWorld 2009).

One of the newest raw material needs is precious metals, such as platinum and palladium, used in catalytic materials necessary to meet Tier IV EPA emissions regulations (refer to Appendix F and section 5.4.1.4 for more information about emissions technology) (Xinqun et al. 2010). These materials can be very costly and are in short supply, coming from either South Africa or Russia (Wehrspann 2009b). In the future, these materials will become an increasing part of raw material costs for the Big Three (Wehrspann 2009b).

The farm machinery industry is also greatly impacted by iron[9] and steel prices. Part of the declines that JD and CNH saw during the 2008 economic downturn were directly related to increasing steel prices impacting their material costs (IBISWorld 2009). Raw materials, as a portion of revenue, increased ten percent from 2005 to 2008, largely due to steel prices (IBISWorld 2009). In the third quarter of 2008 alone, JD saw its raw material costs increase by 425 million dollars (IBISWorld 2009). While some of these costs can be passed along to the consumer, in many cases, given the rapid fluctuations in the market, the farm machinery industry must internalize the increased costs as a decrease in profits (IBISWorld 2009). To maximize competitive advantage, the Big Three need to utilize strategies to minimize costs of raw materials in other ways, such as guaranteeing the most efficient and cheapest transport of the materials to the manufacturing facility and increasing manufacturing efficiency to limit waste (R. Kleinsasser, pers. comm.).

[9] Deere still maintains its own casting mills to fabricate its engine blocks and unit frames.

5.2.2 Education

Educational attainment and the skill set of the available labor force in a particular location are crucial to competitive advantage (Porter 1990). Various models, designed to predict success of an industry in a region, include variables to account for the educational attainment of the existing labor force. Studies have found that the educational policy and educational attainment of a location are a critical part of the siting decision for many large firms (e.g. Fox and Murray 1990). Depending on the function a facility, it may require relatively low-skill labor, as is generally the case with an assembly plant (Fox and Murray 1990), or labor with a very high level of educational attainment (as is often necessary with R&D and administrative functions). Manufacturing can fall somewhere in between depending on the level of innovation in the manufacturing process (Kalafsky 2006). Because farm machinery is often an advanced manufacturing process, semi-skilled workers with some amount of college education are increasingly preferred (R. Kleinsasser, pers. comm.).

While there are no set rules about what level of educational attainment is ideal for different functions, one can imagine sub-optimum conditions. If a facility needs semi-skilled or highly skilled labor, but is situated in an area with primarily low educational attainment, it may have to seek employees from a labor pool outside the region. On the other hand, if the facility needs relatively low-skilled labor, but finds itself located in an area with high educational attainment, attracting workers could also be a problem. Additionally, those workers who do take jobs in the facility may demand a higher level of wages, as compensation for a higher level of training, than the firm planned to pay. Competitive advantage is most readily achieved when the needs of the firm and the skill set of the labor pool match and worker productivity can be maximized (Hill and Brennan 2000).

In looking at the locations of R&D and administrative activities for the Big Three compared to the percentage of the population with a low level of educational attainment (high school diploma or less) (Figure 5.1), medium level of educational attainment (some college) (Figure 5.2), and high level of educational attainment (bachelor's degree or more) (Figure 5.3), certain patterns begin to emerge that can impact competitive advantage. All of the headquarters facilities of the Big Three are located in counties with ten to 25 percent of the population with a bachelor's degree or more education. All of the headquarters are also located in areas with 20 to 40 percent of the population possessing a high school diploma or less. New Holland, Pennsylvania; Racine, Wisconsin; and Duluth, Georgia also all have 25 to 40 percent of the population with some amount of college education, while Moline, Illinois has 40 to 50 percent of the population with some amount of college education. While these numbers do not seem conducive to fostering competitive advantage from a pool of highly skilled workers needed for administrative duties (and, in the case of New Holland and Duluth, also R&D functions), both CNH's New Holland, Pennsylvania headquarters and AGCO's Worldwide Headquarters are located adjacent to counties with higher levels of skilled workers from which they can draw. Also, with the exception of AGCO's facility, all of these headquarters are located in counties that also have manufacturing facilities, so JD and CNH may be seeking a balance in the labor force between the two different types of facilities and their needs.

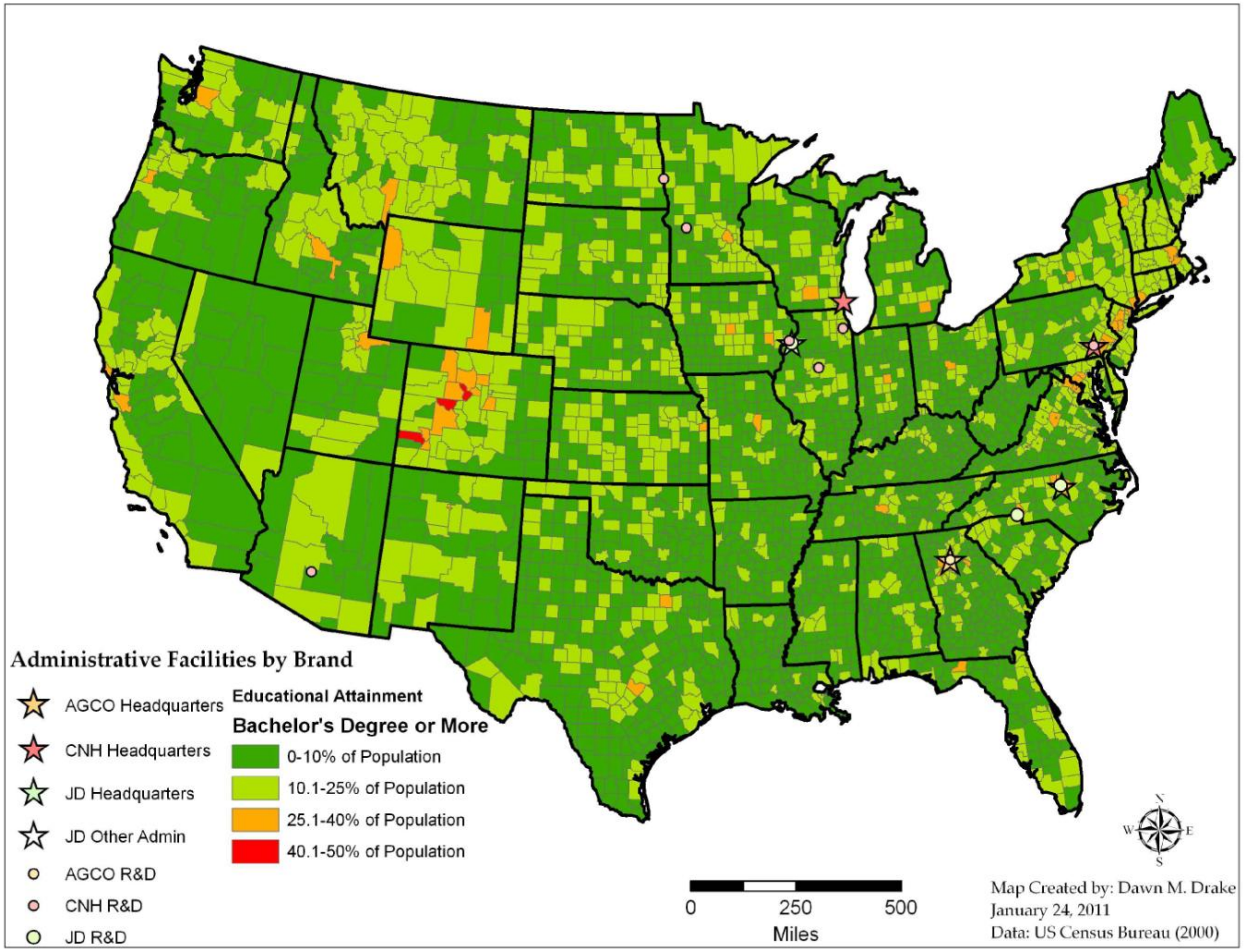

Figure 5.1: Locations of administrative and R&D activities compared to high levels of educational attainment (population 18-65 with bachelor's degree or more education).

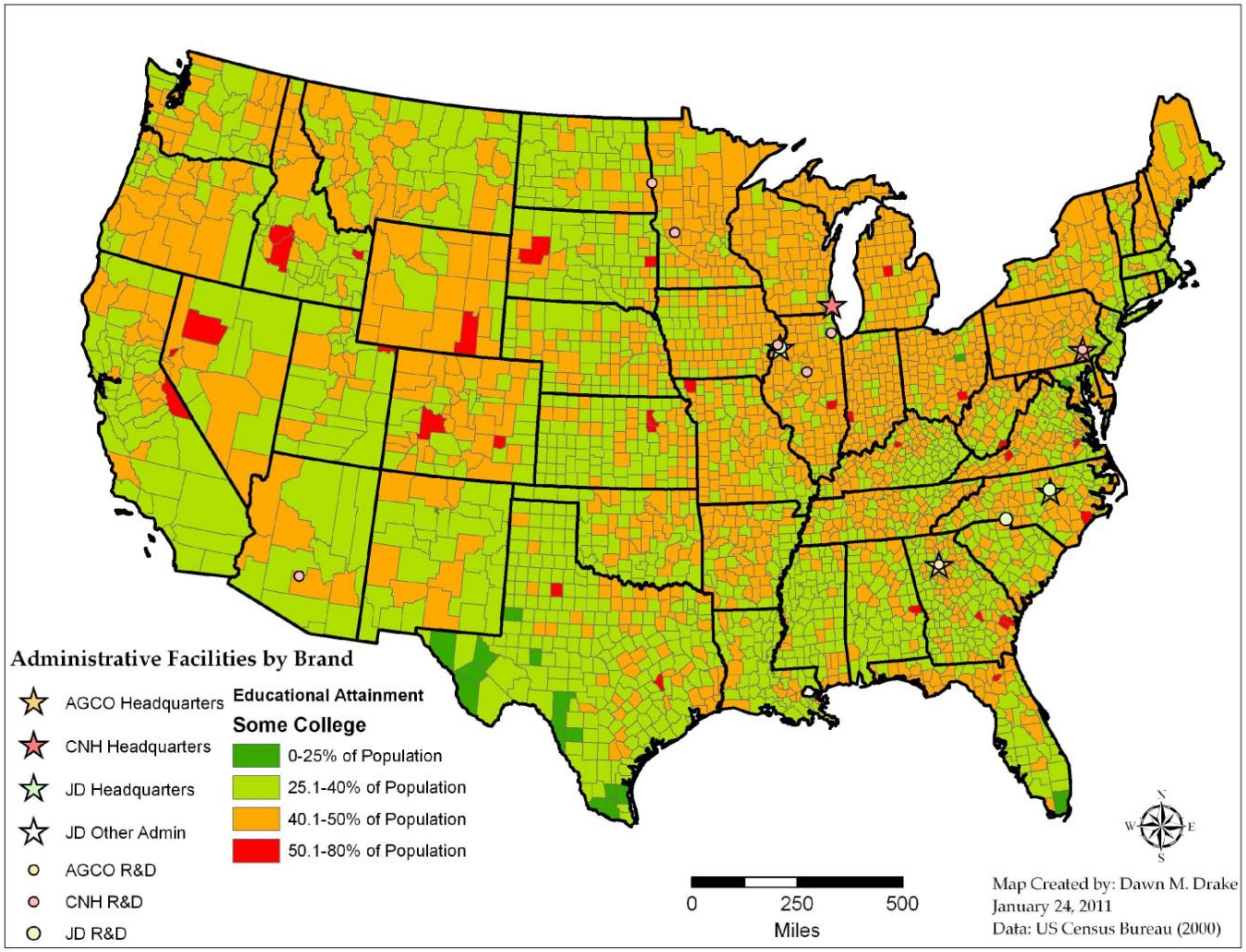

Figure 5.2: Locations of administrative and R&D activities compared to moderate levels of educational attainment (population 18-65 with some college education).

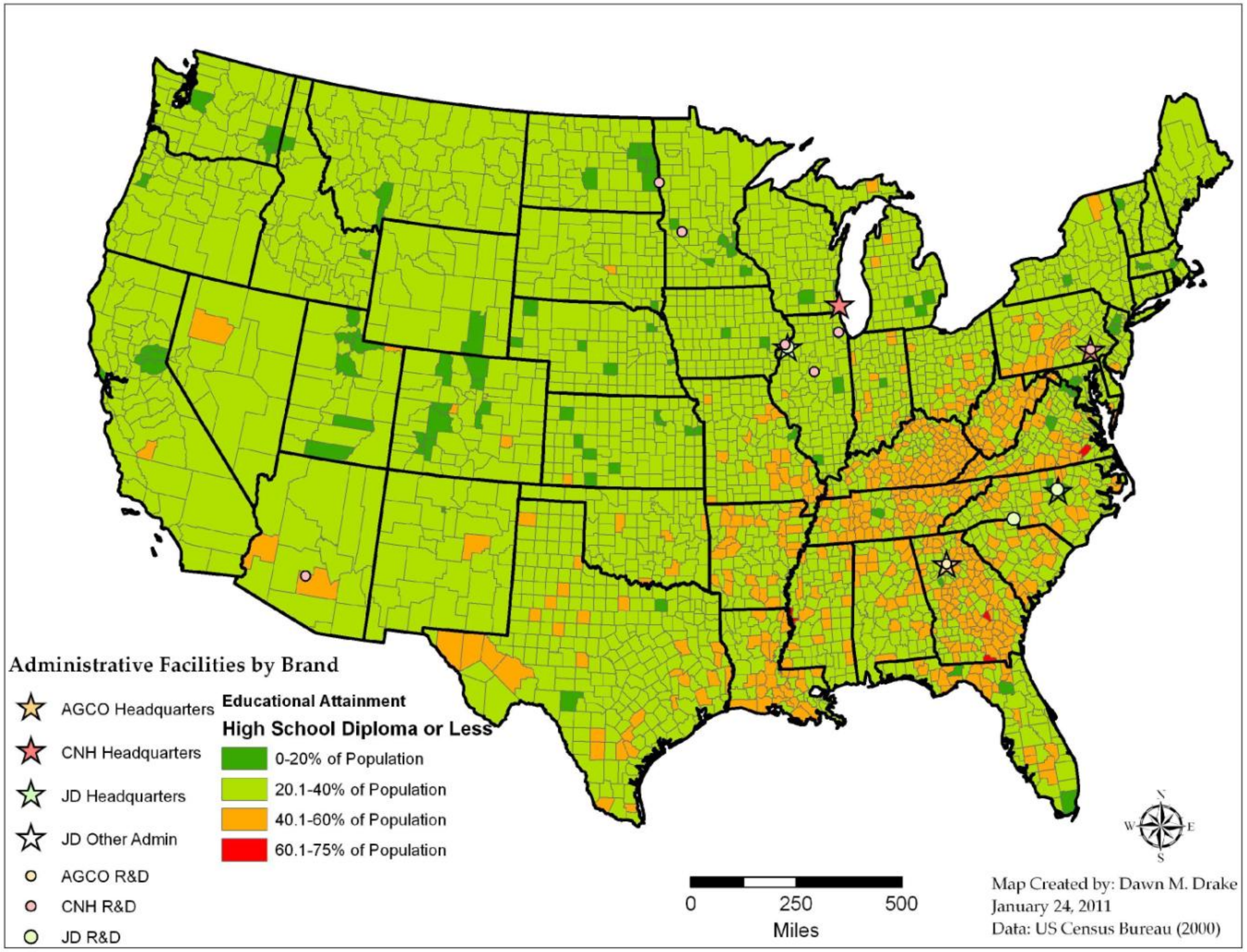

Figure 5.3: Locations of administrative and R&D activities compared to low levels of educational attainment (population 18-65 with a high school diploma or less education).

One administrative location that is well-situated in terms of the desired labor pool is JD's facility for its commercial and lawn and garden equipment division, in Cary, North Carolina, which has 25 to 40 percent of the labor force with a bachelor's degree or more, another 25 to 40 percent with at least some level of college education and less than 20 percent with a high school diploma or less. This facility and JD's R&D facility, adjacent to it, in Morrisville, North Carolina, should have no trouble attracting the type of highly skilled labor that is required for higher-order business functions, given its location in the very highly educated Research Triangle Park region of North Carolina. Many people with the necessary skill set for R&D have been attracted to this region because of the high density of jobs requiring higher order skills and training. This is similar to JD's other R&D facility, in Charlotte, North Carolina, where 25 to 40 percent of the population has a bachelor's degree or above with another 25 to 40 percent having some college education.

In looking at the labor pools available for those CNH's R&D facilities not already mentioned, some are in a better competitive position than others. Seemingly worst off is CNH's Stotonic, Arizona facility, which is located in a county with less than ten percent of the population with a bachelor's degree or more and 20 to 40 percent of the population with a high school diploma or less. Given the fact that this is a testing facility prized more for its remoteness and harsh conditions in which to test machines, this may not pose a competitive disadvantage for the facility ("Letter to John T. Brown, William J. Grede, and M.B. Rojtman from Leon Clausen" 20 Mar. 1957, Library-Archives, Wisconsin Historical Society, Mss 341).

Other R&D facilities that CNH might be concerned about are its sites in Benson, Minnesota and Goodfield, Illinois, both of which have 20 to 40 percent of the population with a high school diploma or less and 40 to 50 percent with some college education. In the county in which the Goodfield site is located, another ten to 25 percent of the population has a bachelor's degree or more, which may indicate the presence of some highly skilled labor pool from which to draw. Benson, Minnesota, on the other hand, has less than ten percent of its population with a bachelor's degree or more, making it much more difficult to find qualified individuals to conduct R&D in this region. What could explain this seemingly uncompetitive situation for these two sites is that they are also manufacturing facilities and CNH has to balance labor needs between the two different functions. The high levels of semi-skilled labor are very desirable for the manufacturing functions of the two sites.

Another one of these dual-purpose sites for CNH that is in a slightly better position for R&D is the Fargo, North Dakota facility. The region only has ten to 25 percent of its workforce with a bachelor's degree or more, but less than 20 percent of the workforce holds a high school diploma or less. While this may pose a problem in attracting any low-skilled labor necessary for manufacturing, given the fact this plant manufacturers and tests CNH's largest and highest horsepower tractors, it is unlikely that there is much demand for low-skilled labor for the manufacturing plant. The facility has the right mix of labor to make both functions work competitively.

The Mt. Joy Testing facility in Davenport, Iowa, however, is not as easily explained as some of the other outliers for CNH. In this instance, CNH is maintaining a purely R&D facility in a location that has ten to 25 percent of the labor force with a bachelor's degree, but another 20 to 40 percent that have a high school diploma or less. The county in which the facility is located though, is nearby to another county with a higher level of educational attainment. This may be a source of labor for the testing facility, but those same workers may also be drawn to job opportunities with JD in nearby Moline, Illinois.

The remaining CNH facility, in Burr Ridge, Illinois, is in a much better position in terms of the educational attainment of its potential labor pool. The proportion of the population with high levels of educational attainment is 25 to 40 percent with another 25 to 40 percent with at least some college education. Less than 20 percent of the population in this area has a high school diploma or less education. Given the fact that this facility is a joint R&D venture between CNH and its sister company, Fiat Powertrain Technologies (FPT), to develop and test the newest engine and tractor technology, this is likely a very competitive location for CNH.

The locations of assembly and manufacturing functions for the Big Three, compared to various levels of educational attainment (Figures 5.4-5.6), presents yet another level of analysis of competitive advantage and factor conditions. AGCO capitalizes on its location decisions in terms of a desirable labor pool, with all three assembly facilities having 20 to 40 percent of people with a high school diploma or less, and only ten to 25 percent with a bachelor’s degree or more education. Considering its manufacturing facilities, all three AGCO plants are in counties with 20 to 40 percent of the population with a high school diploma or less. For the Beloit, Kansas and Jackson, Minnesota facilities less than ten percent of the population has a bachelor’s degree or more, while this number is slightly higher at ten to 25 percent in Hesston, Kansas. The two facilities in Kansas have 25 to 40 percent of the population with some amount of college education, which is the desired skill level for the manufacturing and assembly of farm equipment. Forty to 50 percent of the population of Jackson, Minnesota falls into the semi-skilled level.

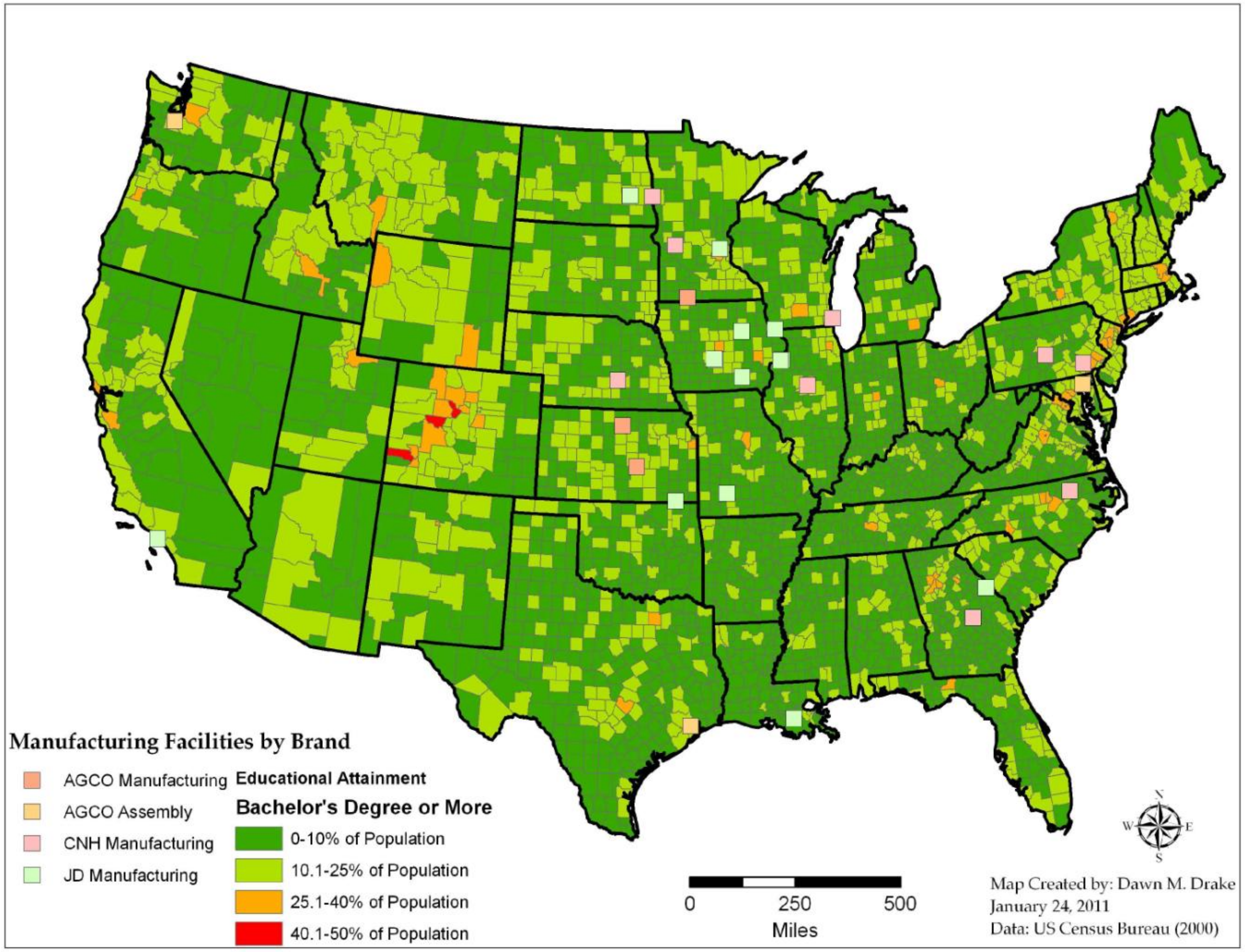

Figure 5.4: Locations of manufacturing and assembly activities compared to high levels of educational attainment (population 18-65 with a bachelor's degree or more education).

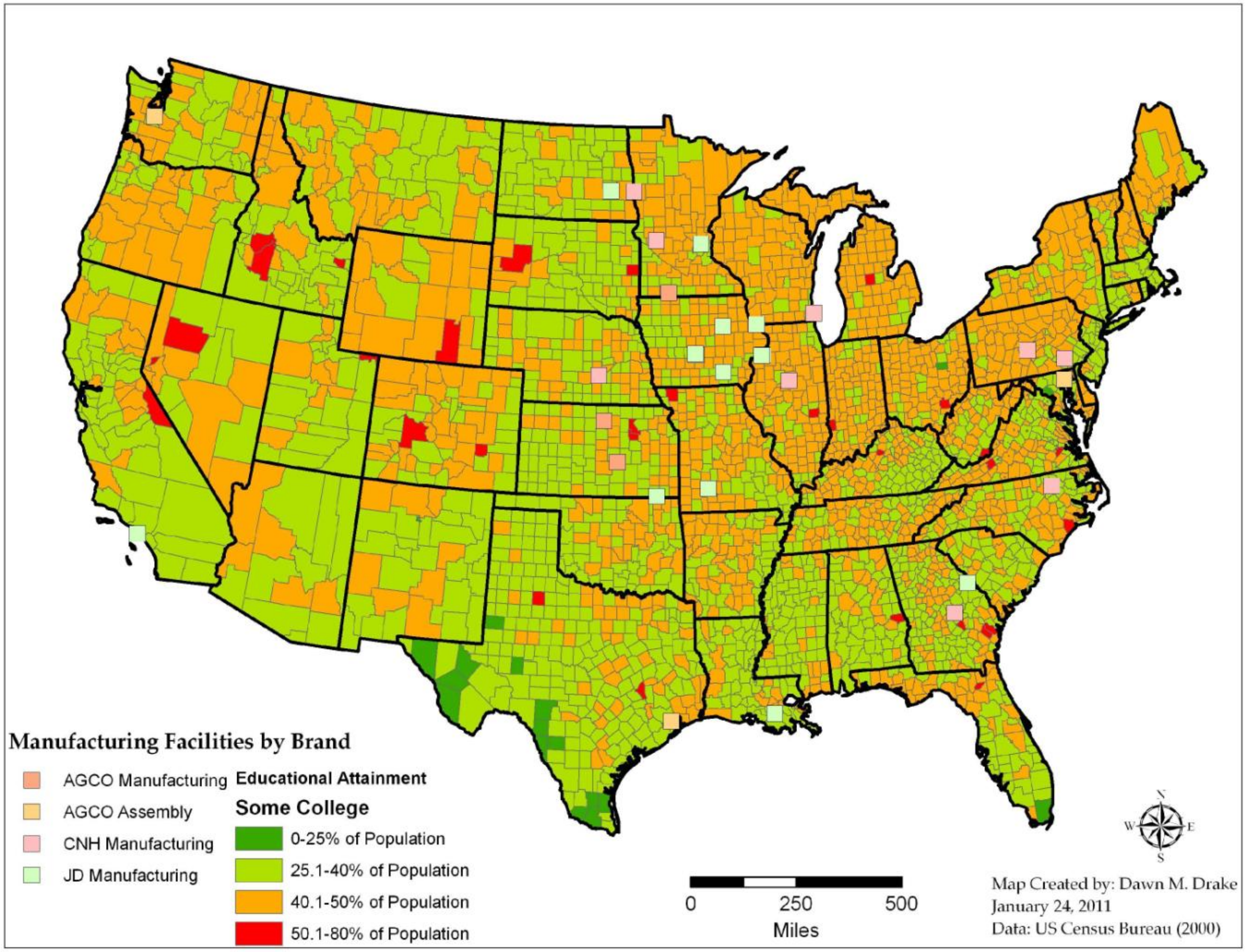

Figure 5.5: Locations of manufacturing and assembly activities compared to moderate levels of educational attainment (population 18-65 with some college education).

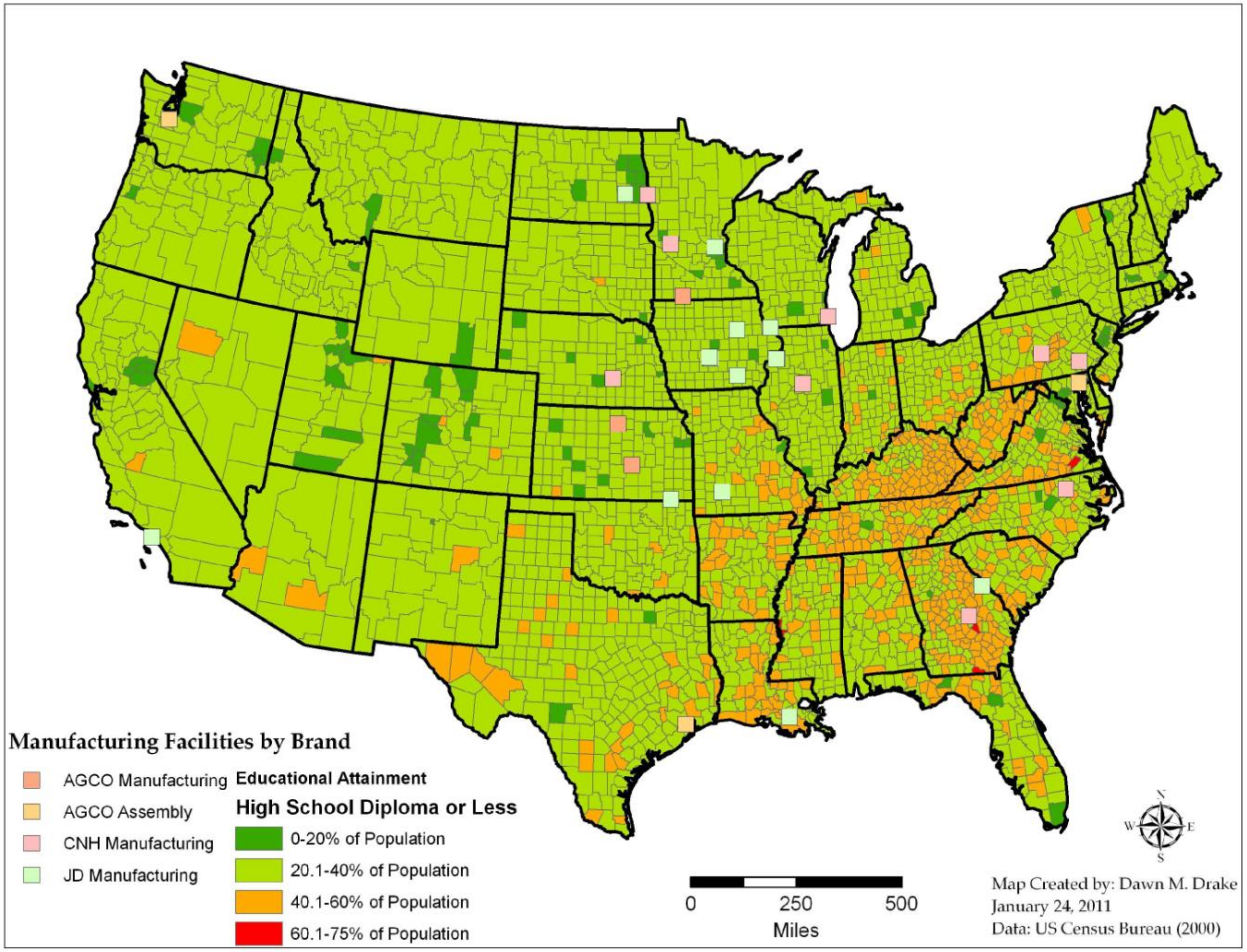

Figure 5.6: Locations of manufacturing and assembly activities compared to low levels of educational attainment (population 18-65 with a high school diploma or less education).

Having already evaluated the educational attainment of the CNH manufacturing plants in Benson, Minnesota; Fargo, North Dakota; and Goodfield, Illinois, as well as the facilities in Racine, Wisconsin and New Holland, Pennsylvania, previously, the remaining manufacturing plants appear individually to be competitive, based on the skill set of the labor pool. Given the fact that the Belleville, Pennsylvania and Dublin, Georgia facilities are primarily assembly plants with only limited manufacturing (J. Daniels, pers. comm.), the desired skill set would be somewhat low. In both locations, less than ten percent of the population has a bachelor's degree or more education. In Belleville, 40 to 60 percent of the population has a high school diploma or less. This number is slightly lower for Dublin, where only 20 to 40 percent of the population has a high school diploma or less, but an adjacent county has 60 to 75 percent of its population with a high school diploma or less – demonstrating the continued concerns that many southern communities face with their low levels of educational attainment (Kalafsky 2006). This makes both of these sites well-suited to their functions and competitive in terms of labor costs compared to other sites for the Big Three.

The CNH combine manufacturing plant in Grand Island, Nebraska has less than ten percent of its population with a bachelor's degree or more, but 40 to 50 percent of its population with at least some college training. Given the higher order of manufacturing occurring at this site, a semi-skilled workforce is desirable. A semi-skilled labor force is also desirable at the Whitakers, North Carolina plant, which is a joint venture with Cummins to manufacture diesel engines. Twenty-five to 40 percent of the population in this county has some level of college training, while ten to 25 percent have a bachelor's degree or more. Case New Holland faces good workforce training conditions in the locations where it is not serving multiple functions at the same time. While it reduces fixed costs for land and buildings by having facilities serve multiple purposes, many of those sites are at a disadvantage when it comes to recruiting labor with the correct skills. Much as was the case of airfreight forwarders in the Philippines that struggled to find skilled labor domestically (Bowen and Leinbach 2006), CNH may have difficulty sourcing labor in some of these locations.

For JD, most of its manufacturing sites that have not already been discussed provide the necessary skill set for the types of manufacturing operations being performed. For instance, the manufacturing site in Fargo, North Dakota, where ten to 25 percent of the population is highly educated and another 40 to 60 percent have at least some college education is manufacturing and assembling all of the electronic components for JD equipment, which requires a highly skilled workforce. Among JD's other plants that would require a highly skilled labor force are Torrance, California, which manufactures GPS units and antennas for JD equipment and Urbandale, Iowa, which manufactures all other components necessary for precision agriculture. Both of these facilities are located in places that may not quite have the required skill level, however. Both Torrance and Urbandale have ten to 25 percent of their populations with a bachelor's degree or more, but only 25 to 40 percent fit into the semi-skilled category. Depending on the number of people working in these plants and how many other firms are competing for the skilled labor pool, JD may have a problem recruiting in these areas.

The Urbandale, Iowa plant is interesting for another reason. Within the same county, there is another JD facility – the Des Moines Works – where JD builds cotton pickers, sprayers, and tillage equipment. The educational attainment of the population of this region may be better suited to this facility, which requires a mix of semi-skilled and low-skill labor. This is similarly the case for facilities in Valley City, North Dakota; Ottumwa, Iowa; and Dubuque, Iowa.

Several of JD's facilities, including the plants in Coon Rapids, Minnesota; Waterloo, Iowa; and Springfield, Missouri have populations with much higher levels of semi-skilled labor (40 to 60 percent of the population). This is appropriate given the high levels of sophistication in the manufacturing processes occurring at these plants. Coon Rapids is a manufacturing center for hydraulic systems. The Springfield plant remanufactures JD engines, meaning that workers refurbish old engines and return them to new running order – a very highly skilled task. In Waterloo, JD has three facilities that build tractors and engines and cast metal for engine blocks and unit frames, all of which require a specified skill set that may be developed through college training.

There are two other manufacturing facilities owned by JD that would benefit from semi-skilled labor. These are the sugarcane harvester plant in Thibodaux, Louisiana and the power systems plant in Coffeyville, Kansas. Both of these plants are located in counties with less than ten percent of the population having a college degree and 25 to 40 percent of the population having some college training. For the Coffeyville plant, this may be an acceptable labor pool given that 20 to 40 percent of the population has a high school diploma or less. The Thibodaux Works, however, is in a region where 40 to 60 percent of the workforce population is low-skill. Given the small batches of sugarcane harvesters that JD produces in a year, the workforce needs at the plant are small enough for JD to attract adequate labor. Also, given the fact that the plant is producing such a specialized product, other location factors, such as nearness to markets and transportation connections, can make up for the competitive disadvantage the labor pool provides.

The Grovetown, Georgia facility, which manufactures and assembles compact diesel tractors, is another of JD's plants that does not need much skilled labor. Like the counties surrounding CNH's plant in Dublin, Georgia, this region has very low levels of educational attainment and is well-suited to an assembly operation. Deere seems to have no difficulties locating workers for this plant.

5.2.3 Research Connections

While appropriate levels of educational attainment, based on the function of the facility, are important to competitive advantage, Porter and Takeuchi (1999), in an empirical study of competitive advantage in Japanese industries, found that the type of training prevalent in the workforce is equally important. Many of the industries in which Japan was inefficient were ones that required training that Japan lagged in providing. While the Morrill Act was designed to guarantee access to agricultural education for all Americans, this has been an increasingly unpopular degree program and the number of schools providing agricultural degrees has decreased (Longworth 2004). To remain competitive, the US farm machinery industry needs both adequate educational attainment and training in appropriate skills. Research connections that support both the industry and institutions of higher education are one way to provide this.

One of the factor conditions that Porter felt would be important for competitive advantage in an industry was the ability to network with institutions of higher learning, both as a means to educate the workforce, but also facilitating knowledge spillovers and R&D partnerships (Porter 1990). While empirical tests of competitive advantage in the pharmaceutical sector found little indication of direct impacts on innovation by nearby research universities, there were indirect impacts for knowledge sharing for firms that located in proximity to a major university conducting research of interest to the firm (Boasson and MacPherson 2001). For the US farm machinery industry, those research connections come from schools with agriculture departments, many of which are land grant universities, funded by the Morrill Act. In fact, when Massey-Ferguson was seeking a location for a North American headquarters in 1965, one of the key factor conditions in the decision was the presence of a school of agriculture with a good reputation (Archival and Special Collections, University of Guelph Library, X41 RHC A0390). By mapping the locations of these schools and then creating a distance buffer, it becomes apparent that many of the facilities of the Big Three are located within a reasonable distance of a school where there are opportunities to partner for research and education of potential employees.

Figure 5.7 divides the facilities based on their function. From this it is apparent that almost all of the administrative and R&D facilities of the Big Three are located within 25 miles (40 kilometers) of a school with an agriculture department. AGCO's headquarters and R&D facility is just slightly further away from its nearest school – the University of Georgia – at approximately 50 miles (80.5 kilometers). One exception to the rule is JD's facility in Charlotte, North Carolina, which is not within 75 miles (121 kilometers) of any schools with agriculture programs. Given the fact this is JD's new Southeastern Engineering Center for R&D, this could be a serious problem. The attractiveness of Charlotte, North Carolina as a second-tier city should, however, allow the facility to draw graduates of nearby agricultural programs, such as from North Carolina State University.

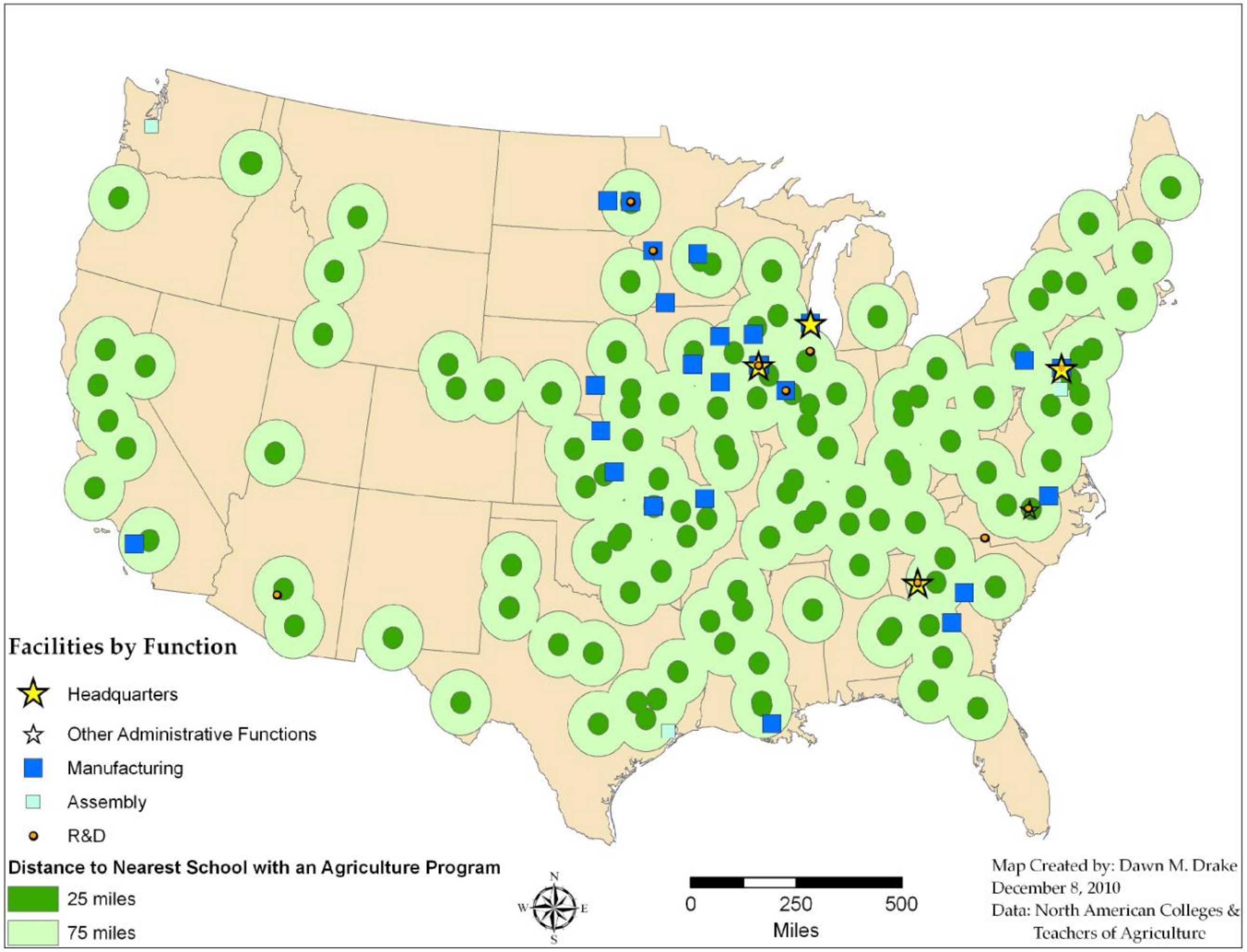

Figure 5.7: Buffer analysis of the locations of schools with agriculture programs and the Big Three's facilities, categorized by function.

With the exception of AGCO's new assembly plant near Tacoma, Washington, all of the manufacturing and assembly facilities of the Big Three are within 75 miles (121 kilometers - or just over an hour's driving time) of a school with an agriculture program. Given that AGCO is assembling tractors in this facility, and not manufacturing or conducting research, this should not be a problem in terms of competitive advantage. For this facility, the location near a port is paramount (*Beef Magazine* Staff 2008). From this analysis, the Big Three are well-situated to make use of connections with institutions of higher learning.

Document and trade show analysis reveal that the Big Three do, in fact, make use of these connections. The biomass harvesting system that JD has recently brought to market (discussed in section 5.4.1.4) was developed through a partnership with Hillco Technologies and Iowa State University. Phoenix Electronics, a division of JD, is located on the campus of North Dakota State University, allowing the company to share R&D and testing costs with the land grant university. Also through a partnership with North Dakota State University, AGCO has been developing a new plant-based material as an alternative to steel for use in the construction of spray booms that will make self-propelled sprayers lighter weight in order to limit soil compaction. Finally, CNH has been partnering with local colleges to find employees to work for its precision farming services divisions, providing money and internship experiences to students enrolled in the Ag GPS/GIS Technology Program at Kirkwood Community College in Cedar Rapids, Iowa (Case IH 2010b).

5.2.4 Transportation

An important consideration in factor conditions for locating facilities is the transportation connections associated with the site and whether those connections meet the needs of the facility.

Bowen and Leinbach (2006) believed that their research on competitive advantage for airfreight forwarder services in Southeast Asia would have benefitted from a more in-depth consideration of transportation linkages. Transportation needs will vary based on the function of the facility, but typically are in the form of roads (Figure 5.8) and railroads (Figure 5.9), access to navigable waterways (Figure 5.10) and ports (Figure 5.11), and/or nearby airports (Figure 5.12). As was outlined in Chapter IV, a transportation connectivity matrix was developed for administrative and R&D facilities (Table 4.5) and manufacturing and assembly facilities (Table 4.6) based on the findings of literature in the field. Examining maps of connectivity for each facility will help evaluate the suitability of each site to maximize competitive advantage.

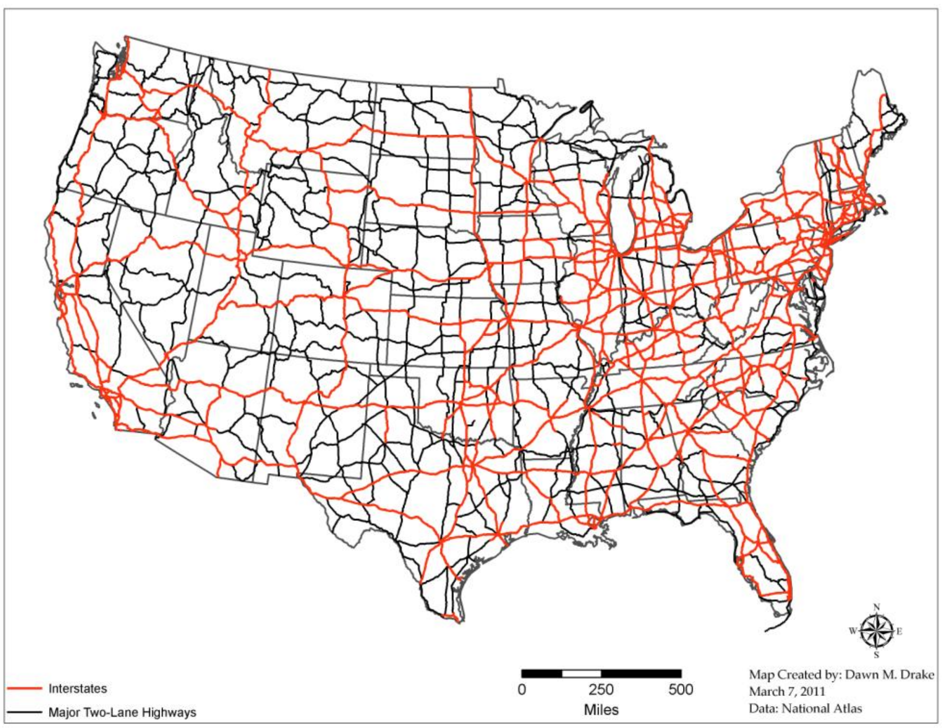

Figure 5.8: The network of roads used to analyze transportation connectivity.

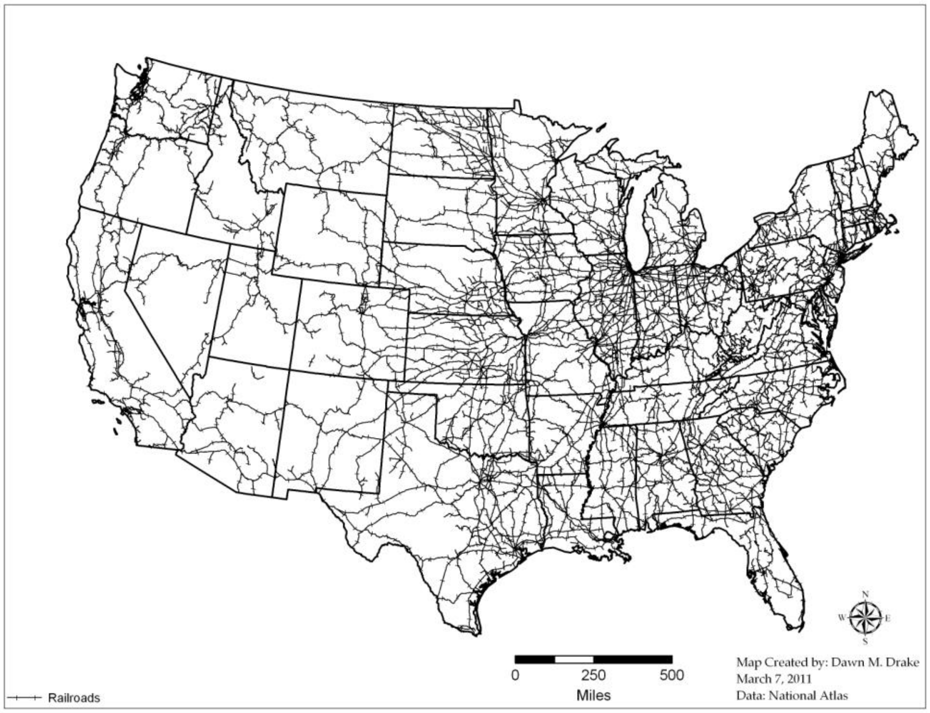

Figure 5.9: The network of railroads used to analyze transportation connectivity.

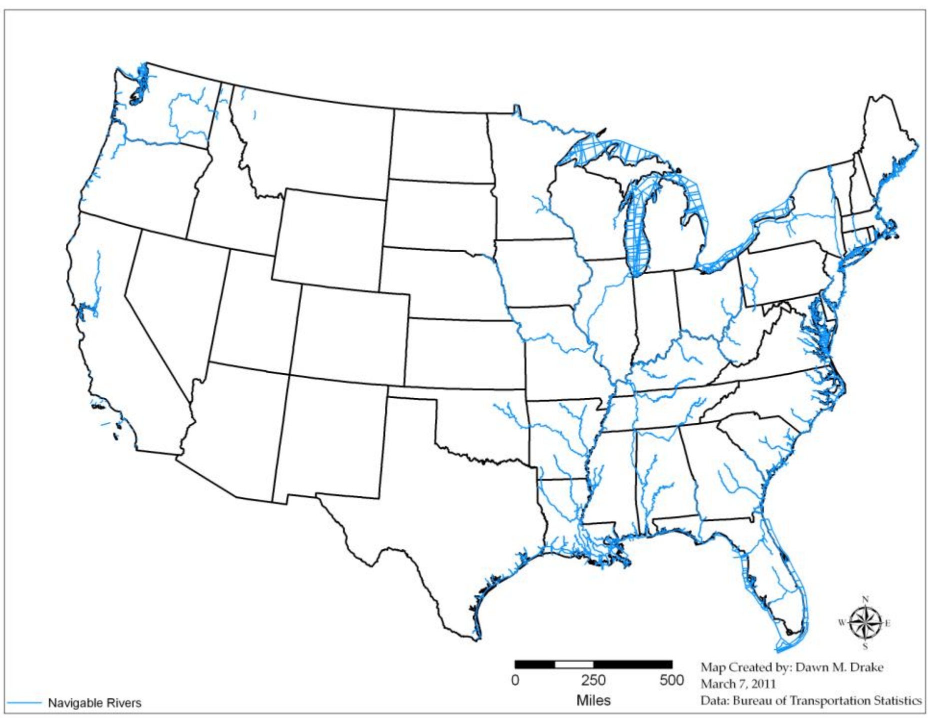

Figure 5.10: The network of navigable rivers used to analyze transportation connectivity.

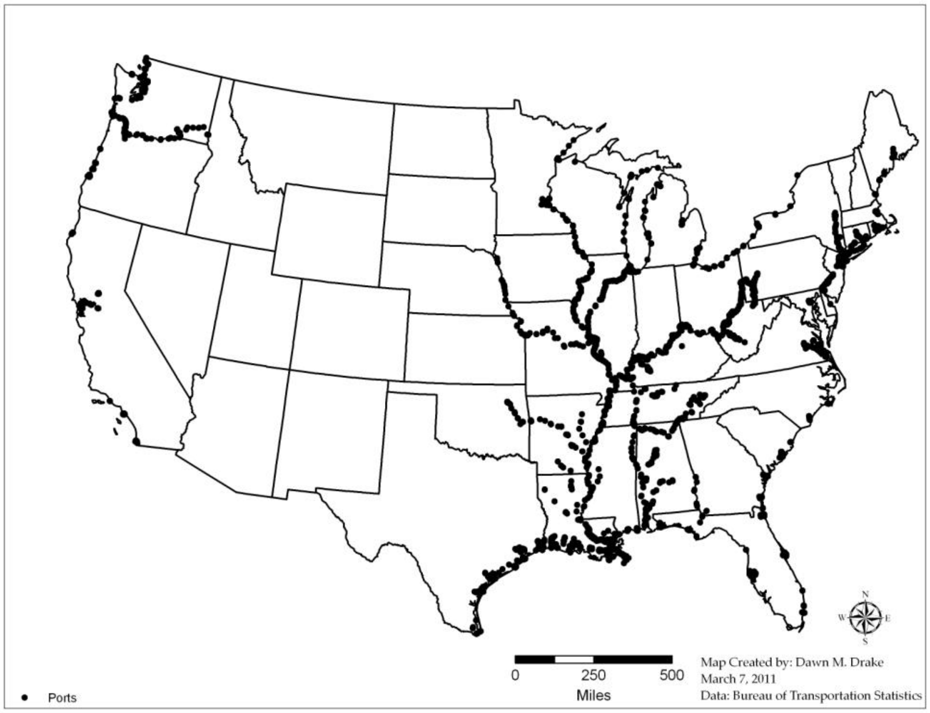

Figure 5.11: The network of port facilities used to analyze transportation connectivity.

Figure 5.12: The network of airports used to analyze transportation connectivity.

In looking at the transportation connectivity map for administrative and R&D functions, classified by the firm that owns each facility (Figure 5.13), it is apparent that R&D functions for the Big Three are well-connected to appropriate transportation networks, including interstates and airports, but headquarters are less well-connected. The notable exception is JD's Worldwide Headquarters, co-located with its main R&D facility in Moline, Illinois, which is located less than 15 minutes from Quad Cities International Airport[10] and adjacent to Interstate 80. Executives from JD can quickly access air transportation, or more likely, given how densely agglomerated JD's facilities are in the Upper Midwest, highway transportation, to any of the company's other facilities. A smaller administrative center and two R&D facilities for JD, located in North Carolina, are also situated in areas in the highest tier of transportation connectivity, making them more competitive than other possible sites.

Among those not well-connected for administrative and R&D functions is AGCO's headquarters in Duluth, Georgia, which is also home to its North American R&D operations. While the Atlanta MSA seems like it should be an area of high connectivity and a much better headquarters city than Moline, AGCO's site choice is distant from Hartsfield Jackson International Airport (over an hour of driving time in peak Atlanta traffic) and is located in the center of an industrial park far from major two-lane highways and interstates. The location is on the edge of an area of very good connectivity and its location has other benefits, so it is not as disadvantageous of a site as it appears from the transportation connectivity.

[10] While the airport in the Quad Cities is not as well-connected as if the headquarters was in a hub city, like Atlanta, given the fact that JD has its own fleet of company jets, the airport provides necessary infrastructure for a headquarters. Moline, Illinois is also better located relative to an airport when compared to either of CNH's North American headquarters.

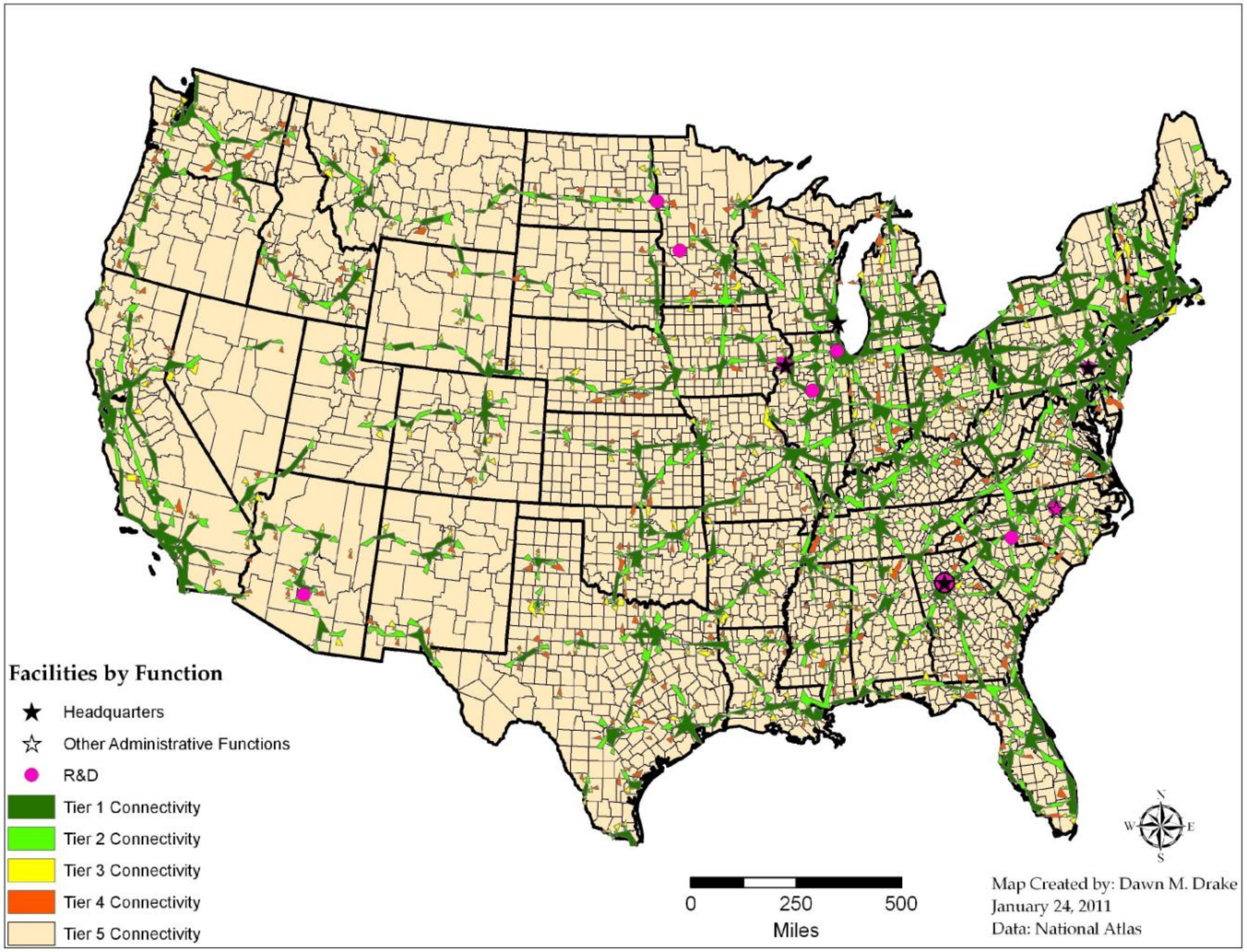

Figure 5.13: Transportation connectivity for administrative and R&D functions.

Both of CNH's North American headquarters are also poorly connected for administrative functions. In the case of the New Holland, Pennsylvania location, this is doubly of concern given it is also a major R&D facility for the company. Both locations are far from airports and are poorly connected to major interstates in the region. This is a function of the age of the facilities as well as the fact that they serve also as manufacturing sites for CNH. Both of these sites were selected in the 1800s, when truck transportation was not a possibility and airplane travel for executives had not been conceived. They may represent a trade off in site selection between the needs of administrative and R&D functions and manufacturing functions. It could also be simply a case of inertia, where CNH does not want to incur the costs to seek new locations that could maximize competitive advantage for itself.

Most of the rest of CNH's R&D facilities are well-connected, including the tractor testing facility in Stotonic, Arizona, a tractor R&D lab in Fargo, North Dakota, and R&D facilities in Davenport, Iowa; Goodfield, Illinois; and Burr Ridge, Illinois. In addition to the New Holland R&D facility, the only other exception, where a CNH R&D facility is not well-connected is the sprayer R&D lab in Benson, Minnesota. Its location, in the center of Minnesota, is distant from both airports and major highways. Since it is also a manufacturing facility, it may be better connected for manufacturing when airports are less important and poor highway access can be overcome with railroad or waterway connections.

The manufacturing and assembly plant locations for the Big Three also are primarily located in areas with good connectivity for their functions (Figure 5.14). This is partially due to the fact that the connectivity matrix is much larger when access to rivers, ports, and railroads are added to the analysis. Research by Fox and Murray (1990) found that transportation connections of these types were critical in the siting decisions of manufacturing firms in Tennessee.

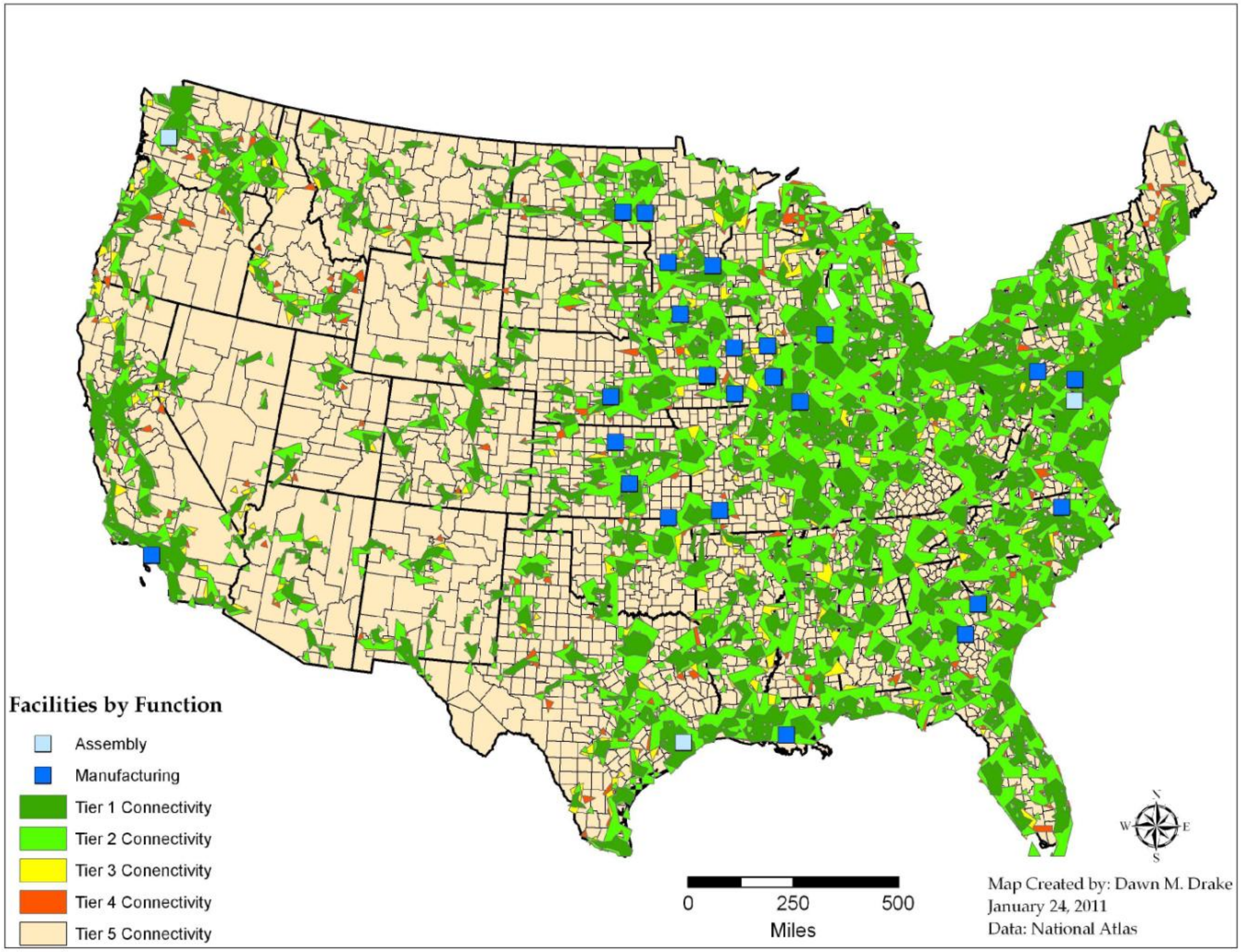

Figure 5.14: Transportation connectivity for manufacturing and assembly functions.

Highways and railroads, especially, were viewed as the critical ways to move goods and receive raw materials, with airport connections being important for access by company management (Fox and Murray 1990). By looking at the connectivity analysis of the Big Three's manufacturing and assembly facilities, it appears that the facilities are situated to achieve competitive advantage via transportation linkages despite the fact that many of them predate modern truck transportation.

This is not to say that all facilities are well-connected. While AGCO's new assembly plants are all in areas of high connectivity (not surprising given their nearness to major ports), only one of the three manufacturing facilities is well-connected. The manufacturing facility in Hesston, Kansas, which manufactures hay tools, combines, and planters, is in the top level of connectivity with good access to railroads and highways. This is a critical advantage given the fact that combines are among the most difficult and costly pieces of farm equipment to ship. The other items that are particularly expensive to ship are high-horsepower articulated tractors and self-propelled sprayers, which AGCO produces in its Jackson, Minnesota facility. Given the lack of railroad and interstate connections at this plant, it is surprising, when only looking at this one component of factor conditions, that AGCO kept it open after acquiring it from Caterpillar in 2002 (Shepherd 2002). Other areas of Porter's model, such as demand conditions, may better explain the site's location. The remaining facility in Beloit, Kansas is also poorly connected to railroads and highways with the main interstate for truck transport (Interstate 40) over 60 miles (97 kilometers) away from the plant, making it hard to bring in materials and ship out finished products. One advantage that the site in Beloit does have, which is not captured by this analysis, is that the plant sits on the banks of the Solomon River, which while not navigable, is a good source of hydroelectric power ("History of Beloit" 2007). This advantage helps AGCO offset higher shipping costs with cheap and abundant power. On the whole, however, given the fact that AGCO has closed many inefficient factories (Moore 2005), it seems surprising that these two, which are so poorly connected to transportation lines, remain open.

Many of CNH's manufacturing facilities are also well-connected to transportation. Among the most important to be well-connected are the Steiger plant in Fargo, North Dakota, which produces high-horsepower articulated tractors, and the combine plant in Grand Island, Nebraska. Both facilities are in the highest tier of connectivity for manufacturing with good access to both roads and railroads, making it much more cost effective to ship the large pieces of equipment manufactured at these sites. Also well-connected to the transportation infrastructure are the plants in Racine, Wisconsin; Goodfield, Illinois; Whitakers, North Carolina; and New Holland, Pennsylvania. The New Holland location was not well-suited to its position as a headquarters and R&D location for CNH, but it is well-connected to railroads for the shipping of manufacturing materials and final products. As I observed during the plant tour, a rail spur runs right through New Holland and the grounds of the plant. While some of the implements are shipped by truck, the rail line is used by CNH to ship implements to more distant locations. The locations in Racine, Wisconsin and Goodfield, Illinois were also well-connected for administrative and R&D functions, meaning that these sites are well-suited for multiple purposes, further advancing competitive advantage for CNH.

Other facilities owned by CNH are connected, but not at as high of a level as the aforementioned facilities. The compact tractor plant in Dublin, Georgia, which enjoys access to the ports of Savannah and Charleston (J. Daniels, pers. comm.), is at a distance from the necessary highway infrastructure to move containers to and from the port (Valverde 1997; Lagneaux 2007). This places it into the second tier of connectivity. Ports are only an effective method of shipping farm machinery if they are easily accessed by navigable rivers, railroads, or highways. In most cases railroads are not the preferable method of accessing ports because the average port hinterland is less than 100 miles (161 kilometers), making highways a more effective shipping method (Valverde 1997).

The sprayer manufacturing facility in Benson, Minnesota is in the third tier of connectivity. While it is still connected, it is probably not connected well enough to make the plant cost-competitive with other firms that are better situated. Given the fact this plant was poorly connected for its R&D functions, this is a location that should be of concern to CNH. When the plant was built in the 1900s, however, Benson was an end of the railroad town that was much better situated as a manufacturing location ("History of Benson, MN Area" 2007).

The only one of CNH's manufacturing facilities that is poorly connected to the transportation grid is its facility in Belleville, Pennsylvania, which is a secondary plant for the manufacture of hay and forage tools. This plant is far from the positive externalities of railroads or highway transportation, but is very close to the benefits of research connections with the local land grant university, Pennsylvania State University, which negates some of the competitive disadvantage of its connections to transportation infrastructure. Also, given the fact that the equipment produced in the plant is lightweight and easy to transport, connectivity of this sort may not be the vital factor condition for the site.

Many of JD's manufacturing facilities are also well-connected to the transportation network. In fact, only one of its plants is poorly connected to the transportation system. This facility, in Coffeyville, Kansas, however, is also one of the older plants in use by JD, being built in 1930 (Gibbard 1998). At the time that the site was selected, JD had limited resources to conduct an exhaustive search and settled on this location (Gibbard 1998).

The rest of JD's facilities are all in the top two tiers of connectivity, which gives the company competitive advantage over CNH or AGCO. Its plants in Thibodeaux, Louisiana; Moline, Illinois; East Moline, Illinois; and Dubuque, Iowa are situated on the banks of the Mississippi River with easy access to both railroad and inland port facilities to move heavy machinery cheaply. One worry that JD may have, in relying on the Mississippi River for shipping, is continuing concerns on the part of numerous private organizations about the reliability of infrastructure, such as locks along the river, in the long run (Munro 2010). If the aging infrastructure on the Mississippi River cannot keep up to the demands of shipping companies, JD will need to find other ways to receive materials and ship finished goods to market.

Other well-connected JD facilities include those in Ottumwa, Iowa; Torrance, California; Coon Rapids, Minnesota; Fargo, North Dakota; Des Moines, Iowa; Grovetown, Georgia; Urbandale, Iowa; Springfield, Missouri; and Waterloo, Iowa. The seeding tool facility in Valley City, North Dakota is slightly less well-connected to highways than the nearby plant in Fargo. Overall, however, JD has the best transportation connectivity for not just administrative and R&D functions, but also for manufacturing.

5.3 Demand Conditions

The US farm machinery industry enjoys a premier position in one of the most demanding and sophisticated domestic markets in the world. Farmers in the US are not easily satisfied with the old way of doing things and are constantly striving to increase efficiency and manage higher yields as a means to a higher margin of profit (*Business Wire* 2007). Not only do US farmers act as superb testers for new products, but they constantly drive the farm machinery industry to innovate and create new products to increase the farmer's bottom line (Schroeder et al. 1995) and have been doing so over the history of the industry (Vicas 1969). They want to see new solutions in operation before they buy and the US farm machinery industry is best equipped to provide that to the US farmer (Grooms 2010b). This is similar to the results of Bowen and Leinbach's (2006) empirical test of Porter using a case study of airfreight forwarders to find that demand in the home market led to innovation for the sector.

The US agriculture sector is not so large as to be the only customers for JD, AGCO, and CNH, however. Approximately half of sales for CNH and JD are domestic, while AGCO exports more than 60 percent of its production in any given year (Kearney 2009). The US farm machinery industry enjoys balance in its demand conditions, with a sophisticated domestic customer network that stimulates growth and innovation, but does not command all of the Big Three's supply, allowing not only domestic, but also global sales leadership.

5.3.1 Market Distance

Demand conditions can be analyzed by examining the locations of facilities relative to high concentrations of demand. While MacPherson and Boasson (2004) found it hard to measure sophistication of consumers from secondary data, it is safe to assume that customers in an advanced economy present a uniform level of basic sophistication. Taking this a step further, customers in an area of high demand can be assumed to be well-informed and able to assess products with educated opinions. Farmers in areas of high demand for mechanized farm machinery, therefore, represent a sophisticated base of consumers for the US farm machinery industry.

Distance to markets has been a deciding factor in location decisions for the farm machinery industry for decades. Archival evidence from 1957, demonstrates that executives from J.I. Case (a predecessor company of CNH) were concerned about locating new manufacturing facilities too far from the markets ("Letter to John T. Brown, William J. Grede and M.B. Rojtman from Leon Clausen" 13 Feb. 1957, Library-Archives, Wisconsin Historical Society, Mss 341). By looking for clusters of farms with high concentrations of 100 horsepower (75 kilowatts) or more tractors or combines, target markets can be identified for the Big Three.

It would be logical to locate manufacturing and assembly facilities for tractors and combines in places that can access these markets easily and minimize transportation costs. It also is intuitive that R&D for tractors and combines would be located close to the consumer who can provide feedback. This is would be of the most benefit to CNH, who uses "customer driven product design" in its Magnum and Steiger tractor R&D (Figure 5.15). The ability to cater marketing to location-based demand linkages could provide competitive advantage for CNH and give the firm closer ties to its customers.

A number of manufacturing plants and R&D facilities are within proximity to areas with average or above average numbers of farm tractors or combines. Combine manufacturing and R&D (Figure 5.16) are located in areas with higher than average demand for these large pieces of equipment. Also, for the most part, facilities that manufacture or conduct R&D for tractors (Figure 5.17) are located in areas with either slightly above or above average tractor ownership.

Figure 5.15: Signage in Case IH's display area at 2010 Farm Progress in Boone, IA advertising its customer driven product design (picture taken by author).

Exceptions include all three of AGCO's new assembly plants, which were built with port facility connections in mind (*Beef Magazine* Staff 2008), as well as CNH's Dublin Works in Dublin, Georgia and JD Commercial Products in Grovetown, Georgia, which appear to be outliers, poorly connected to the market. These facilities, however, are building compact tractors, which are purchased not only by farmers, but also landscapers and the average homeowner, two consumer groups not captured by the Census of Agriculture data. Additionally, because this analysis looks at ownership of tractors over 100 horsepower (75 kilowatts), it is not the correct market for these facilities whose largest products will not exceed 75 horsepower (56 kilowatts). Given the fact that both operations are close to each other, it is likely that they are situated well, despite what the data indicate. AGCO's R&D facility is also outside of the main market, but given the fact that manufacturing plants for AGCO's tractors and combines are in the main market, this is not a major concern. Overall, it seems that the Big Three are maximizing their proximity to consumer markets for large capital purchases through their location decisions.

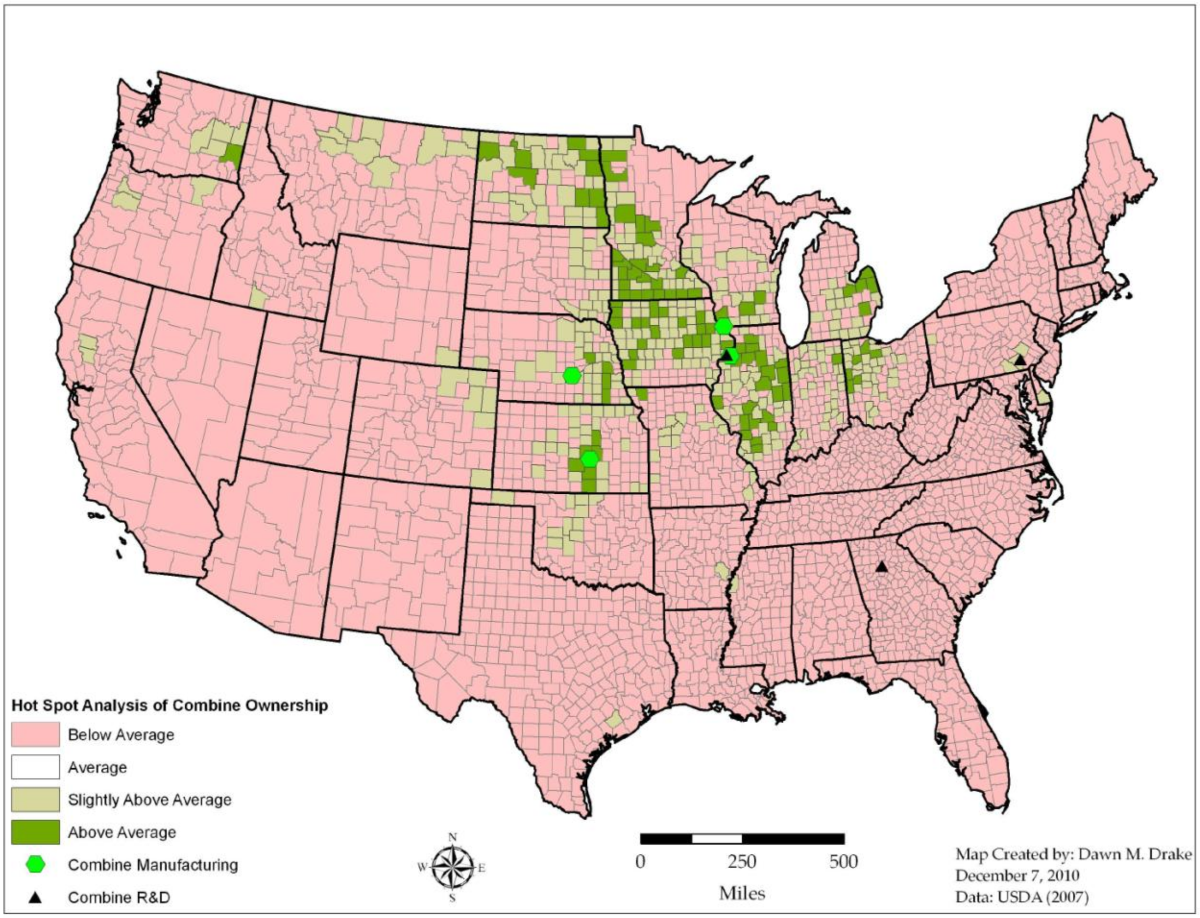

Figure 5.16: Cluster analysis of ownership data of combines from the US Census of Agriculture.

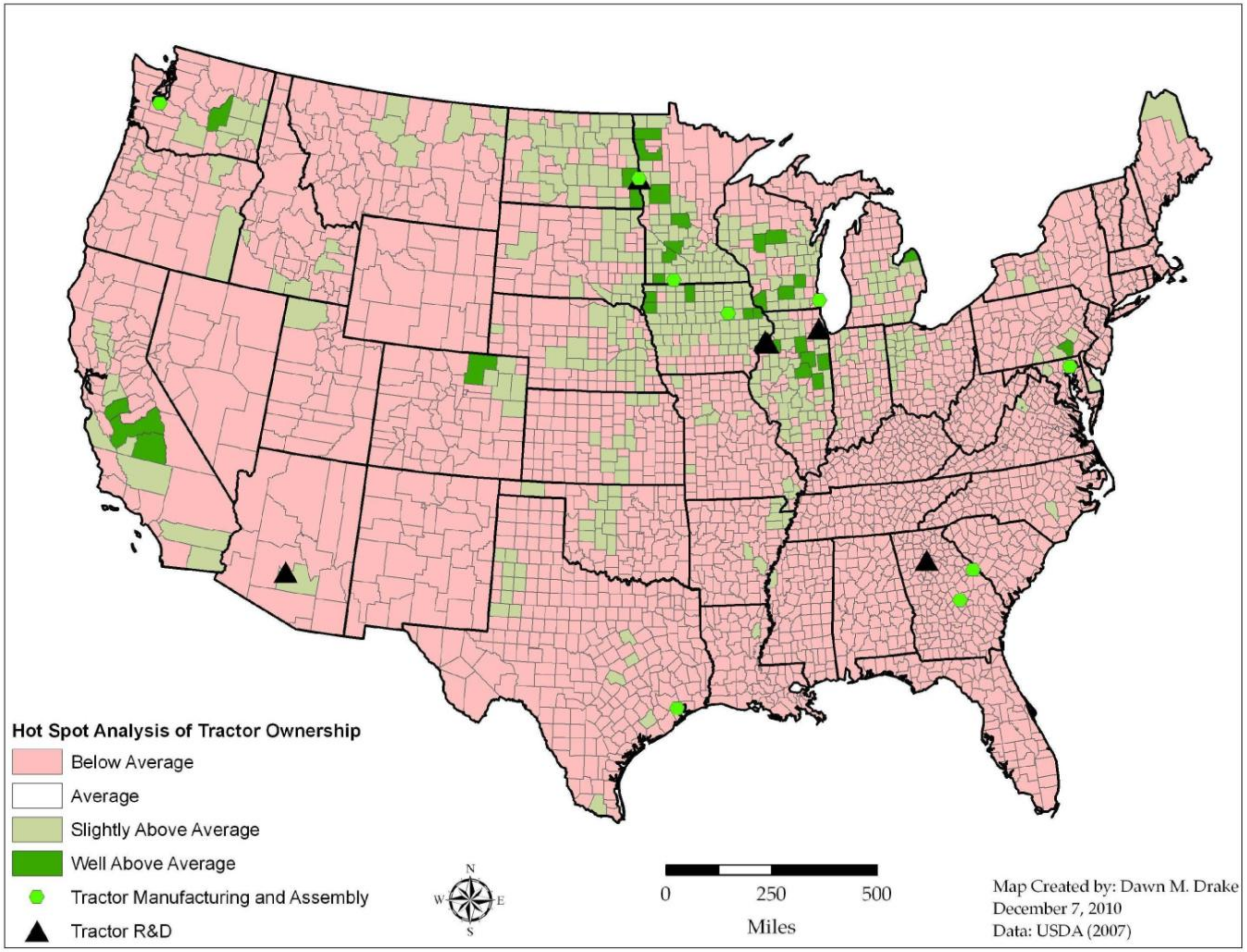

Figure 5.17: Cluster analysis of ownership data of tractors over 100 horsepower (75 kilowatts) from the US Census of Agriculture.

5.3.2 Customer Support

In addition to locating facilities near prime markets, it is also important to competitive advantage for the Big Three to provide support after the sale as well as financing options to allow for large capital expenditures such as combines and high-horsepower tractors (Lessiter 2011). This usually takes the form of a dense and well-developed dealer network that can provide service, training, and technology support. The dealership network of a particular farm machinery company is important to maintaining market share and brand loyalty for the firm (Kanicki 2011). For JD, its expansive and responsive dealer network has often been cited as one of the keys to its competitive advantage (Berg 1989). Most owners rate concerns such as distance to dealer and the ability to obtain parts in a timely fashion as critical to their machinery decisions (Kanicki 2011). If a farmer has to wait two days or drive two hours to get a part when something breaks, that is lost time in the field. Many farmers measure reliability of a farm machinery manufacturer on total uptime of a machine in a given year – greater uptimes equal reputations for higher quality products (Lessiter 2011). A reputation for higher quality will lead to greater brand loyalty and competitive advantage (Kanicki 2011). When the quality of International Harvester planters decreased in the 1970s, the company went from controlling the market to trailing, virtually overnight (R. Kleinsasser, pers. comm.). Because distance to dealer is a critical deciding factor for farmers, the Big Three often struggle with decisions that would reduce their dealer networks (Gaines 2010c). Versatile has set a goal, as it expands its dealer network in the US, to create 60-mile (97-kilometer) service areas, that a single dealer is responsible for, to provide the highest level of service to the customer and make Versatile competitive against the Big Three (Wehrspann 2010f). The Big Three, with very dense networks of dealers all across the US can provide better service and support to its customers than some of the newer international competitors that have yet to establish their presence in the US.

In addition to physical dealer presence, support from the company itself to the customers is also critical, which is why websites for the Big Three provide one-click access to service and finance information from almost every page. Additionally, trade show displays frequently include signage regarding financing opportunities (Figure 5.18), service contracts and warranties (Figure 5.19), as well as access to parts catalogs and product literature. Starting in 2010, AGCO began providing CDs to visitors at its trade show displays that contain the full library of product literature on every piece of equipment in the AGCO line, including parts lists and operator manuals. Case New Holland also makes parts catalogs available to customers at its trade show displays. This improves the customer experience for AGCO and CNH owners and can foster competitive advantage for the firm.

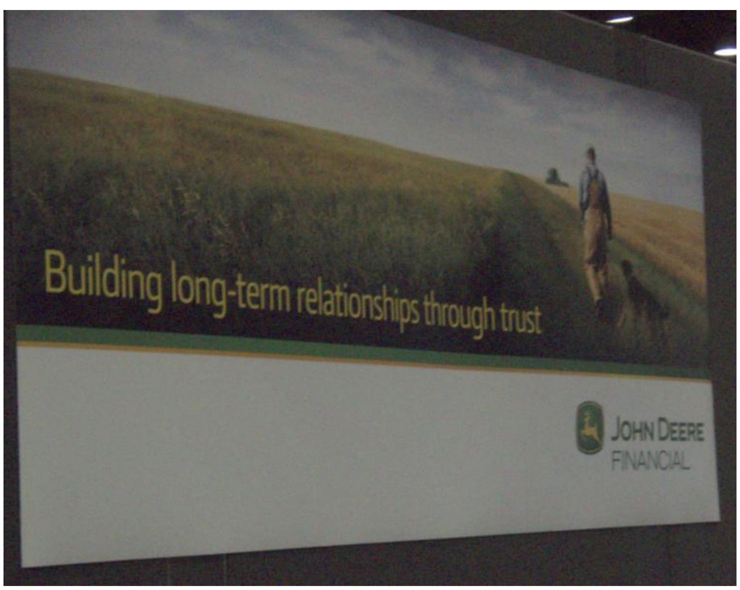

Figure 5.18: Signage in JD's display area at the 2011 National Farm Machinery Show in Louisville, KY advertising its financial solutions (picture taken by author).

Figure 5.19: Signage in Case IH (left) and AGCO (right) display areas at the 2011 National Farm Machinery Show in Louisville, KY advertising their service programs (picture taken by author).

5.4 Firm Structure, Strategy, and Rivalry

Firm structure, strategy, and rivalry manifest themselves in several ways to enable the US farm machinery industry's competitive advantage. A variety of seemingly minor day-to-day business decisions can have major impacts on both the geography of the industry and the competitiveness of individual firms (Porter 1990). In an increasingly globalized economy, the geographic distance between facilities for a particular firm and/or the extent of its global focus can profoundly affect competitive advantage. Other literature, including research into headquarters and R&D siting, as well as studies of the creative class can contribute to this analysis. Manufacturing decisions can be illuminated by examining research into the product life cycle construct and, as a subset of this, green technologies. A brief examination of manufacturing technology is also relevant to this discussion.

Beyond firm strategy and structure, it is also important to examine rivalry for the Big Three both between the three firms and with international competitors. Rivalry can drive innovation and force firms to remain on the forefront of the product life cycle (Porter 1990). Not responding to rivals can have profound negative effects on a company's competitive advantage (Schroeder et al. 1995; Lash and Wellington 2007; Lessiter 2011). One only has to look at the automobile industry for an example of this. Toyota and Honda took the lead in developing more fuel efficient vehicles, while the Detroit automakers continued to build gas-guzzling SUVs. When the price of gas began to rise, it was nearly impossible for General Motors and Chrysler to catch up to the advantages of their foreign competitors (Lash and Wellington 2007), resulting in federal government bailouts. While much of the rivalry in the industry occurs between the Big Three, there are a number of international firms that also drive innovation and allow for knowledge spillovers in the sector. Examining their locations, relative to the Big Three, presents a new farm machinery cluster that has implications for industry life cycle theory.

5.4.1 Business Decisions

5.4.1.1 Agglomerations and Global Strategies

A multi-ring buffer analysis presents a picture of whether individual firms are creating agglomerations within the company. Research has indicated that keeping various types of facilities within proximity to one another can foster competitive advantage (Brennan 2000). As seen in Figure 5.20, AGCO is keeping its manufacturing facilities in the heartland of farm machinery, at some distance from its administrative functions. It is interesting that, despite recycling manufacturing facilities that it received as a result of acquisitions, all of the US plants are approximately 1,000 miles (1,609 kilometers) from AGCO's Worldwide Headquarters. While this may be a calculated strategy, management across this span would be difficult, which

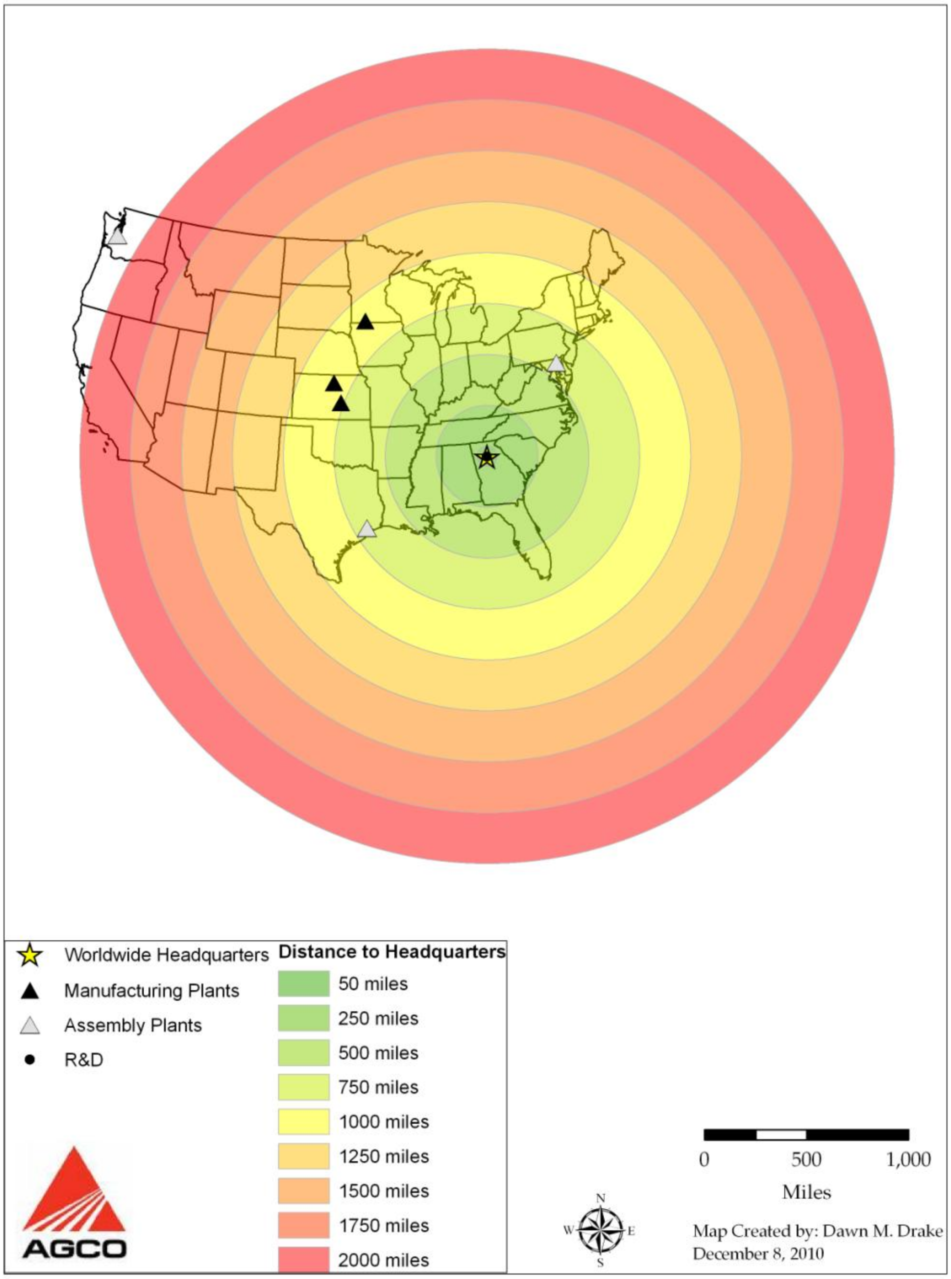

Figure 5.20: A multi-ring buffer analysis from the Worldwide Headquarters to other AGCO facilities.

could have an impact on competitive advantage for AGCO. Two of the three assembly facilities that AGCO recently built are located within 750 miles (1,207 kilometers) of the headquarters, with the third (Tacoma, Washington) furthest from the home base of operations. These three assembly facilities were sited based on their nearness to major ports (*Beef Magazine* Staff 2007), and, as was seen in the transportation connectivity analysis (section 5.2.4), can be easily reached from the headquarters, regardless of distance. The question becomes, is this decentralized model that AGCO employs a part of a larger strategy to focus on its more global connections, with the majority of its manufacturing occurring in South America and Europe?

Case New Holland, on the other hand, is employing a different strategy from AGCO (Figure 5.21). With the exception of its tractor testing center in Stotonic, Arizona, all of CNH's plants and R&D sites are within 750 miles (1,207 kilometers) of one of its North American Headquarters (Racine Wisconsin or New Holland, Pennsylvania). In fact, over two-thirds of the facilities are within 500 miles (805 kilometers) of an administrative center. It is interesting to note that CNH uses a piggy-back method for much of its manufacturing and R&D, where one site is not only building machinery, but also conducting research. This limits fixed costs involved in maintaining separate facilities. From this perspective, CNH should have an advantage in intra-firm knowledge sharing compared to AGCO, in addition to pursuing a more agglomerated focus centered largely on the center of its North American demand in the Midwest Corn and Wheat Belts.

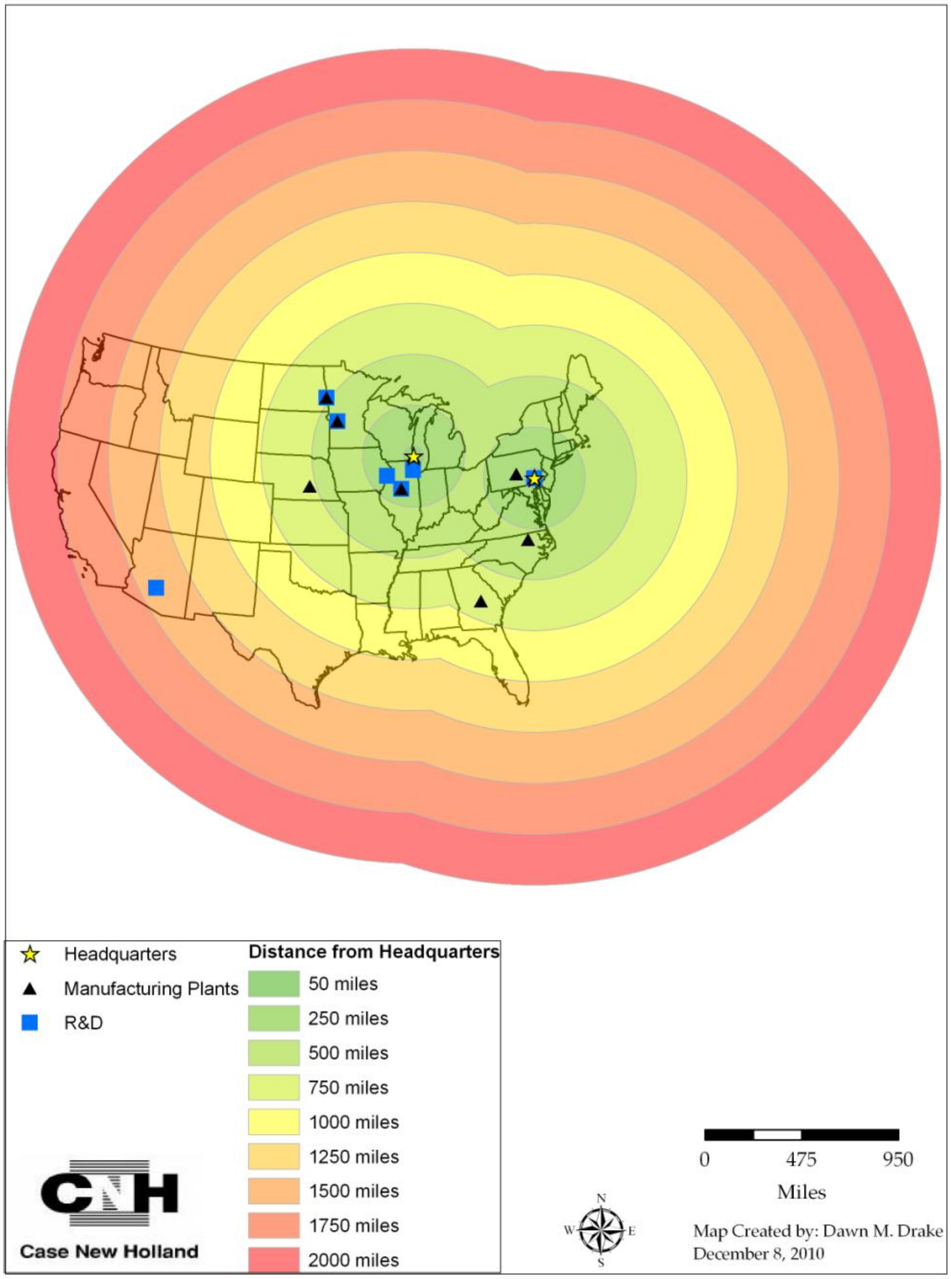

Figure 5.21: A multi-ring buffer analysis from CNH's two North American Headquarters to its other facilities.

Deere also presents an agglomerated system with over 90 percent of its facilities within 750 miles (1,207 kilometers) of Moline, Illinois (Figure 5.22). This allows for a very compact management system with easier communication flows than either AGCO or CNH. Hill and

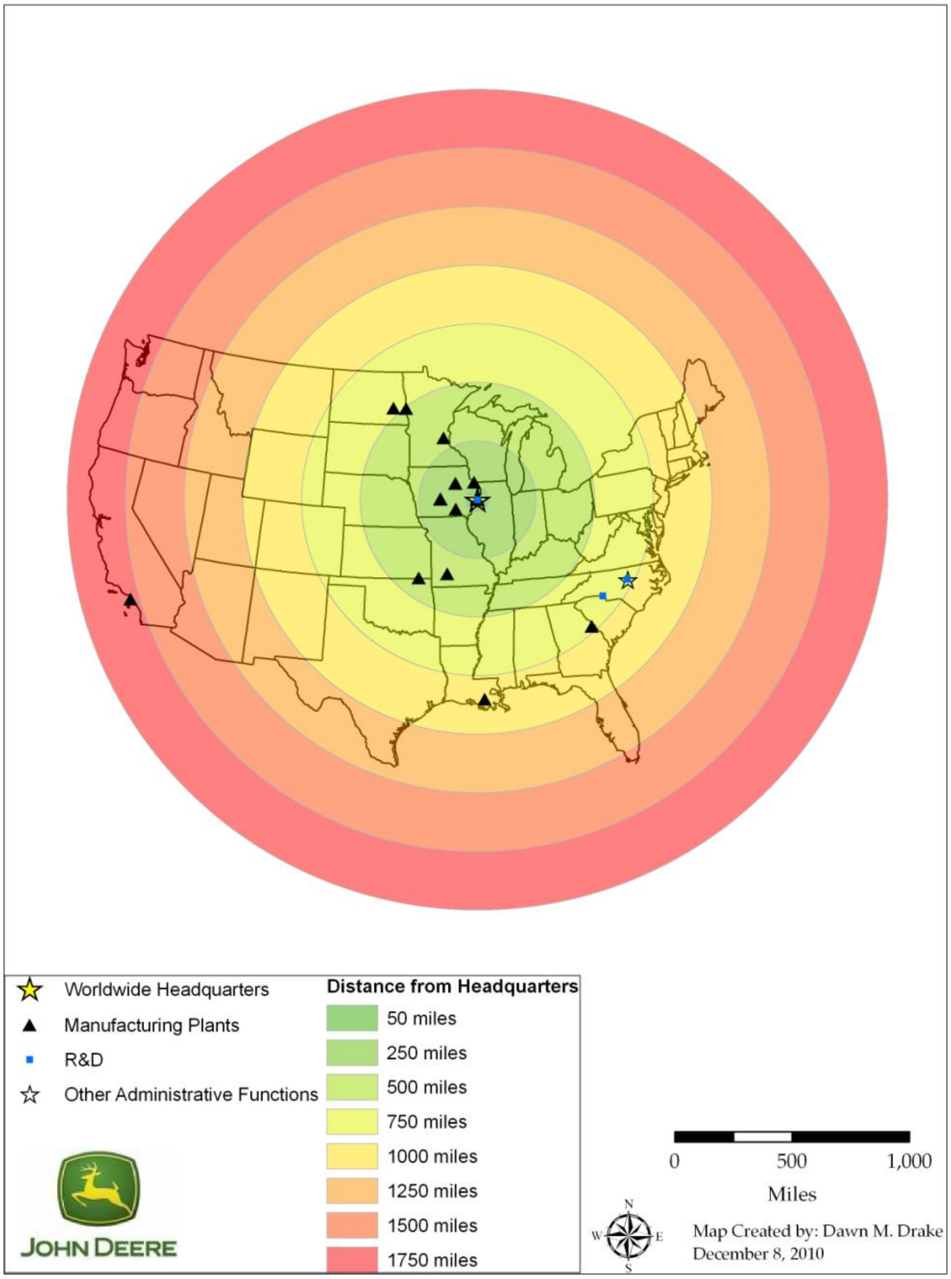

Figure 5.22: A multi-ring buffer analysis from JD's Worldwide Headquarters to its other facilities.

Brennan (2000) found that industrial areas that have headquarters, R&D facilities, and manufacturing plants in proximity are more productive in a capital-intensive industry, like farm machinery (IBISWorld 2009). The only two JD facilities outside the 750 mile (1,207 kilometer) distance band are NavCom Technology in Torrance, California and John Deere Thibodaux in Thibodaux, Louisiana. NavCom is the production facility for JD's navigation, guidance, and precision agriculture systems. By being located in Torrance, it should be able to take advantage of knowledge spillovers from Aerospace Alley as well as, perhaps, Silicon Valley. John Deere Thibodaux is a JD-built production facility for sugarcane harvesters, many of which are either sold into the Gulf region or exported to South America. For these reasons, these two locations make sense, despite being outside JD's closely held network. When looking at all of the locations together, JD is the most internally agglomerated of the Big Three, which gives it a competitive advantage in terms of firm structure, strategy, and rivalry, but it also is an indicator of its lack of a global focus, despite exporting 50 percent of its products.

On the flipside of looking at domestic agglomeration for the individual members of the Big Three is an examination of the level of global strategies that they are pursing. All of the Big Three are increasingly globalized, whether they demonstrate an emphasis on globalization in their strategies or not. Each of the firms has numerous overseas production and sales facilities. There is an overwhelming body of evidence that suggests that success in business and industry today requires globalization of operations and sales (Bourdreau et al. 1998; Porter 1998c). Globalization has been the leading way that the Big Three have increased profits even when the domestic market was weak (*US Industry Profile* 2009). This has included penetration into the key Brazilian, Russian, Indian, and Chinese (BRIC) economies (Shinkle and Marquardt 2008).[11] Having global locations is not enough, however. Firms with the highest levels of competitive advantage go beyond just having manufacturing plants and sales offices around the globe. They must also have a focus on the wider world beyond their home market (a global strategy).

An analysis of the websites of the Big Three can tell one a lot about what the firms think the customer wants access to and what, therefore, are key to each firm's marketing strategies. For JD, an underlying global focus is apparent, but the company appears to be walking a fine line between its domestic and international consumers. When someone navigates to JD's main page, he or she is automatically redirected to the JD site for the country in which he or she is located. This is not unusual. CNH's front pages also direct users to the site for the country in which they are interested. What is special about JD's site compared to CNH is that on 97 percent of the pages, the user is never more than one click away from a page listing all career opportunities at JD in the entire world and a page that lists every worldwide JD location for sales, manufacturing, and parts distribution. On 34 percent of the pages, users can also navigate easily to another page outlining JD's global philanthropic activities. A firm that is pursuing a truly global focus is not only going to be a good local philanthropist, but a true global citizen. The content analysis of JD's website seems to indicate that they are pursuing a strategy that tries to balance the global and the local, emphasizing the importance of their global operations even within the local

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[11] Significant investments have been made in Brazil by AGCO (*Trachbel Magazine* 2010). All three firms have joint ventures in China (Associated Press 2000; Mercer 2001; *Diesel Progress* 2011a). In 2001, Deere opened a plant in India (Kingsbury 2010). In 2005, AGCO entered into a joint venture with Indian company TAFE to assemble tractors in Chennai (Business Line 2009). This was followed by significant investments by AGCO in Russia in 2008 to build tractors and Sisu engines (*Diesel Progress* 2008).

website. This makes sense since JD was the last of the Big Three to enter into global operations (Van Zandt Schreiber 1966), but once it was established, it flourished and gained market share.

For CNH, it is a much more cumbersome process to locate information about worldwide locations and careers. There is single-click access from the front pages to worldwide careers with CNH and also to information about global financing of CNH products, but once the user has navigated away from the front pages, those other pages are harder to find, given that there are no direct links. In terms of global sales, CNH does not widely promote its worldwide dealer network on its web pages. There is a used tractor locator page that allows farmers to search CNH dealers around the world. The investor information page, also accessed from the front pages, discusses the size and depth of CNH's global sales network. Otherwise, it is very difficult to get an accurate impression of CNH's global reach from its North American website without multiple clicks. Case New Holland is trying to cater more to the local than the global through its websites, giving visitors very limited access to information about operations outside their home market.

AGCO's website makes it very easy for the user to access information about the firm's global presence in sales and manufacturing. Foremost, AGCO's website is not made up of a number of separate sites for the individual countries in which they operate. Whether the farmer is in Brazil or Burkina Faso, he or she will access the same website and he or she is almost never more than one click away from a page that shows every manufacturing, sales, and parts distribution facility that AGCO maintains across the globe. Users of AGCO's website are also usually never more than one click away from a page describing the firm's global philanthropic activities. Visitors to AGCO's website are first welcomed with a key piece of the firm's mission statement "….to provide high-tech solutions to farmers feeding the world" (AGCO Corporate

2010). They then can navigate to another page that outlines AGCO's social responsibilities and its philanthropic activities. All of this indicates AGCO's global focus, moving it beyond a local North American view to one that is more indicative of AGCO's leadership in emerging markets such as South America and Asia (AGCO Corporate 2007).

Trade show reconnaissance and content analysis of images demonstrate AGCO's much clearer global focus compared to either JD or CNH. Ag Connect Expo itself is a clear indicator of AGCO's global focus. Ag Connect Expo is the first international trade fair for the farm machinery industry to be located in North America. The driving force behind this was AGCO's CEO, Martin Richenhagen (*Trachbel Magazine* 2010) and in 2011, AGCO was one of the leading sponsors. The company typically has display areas twice to three times the size of JD or CNH at Ag Connect Expo[12], a noteworthy point when one considers that international trade shows usually provide the most return on investment for firms (Rice 1992). Richenhagen envisions Ag Connect Expo as a meeting place for knowledge and innovation in the farm machinery industry, which coincidently is also critical to the mission of AGCO (Gaines 2010e).

Displays by AGCO at both the 2010 Ag Connect Expo and National Farm Machinery Show featured a banner that stated plainly that AGCO "…work[s] globally" (Figure 5.23). At the 2010 Ag Connect Expo, AGCO also had a touch-screen computer center that allowed visitors to learn about its global presence and market leadership in Brazil and Europe.

CNH also tried to instill a global focus in its display area at the 2010 Ag Connect Expo although not to the extent that AGCO did. During the hourly presentations at the Case IH main stage, there were greetings in Portuguese and Spanish as well as English. This tradition was not maintained at the 2011 Ag Connect Expo, however. Also, at Ag Connect Expo in 2010, but not

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[12] At Ag Connect Expo, CNH only displayed products from Case IH and not New Holland.

2011, some of CNH's displays discussed solutions for crops that are more prevalent in other parts of the world than in North America. On the whole, however, AGCO's trade show display areas convey the importance of global focus much more clearly than CNH's.

Figure 5.23: Signage in AGCO's display area at 2010 Ag Connect Expo in Orlando, FL (picture taken by author).

Deere appears to exhibit little interest in advertising its extensive global connections to customers at trade shows in the US or Canada. At Ag Connect Expo in 2010, JD's floor space was much smaller and very distant from the main areas where AGCO and CNH displayed their products. Additionally, JD had **no** display at the 2011 Canadian International Farm Show, despite displays by both AGCO and Case IH. Even when JD does have large display areas, there is rarely an attempt to advertise international locations, global philanthropy, or other global connections, unlike display areas of AGCO or CNH.

Global strategies can provide the Big Three with competitive advantage by insulating them from weak market conditions in the US (D'Amica 2008). This is a strategy that AGCO has fully embraced with the majority of its profits being generated by sales in Europe and Brazil (IBISWorld 2009). Not only does it advertise its global operations, it also is a true global citizen with philanthropic investments in Haiti, Brazil, and India (AGCO 2011d). The only possible concern for AGCO, given leadership in such divergent markets, are the costs to customize products to meet stringent safety and environmental laws in Europe, when necessary fluids, like ultra-low sulfur diesel fuel, required for low emissions engines, are not available in South America presently (J. Rogers, pers. comm.).

Deere has the most global locations, but it appears to be less interested in embracing its globalism, choosing to focus on its North American customers and philanthropy[13]. This lack of global strategy is probably why JD was so late to enter the overseas market and struggled, taking much longer to achieve its global dominance (Van Zandt Schreiber 1966), while predecessor companies of AGCO and CNH flourished. As the population of the world continues to grow and more sales occur in the BRIC economies, a trend emerges which intersects with product life cycle research. Product life cycle research suggests that firms that embrace globalization rather than internationalization may be the ones with the most competitive advantage (Vernon 1979). Among the Big Three, AGCO appears to be embracing globalization rather than internationalization more completely. The companies that have the true competitive advantage,

[13] While JD's website has a section on global citizenship and philanthropy, the majority of its investments are in North America (John Deere 2009).

in this case, however, are those who produce relatively inexpensive tractors that meet the needs of the developing world. This includes firms like Mahindra and Mahindra and other Asian manufacturers (Kingsbury 2010)[14].

5.4.1.2 Headquarters

In addition to examining decisions impacting firm strategy and structure in terms of agglomeration, location decisions related to the siting of headquarters are crucial. Criteria used by firms to select a location are varied and numerous. In a 1965 report evaluating the suitability of Des Moines, Iowa as the location of Massey-Ferguson's North American headquarters, the company stated that its primary concerns were to be located in the Corn Belt, near a major agricultural college, with a stable and well educated workforce and a well-connected airport. Additionally, Massey-Ferguson desired a city with a population less than 500,000 (Archival and Special Collections, University of Guelph Library, X41 RHC A0390). Figure 5.24 presents the locations of the headquarters and other administrative functions of the Big Three. Each firm is pursuing slightly different strategies when it comes to headquarters number and location. The leanest operating system is AGCO, which has a single headquarters facility in the US, located in Duluth, Georgia. That single headquarters is the worldwide headquarters for the company. Deere also maintains a single worldwide headquarters in Moline, Illinois, with a secondary administrative center in Charlotte, North Carolina that manages distribution and employee training issues. Comparatively, CNH has the largest system with two North American headquarters (Racine, Wisconsin for Case IH Agriculture and New Holland, Pennsylvania for

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[14] Both New Holland and JD manufacture versions of some of their smaller tractors that feature less options and are cheaper (J. Daniels, pers. comm.).

New Holland Agriculture). These different strategies and locations all fit into the literature on headquarters siting in different ways and demonstrate different issues for competitive advantage.

Figure 5.24: Headquarters and other administrative function locations for the Big Three.

Deere is located within the heartland of tractor production, but Moline, Illinois is not a major metropolitan area, or even likely to be classified as a second-tier city. On paper, Moline appears to be a disadvantageous location choice, yet JD has maintained high levels of market control and dominance. This is likely a function of inertia and the extreme costs of changing course now. Even if JD identified a better site location for its headquarters, it would be very expensive to try to move operations that have become so entrenched over time.

Orlando and Verba (2005), who state that mature industries are more able to locate in smaller metropolitan or non-urban areas to acquire a competitive advantage, may also shed light on JD's decisions. Mature industries innovate at a more incremental scale and are less dependent on urbanization economies. Urbanization economies contribute to research facilities that generate paradigm shifts in the industry and provide the types of specialized business services, that a younger sector might need. Strong highway, water, and railroad connections make Moline, Illinois a more desirable choice for a mature industry that is dependent on cheap transportation to ship heavy goods. While JD has always maintained its position in Moline, Illinois, perhaps it has gained advantage over time as the industry has matured and is less likely to move due to inertia.

AGCO exemplifies another strain of the headquarters literature. Holloway and Wheeler (1991) found that the majority of headquarter relocations, especially those that tend to disperse and decentralize an industry, are the result of mergers and acquisitions. While CNH's merger and acquisition activity has led to headquarter locations in the same cities as in the very early days of the predecessor companies (Figure 5.25), AGCO has moved far from its roots (Figure 5.26). While essentially a new company, AGCO can be thought of as a product of mergers and acquisitions as well, assuming that, in 1990, AGCO's shareholders acquired the original Allis-Chalmers Corporation that was sold to KHD in 1985. The result was a movement of the corporate headquarters from Milwaukee, Wisconsin, part of the traditional farm machinery cluster, to Duluth, Georgia. The result of these mergers and acquisitions has been a different corporate headquarters geography.

This is not to say that Atlanta is a bad choice for AGCO. As early as 1927, the Atlanta metropolitan area was already being heralded as a center of headquarters activity (Dickinson

1934). Gong and Wheeler (2007) noticed an increased presence of headquarters of major Fortune 500 companies in the region, which can have positive impacts on competitive advantage for AGCO as well. Atlanta has positive externalities for AGCO in many facets of competitive advantage as well as being a city with a legacy of manufacturing that has now shifted to specialize in providing the necessary infrastructure for the higher order functions of administration.

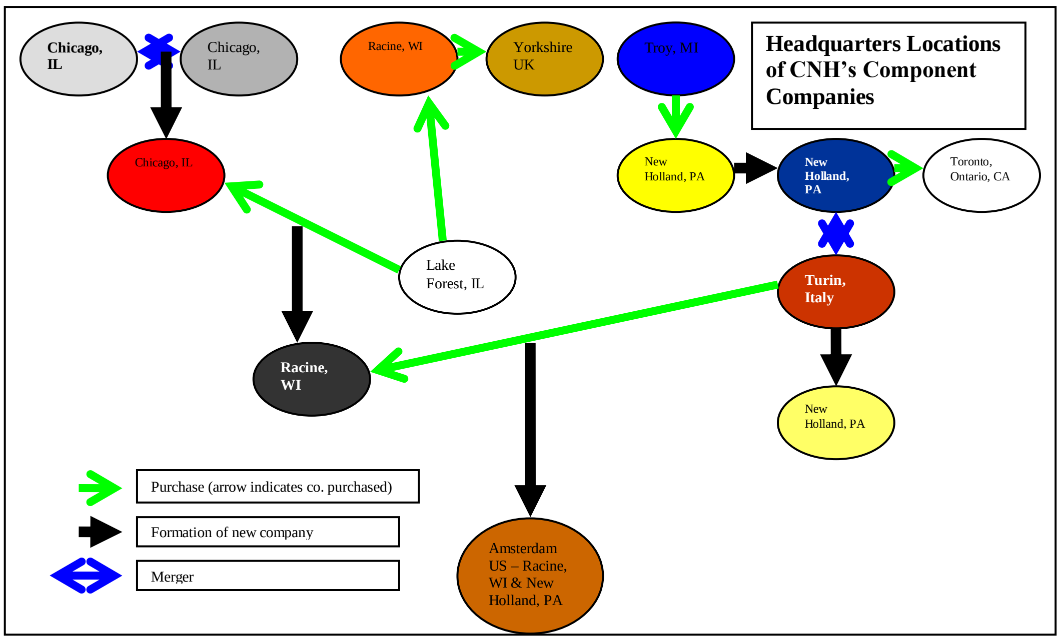

Figure 5.25: The same diagram as Figure 2.3, relabeled with headquarter locations for the components of CNH. The colors of the ellipses are representative of the primary paint color used by each company on its machines. Arrows that begin along another arrow indicate the formation of a new company from the merger or purchase indicated by the arrow that the new company is emitting from.

When looking at CNH's headquarters decisions, a very different picture emerges. The firm operates a developmental subsidiary headquarters model (Rice and Pooler 2009), relegating much of the command and control and executive functions to sites other than the worldwide headquarters. In addition to its Worldwide Headquarters in Amsterdam, CNH also has brand headquarters in Racine, Wisconsin for Case IH Agriculture and New Holland, Pennsylvania for

New Holland Agriculture. The CEO of CNH, Harold Boyanovsky, maintains his office in Racine, which is also where corporate board meetings take place. Each division of CNH has retained not only its own brand and paint schemes, but also distinct marketing and sales offices as well as discrete credit institutions[15]. In addition to the CEO of CNH, there are separate presidents for Case IH Agriculture (Andreas Klauser) and New Holland Agriculture (Franco Fusignani) (CNH 2009).

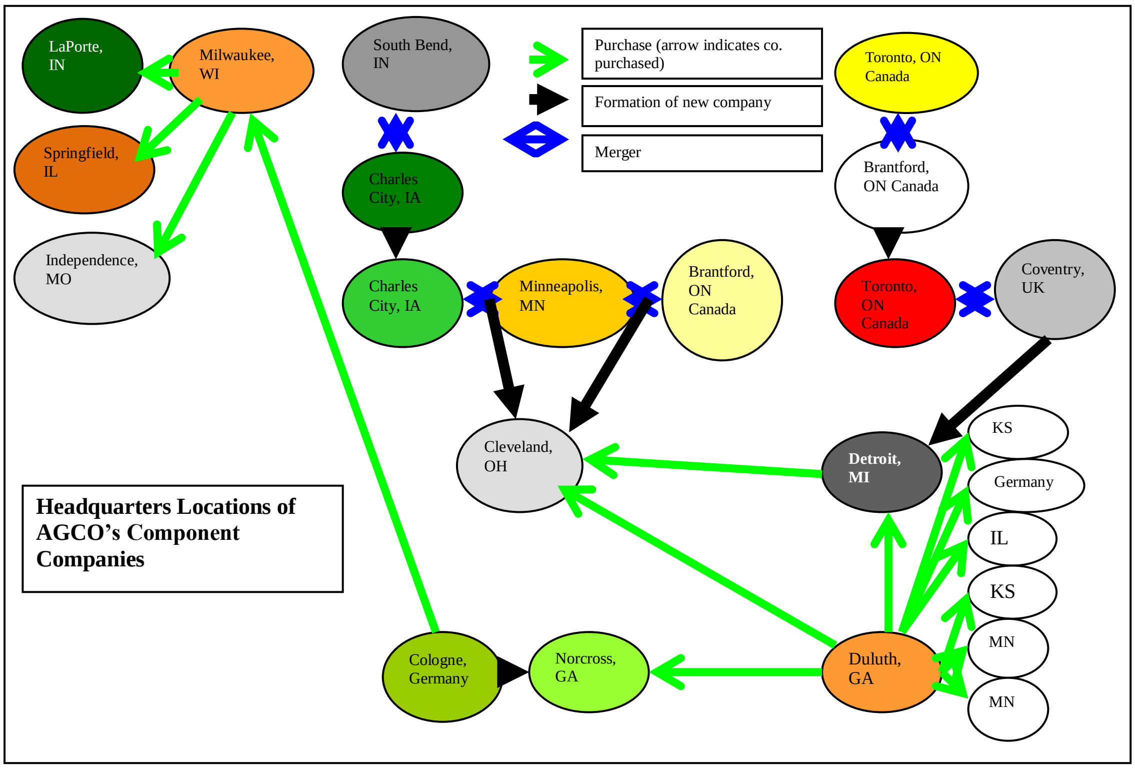

Figure 5.26: The same diagram as Figure 2.1, relabeled with headquarter locations for the components of AGCO. The colors of the ellipses are representative of the primary paint color used by each company on its machines. Arrows that begin along another arrow indicate the formation of a new company from the merger or purchase indicated by the arrow that the new company is emitting from.

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15 While CNH does maintain a single finance division called CNH Capital, farmers who finance equipment will receive statements from Case Credit or New Holland Credit as if they were separate companies.

In terms of relating these locations to the literature, what appears good on paper seems to matter little in real terms for CNH. Based on the general findings of research by Shilton and Stanley (1999) and Porter (2000a), one of CNH's US headquarters (Racine, Wisconsin), located in the Chicago MSA and the heartland of tractor manufacturing, should have all the advantages to be very successful. Yet, CNH, at times, struggles to keep pace with JD and AGCO for US market share. This could be related to its continued pursuit of the split headquarters model with command and control dispersed beyond the Worldwide Headquarters in Amsterdam to Racine and New Holland. New Holland, Pennsylvania is distant from the benefits of location within the farm machinery cluster. Its position in the Lancaster MSA and relative to the nearby Philadelphia MSA likely do little to assist in its competitiveness given the small size of Lancaster and the lack of related and supporting industries in the Philadelphia MSA.

The split headquarters model that CNH is pursing raises another concern for competitive advantage through the marketing of multiple brand names. Marketing under multiple brand names is not unusual in the farm machinery industry, as AGCO markets over 20 different brands, capitalizing on the advantages of economies of scale[16]. It is atypical to operate as if each brand is its own company with individual command and control and higher order functions like finance and marketing. Even AGCO dealers have recognized the problems of having multiple brands that are essentially identical under the paint. Tractors of different brands require a more extensive dealer network, separate sales and service bulletins and maintenance literature, and increased advertising budgets (Gaines 2010c). For CNH, it also means separate service technician certifications.

[16] Recently AGCO announced that in order to invest more money in R&D and technology enhancements, it would stop producing one of its core brands – AGCO, which was a legacy brand that tied the company to its heritage as the Allis-Chalmers Corporation.

Not only does CNH maintain the Case IH and New Holland brands as if they were independent companies with separate dealerships and display areas at trade shows, but many of its products, which are otherwise identical, are given separate names. An example of this is CNH's precision farming systems called Advanced Farming Systems by Case IH and Precision Land Management by New Holland, even though all of the geospatial technology is provided by Trimble in a common platform[17]. The fact of the matter is that every piece of Case IH and New Holland equipment is identical other than the paint and trim it receives as it passes through the factory (R. Kleinsasser, pers. comm.). The brands are not even produced in equal numbers in the factories. Each company has its own core competencies that it caters to. Because Case IH has won awards for its Early Riser planters, 70 percent of all equipment leaving the seeding factory in Saskatoon, Saskatchewan is painted in Case IH colors (R. Kleinsasser, pers. comm.). New Holland has an advantage in the brand recognition of its hay tools, so 85 to 90 percent of equipment leaving the hay tool facility in New Holland, Pennsylvania is painted in New Holland colors. Case IH Axial Flow combines have a reputation the world over for quality and reliability, so 90 percent of combines produced in the Grand Island, Nebraska plant are painted in Case IH colors. While it is commendable that CNH has streamlined production by producing both brands in the same plant, one must wonder what impact this seeming redundancy has had on global competitiveness for the company and the ability to invest in technology and R&D (Gaines 2010c).

One possible reason for this redundancy is that both Case IH and New Holland had strong and loyal followings before Fiat purchased the companies and merged them to form CNH.

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[17] Other examples of this include the fuel efficiency system, known as Diesel Saver by Case IH, but marketed as Ground Speed Management by New Holland (Wehrspann 2010a).

As has been noted in recent research related to brand loyalty in the farm machinery industry, “Strong branding runs deep” (Kanicki 2011: 34). Many industry experts believe that one of JD’s largest competitive advantages is the brand loyalty its customers express to the green machines and the fact that JD is viewed as part of Americana, like apple pie and Chevrolet (Kingsbury 2010). Kanicki (2011) found that JD enjoys a high level of brand recognition, which CNH would not want to lose ground to. It is possible that in order to mask the foreign ownership and maintain status quo, CNH chooses to market the equipment and maintain the split headquarters system as a management strategy. Trade show research has indicated that a well-known and respected brand name is important to a firm (Mitchell and Orwig 2002), but AGCO has been able to maintain well-known brand names without creating the additional, seemingly uncompetitive, layers of firm structure that CNH has. At the same time, AGCO is banking on other recent research that states that the level of “color-blindness” among farmers is increasing (Lessiter 2011). This is evidenced by AGCO’s aggressive marketing to promote Challenger yellow as the new color of farm equipment innovation (Figure 5.27). One of the new slogans for the Challenger line is, “Color isn’t the way to buy a tractor.” If AGCO is successful at convincing farmers of this, it could have implications for CNH’s split system and prove that color or brand is not always what matters.

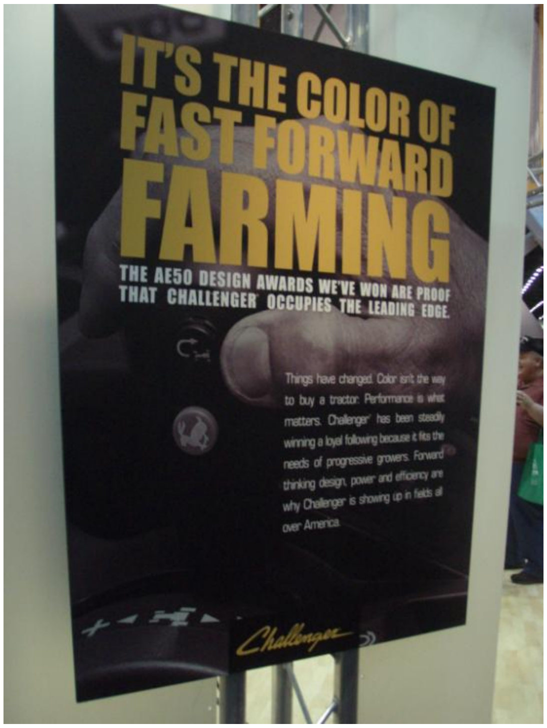

Figure 5.27: A sign in the Challenger display area at the 2011 National Farm Machinery Show in Louisville, KY where AGCO tries to create brand loyalty to Challenger yellow while promoting AGCO's technological leadership (picture taken by author).

5.4.1.3 Research and Development

Industry experts believe that the firm that spends the most time and money on R&D is the one that will gain competitive advantage in the long run (Marquardt 2008). The location decisions that the Big Three make for siting R&D locations are, therefore, vitally important. The literature on R&D locations, when compared to the actual location decisions of the Big Three US farm machinery manufacturers (Figure 5.28), demonstrates a good match for JD and AGCO. They have kept their R&D facilities on the same campus as their corporate headquarters. Vernon (1979) is one of several researchers who have demonstrated the benefits of co-locating R&D and headquarters activities. Deere does not have a perfect location for its main R&D functions, however, since Moline, Illinois cannot be considered a major metropolitan area or even a second-tier city. Given the difficulty that many manufacturing firms have in finding qualified engineers and scientists (e.g. Vernon 1979; Kalafsky 2006), it seems that JD would want to maximize the opportunities for attracting the desired labor pool by selecting a location more attractive to them. Only recently has JD established a second R&D facility in Charlotte, North Carolina, distant from its base of operations in Moline, Illinois, allowing it to take advantage of the benefits of a second-tier city and the human capital availability it can provide.

Figure 5.28: R&D facilities for the US farm machinery industry.

The R&D facility for AGCO, alternatively, enjoys not only proximity to its headquarters, but also a prime location in the Atlanta MSA. Synergies with nearby related and supporting industries in the automobile sector, located along the Interstate 65, 75, and 85 corridors have facilitated the development and testing of AGCO's zero-emission engine technology (AGCO 2009). It has partnered with companies like Mercedes, BMW, and Volvo Trucks to develop and stringently test more environmentally friendly engines (AGCO 2009). This has reduced fixed costs for all the companies involved as well as promoting knowledge sharing among mature industries in the region (AGCO 2009). For AGCO, location decisions related to R&D have positively impacted its competitive advantage.

Once again, CNH defies all of the traditional findings of R&D location research. Not only does it use a diverse model, with R&D facilities located in, among others, New Holland, Pennsylvania; Davenport, Iowa; Fargo, North Dakota; and Benson, Minnesota, but none of the locations, except those in Burr Ridge and Goodfield, Illinois (near Chicago) are located in or around a major metropolitan area or a second-tier city. Most of CNH's R&D locations are not in places where Porter and Stern (2001) believed that the external environment is conducive to stimulating innovation of this type. Campuses for R&D, in isolated locations, supposedly incur more costs and barriers to the acquisition of knowledge in which to develop marketable products (Porter 2000b). Based on the prevailing R&D location literature, as it contributes to multiple points in Porter's Theory of Competitive Advantage (1990), it is not surprising that CNH has traditionally appeared less innovative, although it may believe that it is avoiding opportunities for corporate espionage in the farm machinery industry.

With the exception of AGCO and JD's newest facility in Charlotte, North Carolina, none of the Big Three's R&D locations comply with the expected model of a city that can attract a skilled labor force for R&D. Florida (2002) found that the cities that could most easily attract the type of talent necessary to maintain a competitive R&D facility would be ones with high quality of life and a diverse population. The most attractive locations, according to Florida

(2002) are those with a favorable climate, lots of outdoor activities, and other cultural amenities, such as restaurants and performing or visual arts. Most of the locations for the Big Three are places that are isolated from the benefits of urbanization economies and are located in cold northern climates. The question becomes, how difficult is it for JD and CNH to attract and retain the necessary talent to compete and innovate? Most of these R&D locations would not fall into Florida's (2002) definition of a creative class city, which would be the ideal location to attract the type of talent that the farm machinery industry needs for R&D. Do these location decisions impact either firm's competitive advantage as even the most mature sectors still need to innovate to survive? McGranahan and Wojan (2007) found that the creative class talent who choose to locate in rural areas tend to be less educated than those in urban areas. Does this present a factor condition deficit for JD and CNH and if so is this part of the reason AGCO has been first to innovate in the sector recently? Or do the amenities that Florida (2002) considered vital to attracting creative class talent matter less to highly skilled labor employed by the Big Three? Analyses by Fox and Murray (1990), on companies locating in Tennessee, found an inverse relationship between the importance of amenities to high-skilled labor and the size of the firm. Given the continued market dominance of JD and the strength of CNH, it may not matter where their R&D facilities are located. At one time, it was not very important to firms in the farm machinery industry. Massey-Ferguson, in seeking a site for its North American headquarters in 1965, which would also have R&D facilities, believed that the attractiveness of the city to skilled labor was secondary to other siting concerns such nearness to a land grant university or transportation connectivity (Archival and Special Collections, University of Guelph, X41 RHC A0390). More recent research (Florida 2002; McGranahan and Wojan 2007), however, has shown that locations rich in amenities matter. In the next section, as product life cycles and innovation are discussed, the level of innovation that JD and CNH achieve, in comparison to AGCO may raise concerns about these two firms' ability to maintain competitive advantage given their current geography for R&D.

5.4.1.4 Manufacturing Decisions

Another level of firm structure and strategy that can be crucially important to the competitive advantage of an industry is its manufacturing decisions, including where plants are sited (Porter 1990). Much of this decision making process is driven by other points in Porter's model, such as factor and demand conditions, but in many ways, the location decision is as much a part of firm structure and strategy as anything else.

Some firms might seek the benefits of a more urban location, especially for high technology products. This is the case for JD's plant in Torrance, California, which focuses on the manufacturing of advanced GPS technology for tractors, combines, and self-propelled sprayers. Other firms might seek a more rural location that has space to expand and grow (Colby 1933), especially if the operation is not in need of the specialized skills that are more common in an urban environment (Orlando and Verba 2005). Other considerations may also come into play. As was previously mentioned, JD has kept its facilities much more closely spaced than AGCO has. There is likely some economy of scale benefits to this decision, but at the same time, AGCO enjoys cheaper labor rates in South America and lower shipping costs to its main market by building tractors in Europe. The manufacturing locations that the Big Three occupy in the US (Figure 5.29) additionally present a specific geography for a mature sector of the US economy. Issues of product life cycle and technology development further impact the structure and strategy of these firms, especially in terms of location decisions. It is crucial to examine how these other strands of the organizational studies literature impact competitive advantage and geography for the US farm machinery industry.

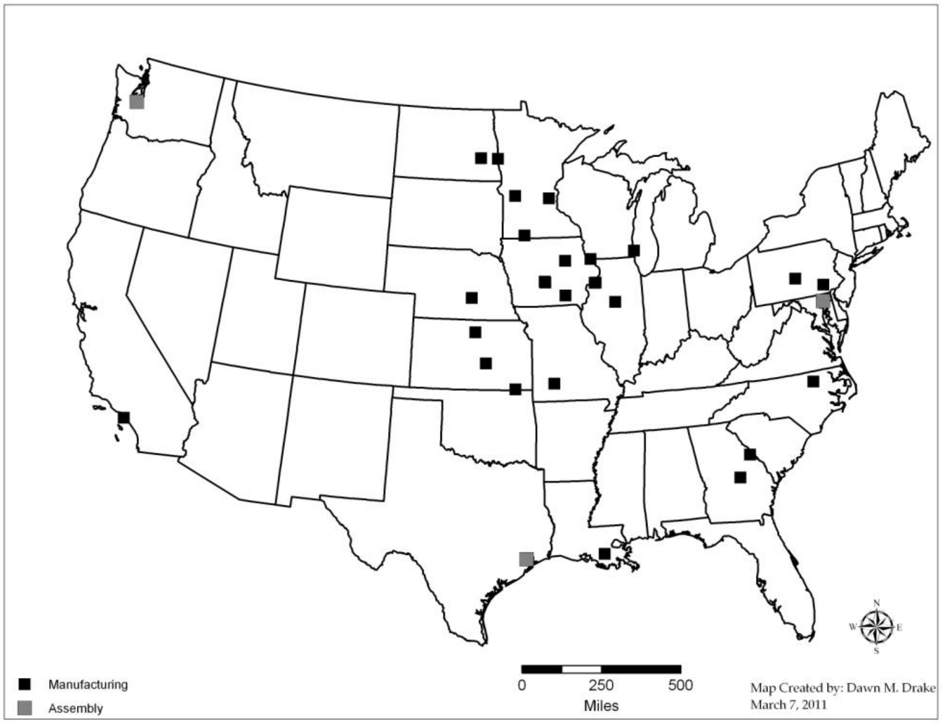

Figure 5.29: Manufacturing and assembly locations for the US farm machinery industry.

In looking at manufacturing locations and how they relate to competitive advantage for the Big Three, it is important to remember that a location decision is not only about factor conditions. It is also about the cost of the manufacturing process (Hill and Brennan 2000) and the influence of inertia. Many of the determining factors in the costs of production are related to the stage of the product life cycle of particular good. Prahalad and Hamel (1990) discovered, in their empirical test of competitive advantage among major international firms, that companies that are continuously innovating, developing new products, and accessing new markets are the most competitive in a global economy. Firms that continue to innovate and create new products that are in the early stages of their life cycle can afford manufacturing locations and processes that are more expensive (Hill and Brennan 2000). They also are more likely to exhibit at a trade show since this is an important forum for introducing new products (Rice 1992).

Product life cycle theory research indicates that as farm machinery has become more standardized and further along the product life cycle, manufacturing production should be moving to lower-cost areas. Much of farm machinery has become standardized, even between competitors and production for the Big Three is not continually adapting to more advanced farm machinery and techniques. At this point, much innovation in the sector is incremental. This fact was observed as early as the late 1960s by researchers examining the number and type of patents issued in Canada for farm machinery (Vicas 1969). The majority of patents are issued for minor alterations to machinery, not the paradigm shifting-changes that were once seen in the sector (United States Patent and Trademark Office 2009; United States Patent and Trademark Office 2010a, b).[18] Yet, the US farm machinery industry maintains a dense network of production sites in the upper Midwest, most in traditional Manufacturing Belt cities, known to have higher costs of production than sites in the US South or in the developing world. The exception to the farm machinery industry's pattern is AGCO, producing the majority of its tractors in Brazil and other parts of South America (AGCO Corporate 2007). Case New Holland and JD, on the other hand, deviate from the expected trend of product life cycle theory. This could have serious implications for the geographic aspects of competitive advantage making JD and CNH less competitive and more subject to higher production costs related to location decisions.

[18] A possible exception to this is AGCO's SCR technology, which was developed by AGCO in Finland (AGCO 2009) and will be discussed later in this section.

Product life cycle theory assumes that for a firm to stay competitive, it must continually innovate and develop new and better technology (Schroeder et al. 1995). While production of the basic equipment in the farm machinery industry has become fairly standardized, there is still a certain amount of innovation occurring in the sector. Large investments by AGCO into R&D have actually led them to shorten product life cycles and introduce innovations more quickly than their competitors (Gaines 2010d). It only takes a few minutes of examining recent advertisements for the Big Three to see how important innovation is with slogans like, "Rise of the Smart Machines" (JD), "We Invented the Self-Propelled Combine in 1923 – We've Been Reinventing it Ever Since" (AGCO), or "For Those Who Demand More" (Case IH). Many times, new technology is requested by the farmers themselves – a place where demand conditions and innovation intersect (Schroeder et al. 1995). Vernon (1979) found that manufacturers are often short-sighted when it comes to determining the needs of their customers and require consumer input to develop the most innovative and popular technology updates, keeping the company on the forefront of the product life cycle. The Customer Driven Product Design utilized by CNH (Figure 5.15), tapping into the wants and needs of the majority of its customers, from R&D conducted in Burr Ridge, Illinois, can maximize competitive advantage and develop new products desired by consumers. Many commercial farmers are being faced with larger acreages and shrinking workforces, which has caused them, as sophisticated consumers, to demand more from their farm machinery in terms of technology and the US farm machinery industry has responded in several ways.

The most cutting-edge solutions that the Big Three have put forth to handle shrinking agricultural labor forces are various autonomous vehicle solutions. Auto-guidance and auto-steering technology have been in use by the Big Three for many years as a way to increase harvesting precision and reduce operator fatigue (Wehrspann 2010b), but these new technologies go beyond that to make the operator obsolete. At Ag Connect Expo in 2011, AGCO announced a partnership with Topcon to test and improve autonomous vehicle technology that the geospatial firm was already developing for the Toyota Prius (*Farm Industry News* 2011d). Using LiDAR systems onboard Challenger tractors, AGCO is attempting to eliminate the need for the operator to do anything more than watch monitors as the tractor passes through the field. Even more hands-off than AGCO's autonomous vehicles is the V2V (vehicle-to-vehicle) technology for which Case IH won a SIMA Innovation award in early 2011 (*Farm Industry News* 2011c). The V2V system synchronizes the onboard navigation systems of a combine and a tractor towing a grain cart, traveling alongside the combine, to guarantee that the tractor maintains correct speed and distance from the combine (*Farm Industry News* 2011c), making the unloading process safer and less labor intensive.

All three firms are also on the forefront of developing technology to assist farmers in site-specific or precision agriculture[19]. Each of the Big Three has divisions of its company devoted to solutions for farmers pursuing this new technology[20]. Trade show display areas typically include large sections devoted to this technology (Figures 5.30-31) and information and support is usually easy to access from the companies' websites. All three firms have also been on the forefront of the implementation of ISOBUS-compliant units in their precision farming

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[19] Site specific or precision agriculture utilizes geographic positioning systems (GPS) and geographic data to help farmers increase efficiency and maximize profits. By applying inputs like seeds, fertilizers, pesticides, etc. to a field at a variable rate, based on the conditions within the field, instead of at a uniform rate across the entire field, farmers save time and money. There are also environmental benefits to site specific agriculture that allow farmers to turn off individual sprayer nozzles in riparian zones and reduce the amount of chemicals applied to a field that could run into a water supply.

[20] AGCO calls its division Advanced Technology Solutions. Case IH calls its division Advanced Farming Systems. New Holland calls its division Precision Land Management. Deere calls its division Greenstar.

applications so that farmers can use systems from multiple manufacturers without hardware conflicts. Both AGCO and JD have additionally been developing telemetry systems to complement their precision solutions and allow farmers to run onboard diagnostics of equipment (*Diesel Progress* 2011b) and manage multiple machines and data collection systems without leaving the office (McMahon and Wehrspann 2011). Precision solutions for farming are clearly one of the technologies on the forefront of the product life cycle for the farm machinery industry.

Figure 5.30: AGCO's precision farming display at the 2011 Ag Connect Expo in Atlanta, GA (picture taken by author).

One of the largest and most important areas where the farm machinery industry is constantly innovating and maintaining its position on the forefront of the product life cycle is in the area of green technologies – especially to lower emissions and generate energy from new fuel sources. The Big Three recognize the importance of this technology, stating that sales are about more than the machine these days. Says, Joe Mastanduno, marketing manager for JD's engine/drive train division, "… we are an emissions solution provider; it's no longer just about metal, it is solutions and data, too" (quoted in Elmore 2010: 23). In order to better understand emissions control for the farm machinery industry, a discussion of the laws and technology are included in Appendix F.

Figure 5.31: Signage in CNH's trade show displays at the 2011 National Farm Machinery Show in Louisville, KY to advertise precision solutions (pictures taken by author).

Each of the Big Three has followed a different path in complying with EPA regulations. Additionally, each has employed a different marketing strategy to promote the technology to its customers and encourage farmers to buy the new machines[21]. By far, AGCO has been the leader in development and marketing of selective catalytic reduction (SCR) technology, employing it as early as Tier III, when most other firms were still using cooled exhaust gas recirculation (cEGR) (J. Rogers, pers. comm.). The E_3 Sisu engines used by AGCO turn standard diesel exhaust into

[21] This promotion strategy, to this point, appears to have fallen a little short as many farmers have chosen to purchase used machinery that does not use the advanced emissions technology. Used machinery prices are currently higher than those for new machines in some parts of the US largely because the older machines will not be required to be retrofitted with emissions technology (D. Mowitz, pers. comm.).

clean water vapor and harmless nitrogen (Wehrspann 2010c). AGCO estimates that these engines are already almost 90 percent compliant with the more stringent Tier IV final standards that will come into effect in 2014 (J. Rogers, pers. comm.).

AGCO first announced its plans for becoming interim Tier IV-compliant at the 2009 National Farm Machinery Show in Louisville, Kentucky (Figure 5.32). The tractors equipped with E_3 Sisu engines were billed by AGCO as "… the cleanest tractors in the industry" (AGCO 2010c: 4). The introduction of the Super Seven Gleaner combines at the 2010 Farm Progress show in Boone, Iowa (Figure 5.33) also made AGCO the first firm to introduce Tier IV interim-compliant solutions for combines (McMahon and Wehrspann 2011). The company made a decision early in the regulation process not to play a waiting game as new tiers were phased in and to instead proceed directly to the SCR technology that would be necessary in the long run (Osenga 2008). When the E_3 Sisu SCR engines were introduced in 2009, AGCO offered farmers the option to buy the cEGR Caterpillar and Perkins engines for Challenger and Massey-Ferguson tractors, respectively, but charged a price premium for the less efficient technology to encourage farmers to start switching to SCR (Fischer 2009).

In addition to being the first to develop the emissions technology, AGCO is the leader in promoting it. Its trade show display areas feature question and answer centers where customers can get information about the engine itself, where to access the necessary diesel exhaust fluid (DEF) (see Appendix F for more information about DEF), and service and maintenance of the new tractors (Figure 5.34). Engine cutaways and industry experts are available to help customers better understand the technology (Figure 5.35). The company promotes the technology while subtly reminding customers of the problems with cEGR. It also emphasizes the number of firms,

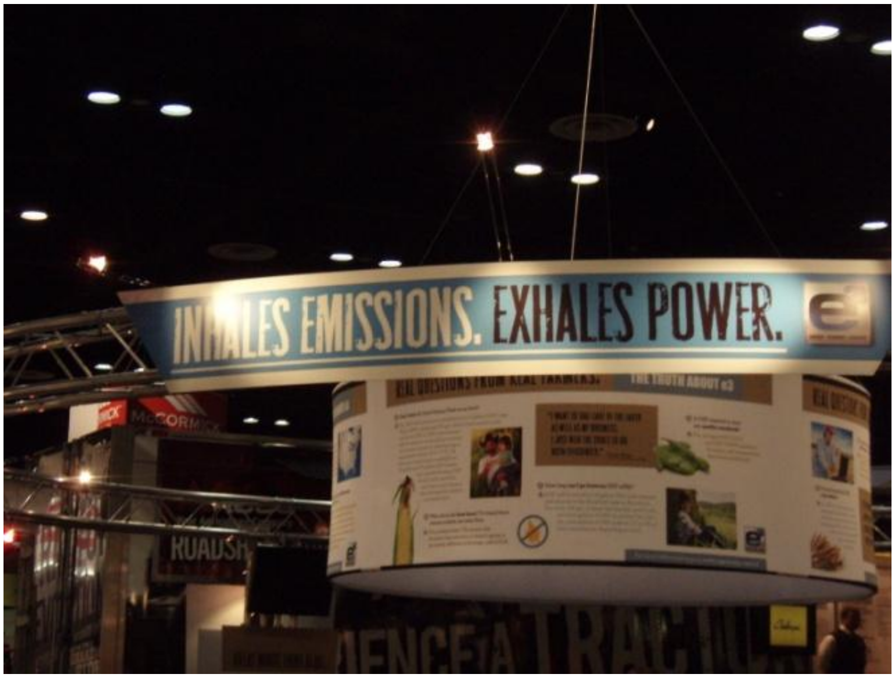

Figure 5.32: AGCO's green technologies trade show display, advertising its leadership in emissions standards compliance (picture taken by author).

Figure 5.33: AGCO's Super Series Gleaner combines, introduced at 2010 Farm Progress in Boone, IA, were the first combines to offer Tier IV-compliant engines (picture taken by author).

both in on-road and off-road industries, that are utilizing SCR to meet EPA emissions standards (Figure 5.36). As a first mover in this area of emissions technology, AGCO took a large risk in its proactive position, hoping to convince the farmer to invest in the new technology. Over time that leadership can pay off and propel AGCO ahead of firms that did not develop emissions technology as quickly (Schroeder et al. 1995). This is a risk that AGCO recognizes that it took in order to propel itself to a new level of leadership in the industry (Wall Street Journal Staff 2009). This leadership in new green technology should, according to Friedman (2008), lead AGCO to a better position in the sector, which may propel the company ahead of JD that seems to be more complacent. Even CNH seems to be more forward thinking when it comes to green technologies than JD.

Figure 5.34: Part of AGCO's SCR question and answer center at the 2011 National Farm Machinery Show in Louisville, KY (picture taken by author).

Figure 5.35: An AGCO employee explaining the E_3 Sisu engine to potential customers at the 2011 National Farm Machinery Show in Louisville, KY (picture taken by author).

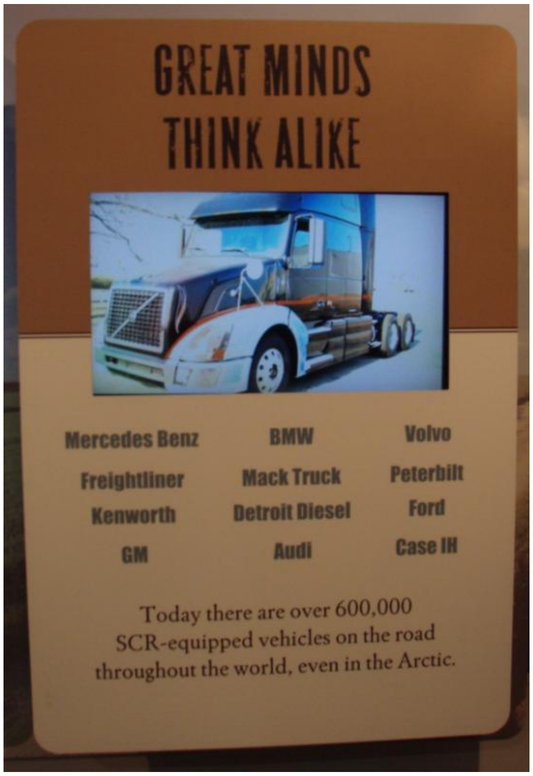

Figure 5.36: Signage in AGCO's SCR display area at the 2011 Ag Connect Expo in Atlanta, GA showing all the companies that use SCR to meet emissions standards (picture taken by author).

Case New Holland has decided to follow in AGCO's wake, also choosing to use SCR engines to make tractors over 100 horsepower (75 kilowatts) Tier IV-compliant[22]. The company, however, took much longer to come to this conclusion than other competitors, only finally announcing its plans at the 2010 Farm Progress show (Figure 5.37). The introduction of the new engines was timed to coincide with the introduction of the next-generation high-horsepower Magnum and Steiger lines, in an effort to provide farmers additional value for the increased cost of the engine technology (Wehrspann 2010d). This also allowed CNH to be the first to announce Tier IV compliance for tractors over 500 horsepower (McMahon and Wehrspann 2011). To build these new engines, CNH has partnered with FPT, a division of the parent company, Fiat, which has been manufacturing SCR engines for European heavy-duty tractor trucks since 2006 (CNH America 2010b). Fiat Powertrain Technologies worked with Sisu, the engine division of AGCO, as well as Volvo and BMW to develop and test SCR technology prior to its introduction (CNH America 2010a). Case New Holland believes that even though it was not the first to introduce the SCR technology for Tier IV compliance, because it waited, farmers will be more satisfied with the product. This is because the infrastructure for and availability of DEF, which SCR engines need to treat the emissions to reduce nitrogen oxides (NOx) and particulate matter (PM) has greatly increased since AGCO's introduction in 2009 (CNH America 2010a).

[22] For engines under 100 horsepower (75 kilowatts), CNH will use cEGR at least through the interim stage of Tier IV (CNH America 2010a).

Figure 5.37: Part of Case IH's display at 2010 Farm Progress in Boone, IA, to introduce its new SCR engines (picture taken by author).

Just like AGCO, CNH is not just selling the technology, but also has become an advocate for SCR, providing farmers with seminars at trade shows and free year's supplies of DEF as part of the purchase of a new Case IH or New Holland tractor. One thing that is striking in CNH's marketing of the technology, however, is that seminars and written information about SCR are primarily only available, at least at trade shows, in the Case IH booths. While Case IH has consistently provided farmers with the necessary information to ease the transition, including cutaway engines and seminars (Figure 5.38), New Holland only had one small sign to provide information to its customers at the 2011 National Farm Machinery Show (Figure 5.39). That small sign really did not answer any of the key questions that customers might have about SCR. In fact, it may have created more questions that would have to be answered by a visit to the Case IH booth – again raising a question about the wisdom of marketing brands as totally separate entities, when AGCO’s one-stop answer center for SCR in all their brands is clearly more efficient.

Figure 5.38: A cutaway SCR engine and a display to explain to customers how SCR works in Case IH’s display area at the 2011 Ag Connect Expo in Atlanta, GA (pictures taken by author).

Figure 5.39: A sign in New Holland’s display area explaining SCR at the 2011 National Farm Machinery Show in Louisville, KY (picture taken by author).

It has only been since late 2009 that JD has responded to AGCO's green technologies challenge, introducing its lower emissions diesel engines (which use the older cEGR technology) into its farm machinery (Associated Equipment Distributors 2009). This is somewhat surprising, given the fact that JD claims to be the pioneer in emissions-reducing technologies, having introduced emissions testing equipment on its tractors as early as 1967 and was the first to introduce cEGR technology into off-road engines, starting with its forestry and construction machinery in 2005 (Deere and Company 2010a). Deere also was the first company to produce a construction machine with more than 175 horsepower (131 kilowatts) that was Tier IV-interim certified (Elmore 2010). The company states that it has selected cEGR because, "…it is proven, simpler, and less costly to operate than the alternate NOx reduction technology of SCR" (Wehrspann 2009b: 46). For its customers in forestry, where jobsites are miles from civilization, the need for an additional fluid, such as DEF, could prove burdensome (Elmore 2010).

At the 2010 Ag Connect Expo, JD displayed its cEGR prototype engine (Figure 5.40) for its farm tractors with very little information or data available to potential consumers. Since then the engine has not been displayed at other trade shows and JD does not widely advertise its interim Tier IV-compliance. In recent publications, JD reluctantly admits that while it is trying to develop improved cEGR technology, it may have to use SCR to meet final Tier IV standards (Deere and Company 2010a). At least through interim Tier IV, however, JD believes that cEGR represents the best value for the farmer to meet EPA standards (Garvey 2010a).

Figure 5.40: Deere's prototype cEGR engine for farm tractors on display at the 2010 Ag Connect Expo in Orlando, FL (picture taken by author).

The technology employed in cEGR is much older than SCR and was employed by heavy-duty truck manufacturers in the early tiers of on-road EPA emissions standards. Truck drivers complained about the technology, however, leading over 90 percent of the heavy-duty truck industry to convert to the use of SCR technology (D. Mowitz, pers. comm.). The cEGR system has been criticized by both competitors and users for resulting in a reduction of horsepower and torque compared to SCR (AGCO 2009; CNH America 2010b) – claims which JD refutes (Deere and Company 2010a).

To get the precise exhaust temperature to limit NOx, the cEGR engine uses suboptimum fuel injection that results in poorer fuel consumption (*Profi International* 2011) (for more information on the engine technology, refer to Appendix F). Engines using cEGR run hotter and require more frequent oil changes than SCR engines[23], which have been proven to be more fuel efficient and durable in tests conducted by both the manufacturers and independent bodies such as the Nebraska Tractor Test Labs (NTTL) (AGCO 2010b; CNH America 2010b). Deere questions the economics of SCR fuel efficiency, however, stating that the cost savings in fuel are offset by the price of the additional DEF needed by SCR engines (Deere and Company 2010a). Independent tests on heavy-duty trucks in use in Europe showed no statistically significant difference in fuel efficiency levels between SCR and cEGR engines, even when the cost of DEF is included (Xinqun et al. 2010). The only benefit that JD can list for the use of the cEGR technology instead of SCR is that it is a simpler engine that does not require the addition of DEF (Deere and Company 2010a). Most engineers believe that, however, that SCR is actually the simpler technology, using basic high school chemistry to neutralize NOx (Wehrspann 2009b).

CNH has widely stated that companies using cEGR will need to switch to SCR technology to meet the more rigorous final Tier IV requirements that will take effect in 2014 (CNH America 2010a). "Industry leading engineers concur that all manufacturers will need to use SCR to meet the even more stringent Tier 4B standards beginning in 2014. While there are other interim solutions, Case IH believes SCR is the most efficient way to meet EPA standards for agricultural applications" (CNH America 2010a: 8). "Manufacturers investing in EGR to meet interim requirements for engines over 100hp will have to play catch-up to meet final 4B requirements in 2014" (CNH America 2010b: 13). Engineers from MTU Detroit Diesel, a division of Mercedes that builds engines for CLAAS, believe that complying with the final Tier IV standards will require a combination of SCR and the diesel particulate filter (DPF) from

[23] Estimates are 300-500 hour service intervals for cEGR, which is longer than in the past, but less than the average service interval for SCR engines which is 600 or more hours (L. Bose, pers. comm.)

cEGR technology (Wehrspann 2010c). Other industry experts have widely stated that DEF will become an industry standard to meet final emissions regulations (Garvey 2010b). One has to wonder how this impacts JD's competitiveness given the fact that AGCO and CNH have both utilized SCR as well as cEGR (for lower horsepower tractors and to meet earlier tier standards) and have more experience and time to familiarize their customers with the technology. Deere may face an uphill climb catching up to AGCO and CNH's technology (Lessiter 2011).

This is not to say that the imposition of Tier IV emissions standards are the only way US farm machinery manufacturers can lead the way in green technologies. There is increasing interest among the Big Three in the use of electric power to reduce fuel consumption (Neunaber 2010). Premium European models of JD tractors are available with high-voltage generators to create power for air conditioning and other auxiliary systems (Neunaber 2010). At Ag Connect Expo in 2010, AGCO debuted its prototype ElectRoGator – the first electric hybrid self-propelled sprayer in the world (Figure 5.41). The ElectRoGator works on the same principles as the Toyota Prius, using braking energy to generate electric power to run the engine fan, hydraulic pump, air conditioning, and air compressor (Lane 2010). The ElectRoGator can save up to 20 percent in fuel and provide 30 percent more power to the ground (*Farm Industry News* 2010). AGCO maintains this is only a preliminary prototype that still requires extensive testing for efficiency and durability under field conditions (Lane 2010), but it does point to the future for green technology in the industry.

Figure 5.41: AGCO's ElectRoGator on display at the 2010 Ag Connect Expo in Orlando, FL (picture taken by author).

Another area of green technology that the Big Three is pursuing is biomass harvesting solutions (Grooms 2010b). Many of the crop wastes (corn stover, corn cobs, soybean plant material), ejected by a combine during normal harvesting activities, can be used in the generation of cellulosic ethanol or as an alternative feedstock for ruminant livestock (Grooms 2010b). Each of the Big Three has developed different systems for effectively collecting and packaging this biomass for later use.

There are two methods for biomass collection – a single-pass system, where the ejected biomass is immediately collected and baled, or a second-pass system that collects the biomass after harvesting activities are completed (Grooms 2010b). Single-pass systems accumulate less tonnage of biomass, but also collect less of the dirt and debris that is undesirable in a biomass bale (Grooms 2010b). At the 2010 Ag Connect Expo, AGCO introduced a prototype for a single-pass biomass collector for its Challenger combines (Figure 5.42). Signage advertising the single-pass biomass collector has also been posted at the 2011 National Farm Machinery Show. By streamlining the collection process to collect only cobs and the top part of the corn plant, AGCO maintains that it is producing a superior bale with lower levels of phosphorus and potash, which are detrimental to the conversion of biomass to cellulosic ethanol (Grooms 2010b).

Figure 5.42: AGCO's single-pass biomass collector for its Challenger combines on display at the 2010 Ag Connect Expo in Orlando, FL (pictures taken by author).

Deere has partnered with Hillco Technologies to also develop a single-pass system, that employs a cob cart (Figure 5.43) that can either be pulled behind the combine or by a tractor following in the combine's wake, to maximize collection of clean biomass and limit impacts on harvesting efficiency (Grooms 2010b). Alternatively, CNH has chosen to pursue second-pass systems, focusing on the use of its round balers as a viable strategy to limit capital outlays for new equipment by farmers (Grooms 2010b). Signage at the 2010 National Farm Machinery Show promoted the use of alternative food and fuel stocks rather than CNH's specific technology (Figure 5.44).

Figure 5.43: The Deere-Hillco cob cart on display at 2010 Farm Progress in Boone, IA (picture taken by author).

Figure 5.44: Signage in the Case IH booth at the 2010 National Farm Machinery Show in Louisville, KY advertising CNH's commitment to biomass harvesting (picture taken by author).

Case New Holland has been making strides in other areas of green technologies. In 2009, it was awarded a gold medal from the SIMA Innovation Awards for its New Holland hydrogen-powered tractor, nicknamed the NH^2, which CNH claims is about three to five years from commercial production (New Holland 2009; Neunaber 2010). The technology was developed in conjunction with the automobile division of parent company Fiat (McMahon 2010). The company recognizes the current expense of hydrogen fuel cells, but wants to have the technology perfected should the price of fuel cells decrease in the future (McMahon 2010b). One advantage NH^2 has is that it utilizes a whole-farm system to generate the hydrogen fuel to power the tractor from manure and other farm wastes, making it a self-contained unit with fewer of the problems that other hydrogen-powered vehicles face (New Holland Agriculture 2010). This on-farm system is called the Energy Independent Farm by CNH (New Holland Agriculture 2010). At the 2010 Farm Progress show, CNH introduced the NH^2 to the North American market (Figure 5.45), displaying a fully functioning tractor that produces zero emissions and only releases a small amount of steam into the environment (New Holland Agriculture 2010). In addition to the introduction of SCR engines, NH^2 appears to be CNH's newest and perhaps most innovative way to pursue green technology as a way to increase market share and improve competitive advantage in comparison to the rest of the industry.

Figure 5.45: The NH^2 tractor on display at 2010 Farm Progress in Boone, IA (picture taken by author).

In addition to reducing emissions and handling biomass, another area of green technology for the Big Three has been in the area of fuel efficiency. Technology like Case IH's Diesel Saver Auto Productivity Management system is designed to automatically adjust the settings of the tractor's engine and transmission to maximize fuel savings by up to 25 percent (Wehrspann

2010a) and find what Case IH calls the “sweet spot” between power and performance (Wehrspann 2009a). Another fuel saving system, increasingly employed by the Big Three, is continuously variable transmissions (CVT), or in the case of JD, infinitely variable transmissions (IVT). Both CVTs and IVTs are designed to work with programs, like Diesel Saver, for clutchless shift of the transmission to select the most efficient engine revolutions per minute for the task, thereby reducing fuel consumption (Wehrspann 2009a; Wehrspann 2010e).

Bragging rights for highest fuel efficiency have become a sticky situation in the farm machinery industry in the past year. One of the benefits of SCR technology is that the engines are able to achieve a more complete fuel burn, which improves fuel efficiency up to 15 percent (Wehrspann 2009a). Tests conducted by NTTL, on the entire line of AGCO tractors (Massey-Ferguson, Challenger, and AGCO) in the 300 horsepower (224 kilowatt) class, confirmed these findings (AGCO 2010a; Garvey 2010b). This is an achievement that AGCO has marketed widely in its trade show displays (Figure 5.46). Prior to this, NTTL had given the same award to JD for a test on its 8320R tractor (only one of the tractors JD sells in this horsepower class) (Garvey 2010b). This has started a bitter debate between the two firms over who has supremacy in the critical horsepower per hour per gallon test (Garvey 2010b)[24]. The fact of the matter is that NTTL conducts a battery of fuel efficiency tests on every tractor that it evaluates and while AGCO led in many of the categories, surpassing JD by as much as four percent (AGCO 2010a), JD led in other testing categories (Garvey 2010b). While JD led in many of the traditional horsepower tests that measure fuel consumption while using implements, AGCO excelled in tests of the tractor under load – including the ballasted horsepower test, which many believe to

[24] As of January 2011, CNH had not had any of its SCR engines meet final approvals to be tested by the NTTL, but saw marked fuel efficiency increases in European tests (L. Bose, pers. comm.).

be a true measure of a tractor's fuel efficiency (Garvey 2010b). Deere's tractor was not tested under the ballasted conditions, so until JD sends more tractors to NTTL for evaluation, this will continue to be a hotly contested issue (Garvey 2010b).

Figure 5.46: Various signs that AGCO has used at trade shows to advertise its fuel efficiency ratings (pictures taken by author).

A careful examination of the websites of the Big Three demonstrates how widely the companies' foci on green technologies vary. There is, however, a clear leader in green technology. Every single page on AGCO's website contains a single-click link to take visitors to information about AGCO Sisu Power, which is the division of AGCO that produces the majority of the engines used in AGCO machines. It is also the division of AGCO that developed the E_3 SCR engines that meet interim Tier IV EPA emission standards. From the AGCO Sisu Power page, visitors can access information about SCR including performance test results and frequently asked questions for potential consumers.

Other common indicators of green technology focus, such as clean energy solutions, biofuel usage[25], and fuel economy are less present on AGCO's website. Fuel economy is mentioned on approximately nine percent of the pages, mostly related to recent findings of increased fuel economy in AGCO tractors equipped with CVT. Unlike some of its competitors, AGCO has resisted the urge to diversify into other areas of clean energy production, such as wind power. Similarly, it does not strongly advocate on the website for the use of biofuels in its equipment. This is a departure from both JD and CNH, but is related directly to performance issues with the E_3 Sisu engines. B100 (100 percent diesel produced from plant biomass), refined in the European Union, is much cleaner than US biodiesel and can be used in AGCO E_3 Sisu engines without buildup in the emissions filtering system. AGCO does authorize the use of B100 in its tractors equipped with the less clean-running Perkins and Caterpillar diesel engines (J. Rogers, pers. comm.). Given these wide variations in biodiesel readiness among its products, it is not surprising that they are mentioned on less than four percent of the pages of AGCO's website.

JD's website demonstrates a very different focus for green technology. Less than five percent of JD's web pages discuss solutions to meet interim Tier IV EPA emissions standards or the ability to use biofuels in JD engines. The one page that discussed fuel economy mentioned recent independent tests conducted at NTTL in October 2009 with the JD model 8320, when JD set fuel efficiency records for horsepower per hour per gallon of fuel burned with the cEGR engines.

[25] While biofuels are often not considered any greener than traditional oil-based fuels, for the farm machinery industry this is considered part of a firm's green technology.

What JD does focus on within its website is its wind energy division. About 16 percent of the pages on JD's website mentioned John Deere Wind Energy, a wholly-owned subsidiary that provided consumers, interested in generating wind power, a one-stop company for wind farm design, financing, installation, and management (Deere and Company 2010). John Deere Wind Energy was a key component of JD's global philanthropy and was clearly the most important part of JD's green technology strategy prior to its sale in January 2011 (*Diesel Progress* 2011a).

For CNH, the key component of a green technology strategy, at the time of the analysis[26], was the use of biofuels in its tractors and combines. There is no mention of alternative energy generation sources being pursued by CNH. There is broad coverage of the New Holland NH^2 prototype tractor, perhaps reflecting some interest in alternative energy sources for equipment. Visitors to New Holland's website are able to access information on the NH^2 on about 55 percent of the web pages. Other than the NH^2 links, at the time of the analysis, there was little mention of meeting interim Tier IV emission standards. Today, a visitor to Case IH's website can easily access information about SCR technology and CNH's solutions to meet Tier IV interim standards and beyond. That information still is not available from the main page of New Holland's site, however, which makes answers for half of CNH's customer base much harder to come by. Fuel economy is also only mentioned on about four percent of the pages on CNH's websites, primarily in reference to Case IH's Diesel Saver system.

At the time of the analysis, over half of the pages on CNH's websites did, however, make some reference to biofuels, either in terms of equipment that is sold ready to run biodiesel or providing farmers, who want to use biodiesel, the necessary support and information regarding

[26] Images of websites used in the analysis were captured in February 2010

horsepower tradeoffs and emissions standards. Even today, despite the introduction of SCR engines, there is a biodiesel support page that offers users links to all the necessary information regarding various blends of biodiesel for use in CNH machinery. Throughout the websites, there is also wide coverage of the fact that all CNH machinery is shipped from the factory with a biodiesel blend in the tank. CNH has long been the leader in biodiesel integration and usage for its equipment and this is reflected in the content of its websites.

Content analysis of pictures taken at trade shows reveals a varying level of promotion of green technologies by the Big Three. Deere's display areas reflect very little focus on green technology, with a few tractors being labeled as "fueled by biodiesel," although this is also decreasing. At Ag Connect Expo in 2010, JD also had a poster advertising the introduction of new tires for row crop tractors that will increase fuel economy. Other than that, JD does not provide much evidence in its trade show areas of a green focus. Whereas CNH and AGCO have devoted huge proportions of floor space to the promotion of Tier IV-compliant engines, JD seems to rest on its laurels when it comes to promotion of new environmentally friendly technologies.

For CNH, at one time, a green focus was demonstrated by almost every piece of self-propelled equipment in the display area having a sticker to tell potential customers that it was biodiesel ready and that biodiesel was a clean energy source. There also is information regarding solutions for biomass collection to support alternative energy generation, which is not at all reflected in the content of CNH's websites, despite CNH claiming to be the industry leader in prototype development. This interest in alternative energy has continued with CNH sponsoring a seminar at the 2011 Ag Connect Expo, led by General Wesley Clark, to discuss alternative fuel implications for farmers as it related to both profit and homeland security.

Since Farm Progress in 2010, however, CNH has displayed an increasing focus on emissions technology in its trade show areas, especially for the Case IH brand, with information about SCR engines and Tier-IV compliance as well as an increasing promotion of the fuel savings achieved by tractors equipped with CVT. Emissions reduction and fuel savings are increasingly marketed together as EP – Efficient Power (Figure 5.47). New Holland has been less aggressive in its green technology promotion, although the introduction of the NH^2 at Farm Progress was part of a larger clean energy display for the company (Figure 5.48).

Figure 5.47: An Efficient Power banner in Case IH's display at the 2011 Ag Connect Expo in Atlanta, GA (picture taken by author).

Figure 5.48: This area at 2010 Farm Progress in Boone, IA displayed New Holland's various green technologies including CVT and the NH^2 (picture taken by author).

For AGCO, trade show display space is largely designed to emphasize the importance to the company of the environment and green technologies. In addition to a huge area devoted to answering farmers' questions about the E_3 Sisu engines and SCR technology, every tractor that is equipped with a Sisu engine is labeled as such. At the 2010 National Farm Machinery Show, AGCO also used large signage to promote the results of the NTTL fuel efficiency tests for SCR engines (Figure 5.46). But it was not only the E_3 Sisu engines that AGCO used to demonstrate its interest in green technologies. In addition to introducing the one-pass biomass harvester and ElectRoGator, there has also been an increase in the number of signs that advertise its overall commitment to preserving natural resources (Figure 5.49). On average, it seems that AGCO is very motivated to demonstrate its interest in green technologies not only through its website, but also in its trade show display areas.

Figure 5.49: Signage in AGCO's display area at the 2011 National Farm Machinery Show in Louisville, KY demonstrating its commitment to the environment (pictures taken by author).

Just because all of the Big Three are continuously innovating and trying to stay at the forefront of the product life cycle with new technology for their products, it does not mean that all of them do an equally good job of promoting the new technology. This is apparent from both website analysis and trade show reconnaissance. While over 98 percent of AGCO's web pages have one-click access to AGCO Technologies (AGCO's R&D division), where visitors can find out about AGCO's innovations and awards, and over half of Case IH and New Holland's web pages make mention of innovations and technology being developed by CNH, only about five percent of JD's web pages make mention of innovations. While JD is famous for advertising slogans like "Your Tractor is Calling" (promoting their new iPhone app to monitor engine diagnostics), “Ride into the Future with Visionary Technology Today”, and Right Technology Right Now,” it does not always demonstrate this innovative focus in trade shows displays. At trade shows, JD has huge displays of its precision farming solutions and every tractor on the floor usually is fully equipped with the necessary antenna and controller to operate precision implements. It does not, however, highlight the fact that its units are ISOBUS-compliant (see earlier in this section for an explanation of ISOBUS-compliance), except when it is noted by industry experts (Wehrspann 2010e). In fact, AGCO is the only one of the Big Three that emphasized ISOBUS-compliance in its display areas (Figure 5.50).

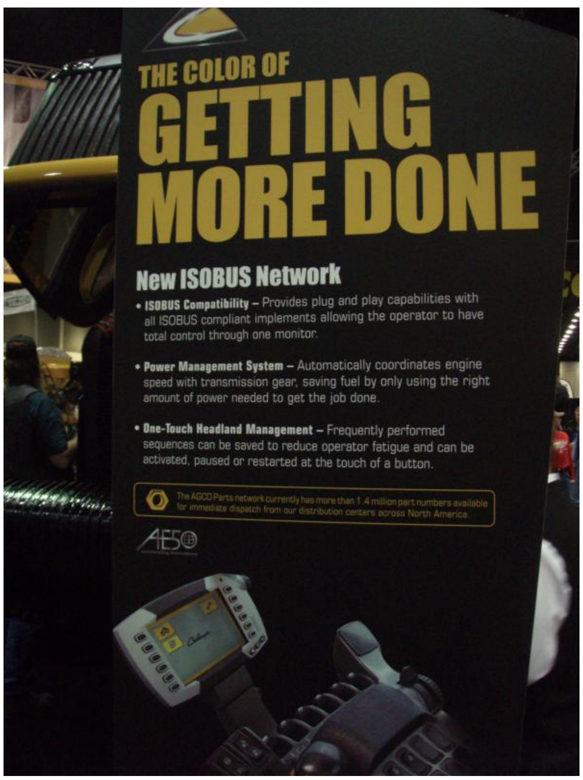

Figure 5.50: A sign in the AGCO display at the 2011 National Farm Machinery Show in Louisville, KY advertising ISOBUS-compliance for its equipment (picture taken by author).

This is not the only place where JD fails to promote its leadership in technology and innovation. At the 2009 National Farm Machinery Show, JD's display area featured large banners with slogans like "Driving Innovation, Driving Green" and "Harvesting Innovation," but since then the company has been more reluctant to advertise its innovative technologies. Recently JD won an award for its new steer-by-wire system on its tractors, which is technology utilized on Boeing aircraft and Formula One racecars to improve handling and stability (McMahon 2010b), but JD fails to advertise that in display areas or on its website. Also JD is a leader in the development and production of the catalytic technology necessary for all diesel engine manufacturers to meet Tier IV standards (Xinqun et al. 2010), yet it fails to recognize that leadership in any way to the general public. There must be some negative impact on competitive advantage by being on the forefront of technology, but failing to advertise it.

Many researchers have pointed to the fact that firms who fail to innovate will lose competitive advantage (Schroeder et al. 1995; Lash and Wellington 2007; Lessiter 2011), but if a company does not market innovation in a manner that makes its products competitive to others, is it like not innovating at all? Or is it that JD believes it is so big and its customers are so brand loyal (Kanicki 2011) that it does not need to advertise its innovations? One dealer was recently quoted as saying "Perception is often more important than reality" (M. Lynch quoted in Lessiter 2011: 51). In an age where "color-blindness" is increasing and brand loyalty is disappearing (Lessiter 2011), a lack of advertising is a risky gamble (Lash and Wellington 2007) for JD to make with its competitive advantage. Recent industry-level research has indicated that customers rate product engineering and innovation as one of the largest motivators in their buying decisions today (Kanicki 2011). Not marketing innovation will have profound implications for JD's competitive advantage in the long run.

5.4.1.5 Manufacturing Technology

In addition to technological innovations, competitive advantage for the US farm machinery industry also comes in the form of manufacturing process innovations that improve efficiency and reduce wastes of both time and materials (Schroeder et al. 1995). Porter and Takeuchi (1999) discovered that many innovations in Japanese manufacturing, designed to reduce manufacturing space and land area consumed and make operations more efficient, contributed greatly to the competitive advantage of those industries. Many of those same innovations have been adopted in manufacturing the world over to improve competitive advantage and increase profits. Lean manufacturing processes, such as JIT, designed to reduce costs and increase efficiency (Porter and van der Linde 1999), have been integrated into the manufacturing systems of all of the Big Three in the past 20 or more years to help them maintain competitive advantage.

Deere was the first to adopt JIT strategies in its manufacturing operations. As a result of severe downturns in the farm machinery sector in the 1980s, the company wanted to reduce its manufacturing costs, allowing JD to keep as many workers employed as possible through the downturn. As a result, the company sent its executives to Japan to learn about lean manufacturing and JIT inventory systems (Berg 1989). From that time forward, JD continued to improve its manufacturing technology to make production, "…leaner, smarter, and faster…" to eliminate waste and allow it to focus resources on innovation and expansion (Kingsbury 2010: 12).

It was shortly after the formation of AGCO that its CEO, Robert Ratliff, also began to focus on streamlining manufacturing to improve efficiency and reduce fixed costs (Nesbitt 1992). In 1991, AGCO instituted a two million dollar renovation project at its Coldwater, Ohio plant[27] to add a tractor manufacturing line to the existing combine manufacturing line (Nesbitt 1992). By instituting JIT in this plant, AGCO was able to free up the 500,000 square feet that was required to add the second line, rather than build a new plant (Nesbitt 1992). At the same time, the company also instituted a new work group process where four to eight employees were all trained on a series of related assembly and manufacturing operations, so that they might rotate positions throughout the workday. This is much like the systems used in US automobile plants owned by Japanese and European companies, and results in less waste and higher quality products (Nesbitt 1992).

Manufacturing efficiency continues to be an area of focus for AGCO. In 2007, a review of shift organization at the Fendt plant in Marktoberdorf, Germany, revealed inefficiencies in the manufacturing process. After instituting new machine technology to reduce wastes as well as streamlining job responsibilities, capacity at the plant increased by 12 percent and fixed costs decreased markedly (AGCO 2011a). Additionally, the AGCO *Chairman's Recognition Program* awards employees who make significant contributions to the company that result in improvements in product quality and manufacturing efficiency (AGCO 2011d). All of these point to a commitment on the part of AGCO to update manufacturing technology to provide the most competitive advantage to the firm.

The time line for implementation of lean manufacturing strategies varies based on the production facility for CNH, but the most aggressive streamlining of production to achieve competitive advantage has happened since Fiat acquired Case IH in 1999 (R. Kleinsasser, pers. comm.). Plants that were owned by New Holland prior to the merger with Case IH had already

[27] AGCO further streamlined operations in 1999 by closing the Coldwater plant and moving combine production to Hesston, Kansas and tractor production to facilities in Brazil and Finland (Moore 2005).

been using JIT since the mid-1980s. Prior to implementing JIT, many plants kept several weeks worth of parts in on-site storage. After the introduction of new inventory systems, only what was needed for the day was kept on hand, reducing storage costs and making operations more efficient (R. Kleinsasser, pers. comm.). After Fiat acquired all the facilities of both New Holland and Case IH in 2000, JIT was universally applied to manufacturing operations as a part of a larger program aimed to increase efficiency and reduce waste (R. Kleinsasser, pers. comm.). This program is part of Fiat's World Class Manufacturing (WCM) division and also mandates that factories conduct periodic internal and external audits to evaluate manufacturing technology and efficiency. As a result of implementation of WCM, the planter facility in Saskatoon, Saskatchewan keeps only four hours of parts on hand and reduced production costs by 40 percent (R. Kleinsasser, pers. comm.). In 2010, Fiat hired an outside auditor from Japan, schooled in JIT, to evaluate the largest plants in the CNH organization to further streamline efficiency and reduce costs as a means to increase competitive advantage for CNH.

Fiat has also introduced some improvements to manufacturing technology to reduce costs and improve quality. New laser machine tools use software designed to limit wasted steel when parts are cut (R. Kleinsasser, pers. comm.). Kitting, or bundling, of hardware and parts for specific steps in the manufacturing process has also saved thousands of dollars and man hours for CNH in an effort to improve its bottom line (R. Kleinsasser, pers. comm.). While CNH may have been the last to fully embrace lean manufacturing, it is pursuing advances rapidly to keep up with competitors. On the whole, all of the Big Three are pursuing aggressive advancements in manufacturing technology as a way to increase profits and increase competitive advantage in the farm machinery industry.

5.4.2 Rivals

It is not just day-to-day business decisions that are integral to competitive advantage. Rivalry is also an important part of this segment of Porter's model. Many empirical tests of Porter's model have reinforced the importance of strong rivals and competition to create advantages for industry (e.g. Porter and Takeuchi 1999). Deere, CNH, and AGCO lead not only domestically, but also internationally because they must compete with one another, which drives innovation in the US farm machinery industry and allows for opportunities to share knowledge and resources. As early as the 1960s, Ford and International Harvester were sharing resources and acting as suppliers to one another for facilities in Australia ("Report on Trip to Australia Made by Duncan, Metcalfe, and Burgess," ca. 1948, Archival and Special Collections, University of Guelph Library, X41 RHC A0417). In addition to competing with one another, there is an increasing amount of international competition. Between 2004 and 2009, import penetration of the US farm machinery market increased from 21.3 percent to 23.5 percent, although a significant portion of that is actually the Big Three importing items from their own overseas operations (IBISWorld 2009). A large portion of AGCO's sales in the US come from its Fendt division, which are imported from Europe (IBISWorld 2009). There has also been an appreciable increase in the number of international competitors who have opened headquarters and manufacturing or assembly plants in the US to meet the needs of US farmers and to attempt to take some of the Big Three's market share. For example, in 2007, CLAAS introduced its Xerion line of tractors, which were popular among German producers, to US farmers as a very versatile and affordable option that could perform a variety of tasks including tillage, spraying, and grain hauling (Wehrspann 2010a). Figure 5.51 shows the location of all of the international competitor facilities to the Big Three in the US in 2010.

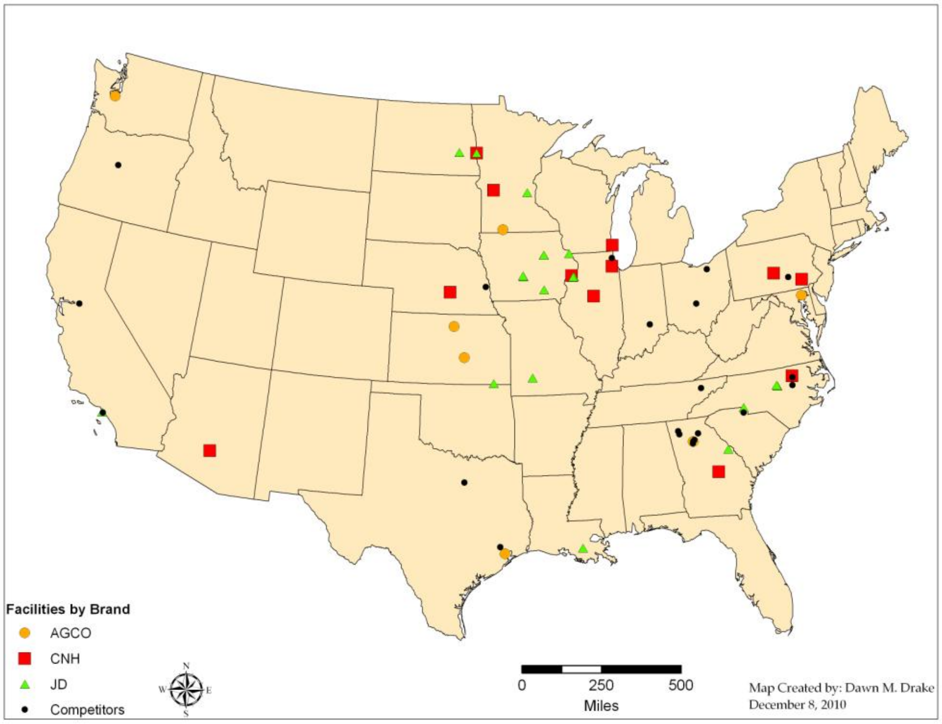

Figure 5.51: A map of the Big Three's US locations in comparison to international competitors.

In looking closely at the locations of international competitors, it is apparent that most of the facilities of international competitors are located in proximity to one another or one of the facilities of the Big Three. This can facilitate sharing of resources and knowledge as well as foster a competitive spirit of innovation among the firms. By locating close to one another, firms can maximize the competitive advantages of a region (Hill and Brennan 2000). Most of the firms for the Big Three are located nearby to another Big Three facility or an international competitor. Exceptions that might cause concern for competitive advantage include all of AGCO's manufacturing facilities. The AGCO assembly facilities, however, have more ready access to competitors, despite the fact the nearest competitor to Tacoma, Washington is in Oregon. For CNH, the facility in Benson, Minnesota raises the most concern because of the lack of nearby competitors. Deere has the most facilities that are distant to a competitor, whether foreign or domestic. Its facilities in Coffeyville, Kansas; Coon Rapids, Minnesota; Springfield, Missouri; and Thibodaux, Louisiana are among the most disconnected from rivals. Even the facility in Urbandale, Iowa can be considered disconnected, even though the neighboring Des Moines plant is not. The Des Moines plant, which manufactures harvesters, benefits from knowledge spillovers of the Nebraska-based CLAAS plant, whereas the Urbandale facility, which manufactures electronics for precision agriculture would not enjoy that advantage.

Also what is apparent from examining the map of competitor locations is that international competitors prefer coastal locations, likely because they still import an appreciable amount of parts and, in some cases, whole machines. West coast distribution centers of Asian firms Kubota in California and TYM in Oregon are supplied via container ships from Japan and South Korea, respectively. From the map, it is also obvious that there are very few foreign competitors located in the traditional farm machinery cluster in the upper Midwest. The two exceptions to this are CLAAS' combine manufacturing facility in Omaha, Nebraska, which is centrally located to its market, and Kubota's Lincolnshire, Illinois manufacturing plant, which can source parts through its location on Lake Michigan and benefit from the urbanization economies of Chicago.

Recent industry reports have indicated the decline of the Midwest as a concentrated area of the industry, with most of that concentration moving to the Southeast (IBISWorld 2009). This is apparent in the map of competitors by looking at the dense cluster of farm machinery manufacturers, both foreign and domestic, that are located in and around the Atlanta MSA. In the last few years there has been an appreciable influx of foreign farm machinery companies into the region, which is not surprising, given the high levels of FDI in the South in the last 20 years

(Kalafsky 2006). Within a few miles of AGCO's Worldwide Headquarters in Duluth, Georgia, in 2003, Mahindra and Mahindra opened its second US tractor assembly plant[28] (Mahindra USA 2009). SAME Deutz-Fahr's North American Headquarters is in the Norcross, Georgia building where AGCO got its start in 1990 (SAME Deutz-Fahr North America 2009). Japanese companies, Yanmar and Kubota also maintain facilities in the region (*Business Wire* 2004; *PR Newswire* 2007). The North American headquarters of McCormick International, once a part of International Harvester, where it plans to begin manufacturing in the next few years (McCormick International 2010) is also located nearby to AGCO. Even JD[29] and CNH have compact diesel tractor plants in Georgia (Figure 5.52).

The map of competitors, both foreign and domestic, reflects patterns commonly seen in industry life cycle theory, which states that industries tend to cluster at the beginning and end of their lifetimes (Audretsch and Feldman 1996). In the early stages of the development of the tractor, almost all of the hundreds of small farm machinery firms in the US were concentrated in the Upper Midwest. Clustering was essential to access the benefits of knowledge spillovers (Hill and Brennan 2000); the types of knowledge that Marshall (1890) believed were "in the air." Studies of Japanese industries, conducted by Porter and Takeuchi (1999), found that most of the successful sectors, such as robotics and business machines, had clustered early on to achieve competitive advantage. MacPherson and Boasson (2004) found that industry clusters in the pharmaceutical sector were more innovative than individual firms. Because of the increased levels of innovation, pharmaceutical clusters are more competitive than stand-alone firms (Boasson and MacPherson 2001).

[28] The other US assembly plant is located at its US headquarters in Tomball, Texas.

[29] In fact, JD uses an engine sourced from Yanmar in some of the tractors produced in this plant. Yanmar, a Japanese firm, is one of the farm machinery companies that has recently moved into the Atlanta MSA.

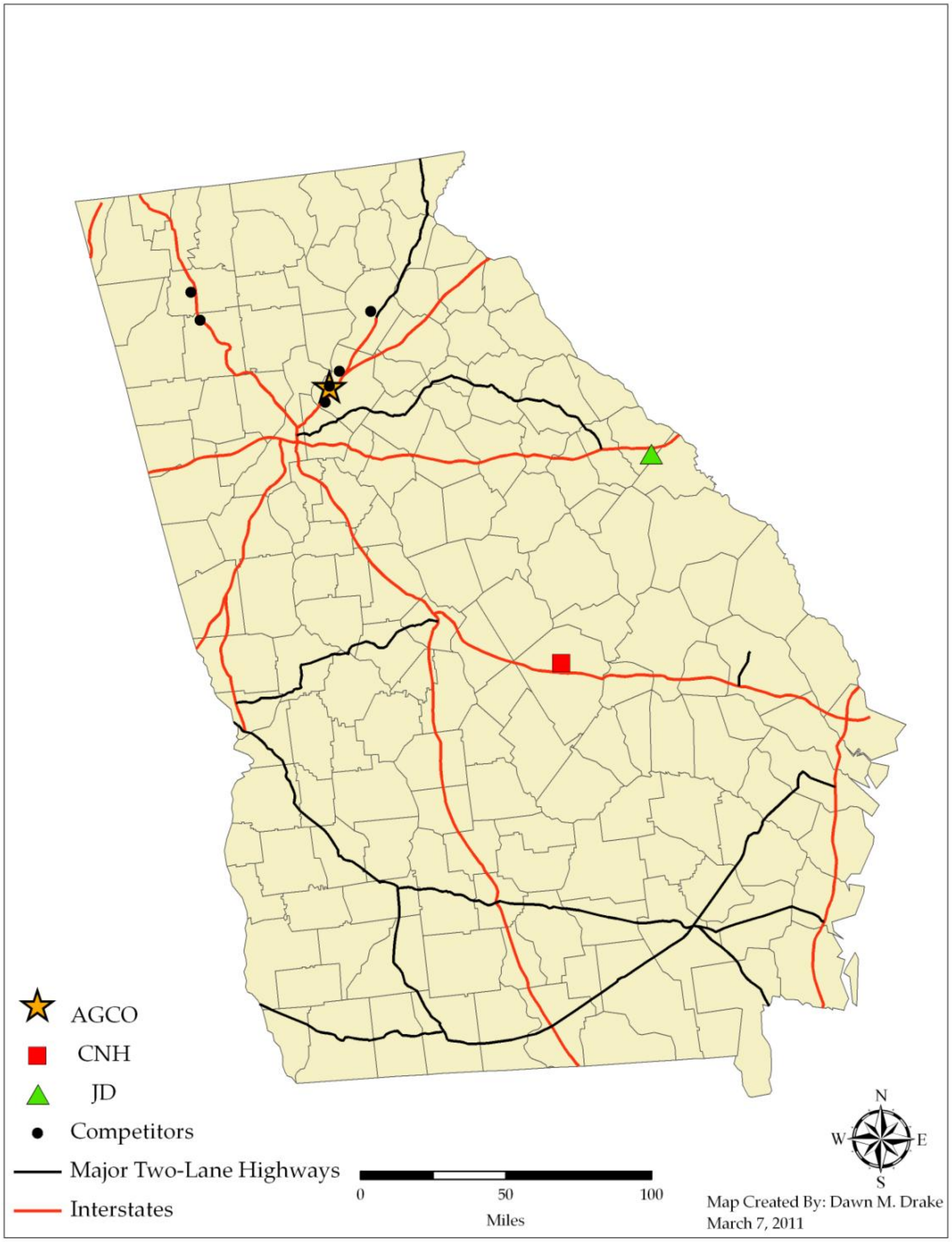

Figure 5.52: A map of the farm machinery firms in and around the Atlanta MSA.

Examples of the advantages of clusters are also prevalent in the farm machinery industry. International Harvester was so concerned with the tacit knowledge that could be accessed in the center of JD's operations in Moline, Illinois in the late 1920s, that it purchased land in Rock Island – the only town in the Quad Cities not under JD's influence. In the 1930s, International Harvester opened a combine plant just down the street from JD's East Moline combine plant. By the 1960s, Brooks McCormick, CEO of International Harvester, ordered his managers to become more involved in the philanthropic community in the Quad Cities in an effort to penetrate the same circles in which JD's managers and executives operated (Marsh 1985).

As the farm machinery industry matured, operations became more widespread and less clustered, with the Big Three building plants all over the globe. AGCO moved its headquarters out of the Upper Midwest and into the Southeast. One must wonder if that was the beginning of the new cluster that Audretsch and Feldman (1996) predicted as industries entered the declining phase of their life cycles. Industry experts believe that the farm machinery industry is in the mature phase of its life cycle (IBISWorld 2009). Atlanta may offer more favorable factor conditions for a new cluster, such as lower labor costs, when compared to the upper Midwest (Hill and Brennan 2000). By clustering in the Atlanta MSA, the farm machinery industry can reinvent itself and create a new form of competitive advantage.

5.5 Related and Supporting Industries

The location of related and supporting industries to a particular sector can be vital to competitive advantage (Porter 1990). Related industries can facilitate knowledge spillovers and cost sharing for infrastructure and research. In some cases they can even stimulate competition, which will also drive innovation (Caterpillar 1995). For the US farm machinery industry, there are two main sectors to consider as complements: 1) the construction industry, led primarily by Caterpillar of Peoria, Illinois[30], and 2) the heavy-duty truck industry, which has led the way for the farm machinery industry in emissions technology. The geographic distribution of suppliers also has impacts on competitive advantage for a firm. Nearby suppliers can be more responsive to the needs of the firm, share R&D and infrastructure costs, and reduce transportation expenses (Porter 1990). While finding information on suppliers for the Big Three is difficult at best because supplier information is a tightly guarded secret in the industry, two major materials that can be mapped are diesel engines from Cummins, Perkins, and Caterpillar and tires from Firestone, Goodyear, and Michelin. Where the Big Three locate in reference to related industries and suppliers can have impacts on competitive advantage.

5.5.1 Related Industries

The presence of Caterpillar and other related firms in construction machinery drives innovation for farm machines.[31] Rubber track technology was developed through a series of unrelated R&D investments by Caterpillar in the 1980s (Caterpillar 1995). The compound necessary to manufacture rubber tracks was developed as a result of research into new tire types for large earthmovers, while the steering systems, that allow track machines to spot-turn, were developed for use in Caterpillar's bulldozers (Caterpillar 1995). The blending of these two technologies led to the introduction of rubber track farm machines by Challenger in 1987[32] (Figure 5.53) (Caterpillar 1995). Similar technology is used by CNH in its articulated Quadtrac

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[30] Given that the second and third largest construction machinery firms in the US are CNH and JD, respectively (SBI 2007), Caterpillar is the only one analyzed here.

[31] There are several examples of Caterpillar partnering with the farm machinery industry, including with AGCO, prior to the sale of Challenger in 2002, and also with CLAAS (*PR Newswire* 2002)

[32] Caterpillar used the Challenger name for its agricultural tractors before selling the line to AGCO in 2002.

machines (Figure 5.54) to provide a “lighter footprint” than other four-wheel drive tractors in the industry. The advantages of rubber track technology for farm tractors are improved traction in muddy soils and reduced soil compaction (Caterpillar 1995; Case IH Agriculture 2009).

Figure 5.53: An AGCO Challenger rubber track tractor on display at the 2011 Canadian International Farm Show in Mississauga, Ontario (picture taken by author).

Figure 5.54: Case IH Quadtrac on display at the 2010 Ag Connect Expo in Orlando, FL (picture taken by author).

The location of the Big Three's facilities in relation to Caterpillar's US operations (Figure 5.55) reflects numerous opportunities for Caterpillar and the US farm machinery industry to share information and resources. There are several exceptions to this of course, many of which are owned by JD. For AGCO, the only two facilities that are distant to any Caterpillar facilities are those in Hesston, Kansas and Tacoma, Washington. Similarly, CNH has two facilities far from Caterpillar. These are the plants in Benson, Minnesota and Fargo, North Dakota. This is somewhat interesting, given the fact that Quadtracs are manufactured in Fargo, North Dakota. These disconnected plants are less likely to reap competitive advantages from networking with Caterpillar, but make up a small portion of CNH and AGCO's operations.

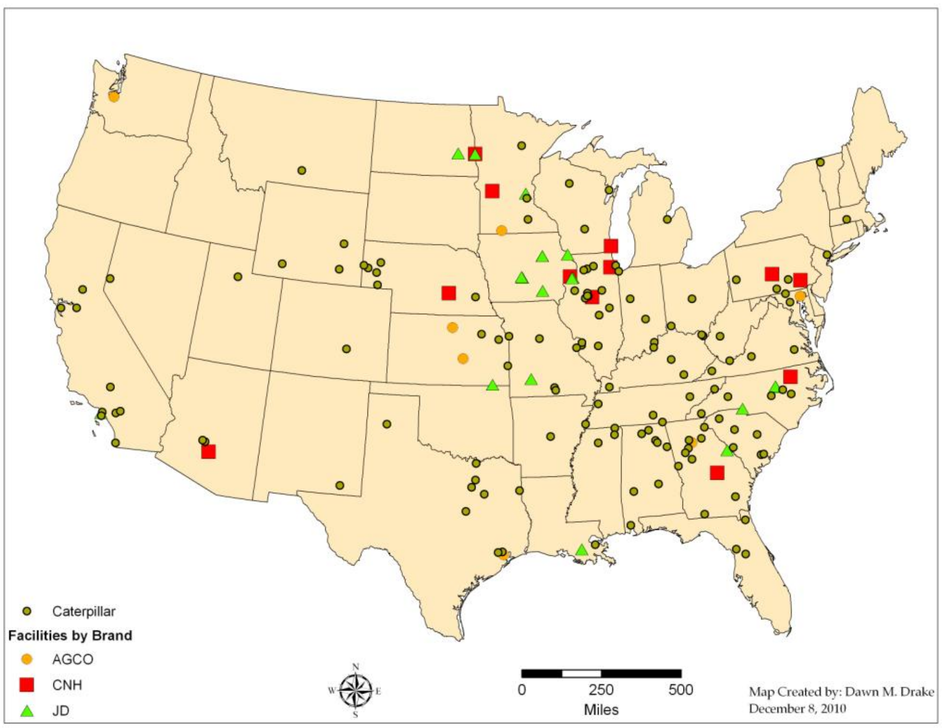

Figure 5.55: Facilities for Caterpillar and the Big Three in the US.

Deere, on the other hand, has at least eight facilities that are distant from any Caterpillar operations. Plants in Springfield, Missouri and Coffeyville, Kansas have Caterpillar facilities relatively close, but not as near as some other facilities. Plants in Des Moines, Urbandale, Ottumwa, and Waterloo, Iowa are all much more distant. Also disconnected are sites in Fargo and Valley City, North Dakota. This limits the amount of knowledge and resource sharing with Caterpillar that JD can tap into, which could be detrimental to competitive advantage.

Emission laws mandated by the EPA for diesel engines have typically been imposed in the heavy-duty truck industry three to four years before the farm machinery industry (Xinqun et al. 2010). For this reason, heavy-duty truck manufacturers and owners have been an important testing market and source of information for the Big Three, as is evidenced by AGCO's research and testing connections with Volvo Trucks. One of the reasons that AGCO was able to market SCR technology, when the distribution network for DEF was undeveloped, was because it could offer owners access to DEF not only from the AGCO dealer, but also from Daimler/Freightliner and Volvo/Mack dealerships as well.

To compare the locations of the major US truck manufacturing plants (including engine plants) to the Big Three, only those facilities that use or test engines were included in the map (Figure 5.56). Among the Big Three CNH has the opportunity for multiple collaborations with heavy-duty truck manufacturers, given proximity with plants and R&D centers in Whitakers, North Carolina; Belleville and New Holland, Pennsylvania; Racine, Wisconsin; and Davenport, Iowa. Perhaps most interesting is the practical co-location of CNH's testing facility in Burr Ridge, Illinois, a facility it shares with FPT to develop and test engines (E. Guzman, pers. comm.), and the Navistar engine plant in Melrose Park, Illinois. Navistar was once the truck division of International Harvester before the company was reorganized in the 1980s (Marsh

1985). While this appears to be a competitive advantage for both firms, Navistar is one of only two heavy-duty truck manufacturers in the US to employ cEGR technology in its trucks (Navistar 2011) and CNH uses the experience of Fiat's heavy-duty truck division in Italy for research assistance (E. Guzman, pers. comm.).

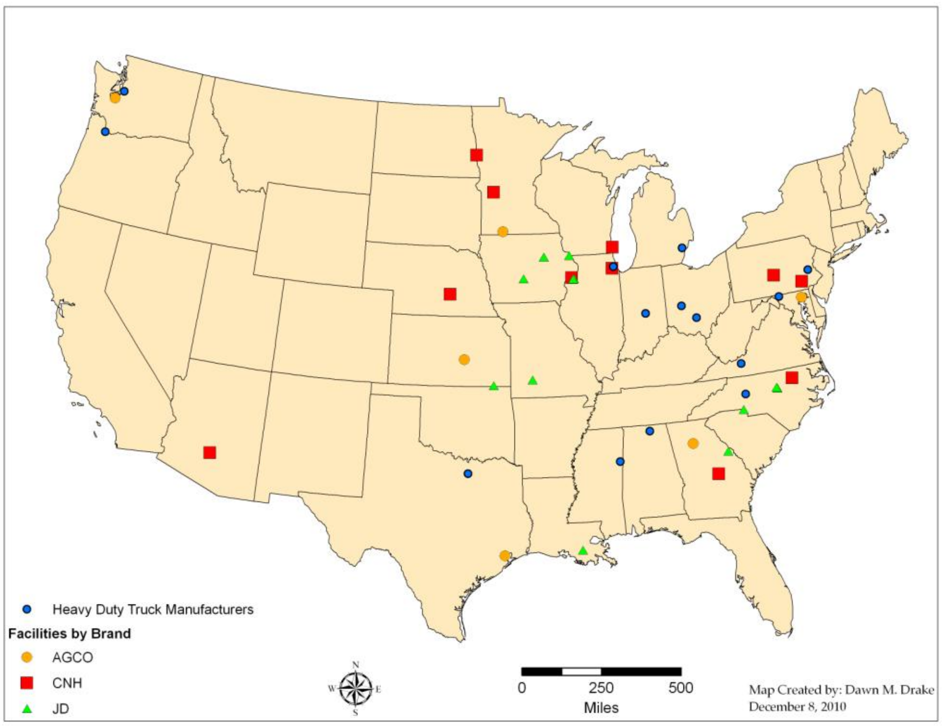

Figure 5.56: Locations of US heavy-duty truck manufacturers and US farm machinery facilities that use or test Tier IV-compliant engine technology.

More than half of AGCO's qualified facilities are located near a heavy-duty truck manufacturer. Not surprisingly, given the partnership between Volvo Trucks and AGCO, the AGCO assembly facility in Baltimore and Volvo's engine plant are within a two hour drive of one another. For JD, there are fewer opportunities for connections, which raises another interesting question. Has JD been lagging in adopting SCR technology because it honestly feels cEGR is the best option, or because it has not been able to partner with a heavy-duty truck manufacturer, like CNH and AGCO have, to share R&D and testing costs? If it is the latter, this is a clear indication of the importance of related industries to competitive advantage.

5.5.2 Supporting Industries

Suppliers have been crucial to the success of US farm machinery manufacturers throughout time. Many suitability reports, evaluating overseas locations, were concerned about access to raw material and suppliers (e.g. "The Austin Company Plant Location Survey" ca. 1960, Archival and Special Collections, University of Guelph Libraries, X41 RHC 0390; "Feasibility Study: Tractor Manufacture in South Africa," ca. 1962, Benson Ford Research Center, the Henry Ford, Accession 689). A smaller subset of facilities of the Big Three benefit from connections to engine and tire suppliers (Figure 5.57). In fact, the notion of third-party engine suppliers is becoming almost obsolete in the farm machinery industry with JD supplying almost all its own engines, as well as, at one time, providing engines to international companies like Versatile (Wehrspann 2010f). After a long time partnership with Cummins, which include the joint venture in Whitakers, North Carolina, CNH will be phasing out engines other than those built by FPT in its agricultural equipment (L. Bose, pers. comm.). Additionally, AGCO is continuously decreasing its use of Caterpillar and Perkins engines (J. Rogers, pers. comm.). There still may remain some opportunities for knowledge sharing between these firms, but the impact will continue to decrease[33]. Many of the plants do, however, still need tires for self-propelled machines and tow-behind implements.

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[33] In international markets where ultra-low sulfur diesel fuel, which is necessary to zero emission engines, is not available, such as South America and Russia, CNH and AGCO continue to use third-party engines in its tractors.

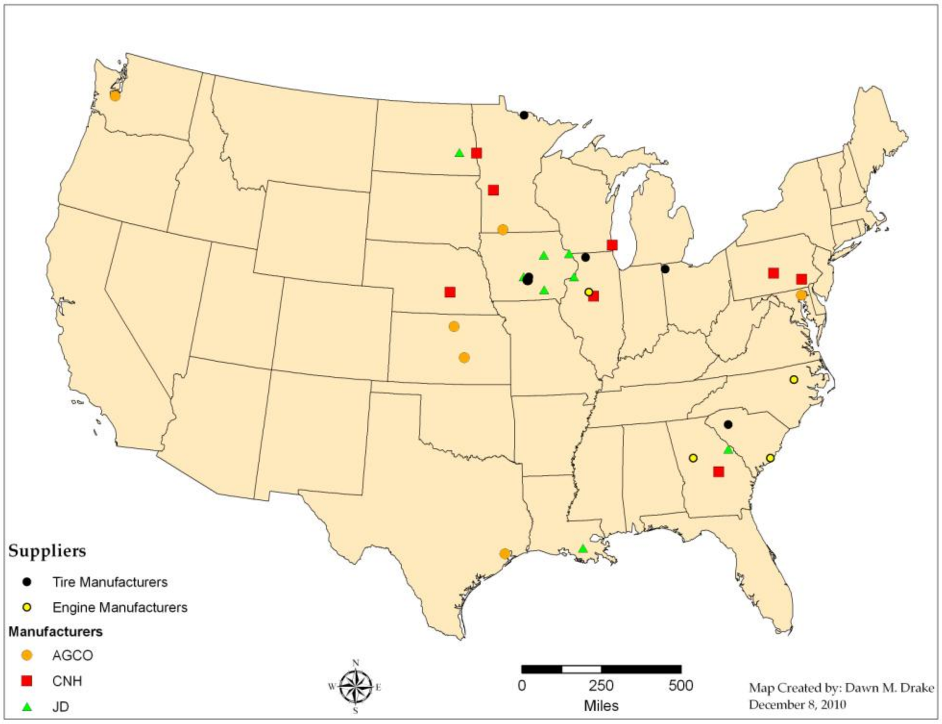

Figure 5.57: Tire and engine manufacturers compared to a selected subset of Big Three facilities.

Given that engine plants are far and few between and that Michelin and Firestone each only maintain one plant to manufacture agricultural tires in the US, it is not surprising that very few of the selected plants are well-connected to suppliers. Deere has the most advantage with its dense agglomeration and the nearness of the Titan[34] and Firestone plants in Des Moines, Iowa and another Titan plant in Freeport, Illinois. The CNH tractor manufacturing plant in Racine, Wisconsin also benefits from the Freeport, Illinois Titan plant. The Dublin, Georgia compact tractor plant, owned by CNH, is also well-connected to Michelin in South Carolina and a Titan distribution facility in the same industrial park as the plant (J. Daniels, pers. comm.). While the impact of these selected suppliers is small[35], it seems likely that JD may experience some cost

[34] Titan is the agricultural and construction tire division of Goodyear

benefits in having nearby tire competitors and reduced shipping distances compared to AGCO or CNH.

Despite findings by Porter and Takeuchi (1999) in studies of competitive advantage in Japanese industry, which emphasized the importance of close supplier networks, supporting industries are less important to the farm machinery industry. In an age of rapid transit and high speed communications, suppliers can provide materials and share knowledge over greater distances without a loss of competitive advantage for either the supplier or the firm receiving the supplied goods.

5.6 Government

Outside forces, created by government, have huge impacts on competitiveness (Porter and van der Linde 1999). Research on Japanese industries has shown that the ways in which the government can impact a sector of the economy can be overt, such as taxes and tariffs. It is often times more latent, such as was the case for the fax machine industry in Japan, which was stimulated by early adoption by the Japanese government (Porter and Takeuchi 1999). For the US farm machinery industry, government intervention has both helped and hindered. The government, whether local, state, federal, or in some cases foreign (Fox and Murray 1990), can impact the farm machinery industry. These interventions can come in the form of laws that require modifications to equipment designs or for farmers to purchase new machines that meet more stringent regulations. Other interventions have included income tax abatements for companies and economic incentives to farmers to buy new machinery. Perhaps most significant

[35] Future analysis might include suppliers for GPS units and antennas as each company has a dedicated source with JD manufacturing its own, AGCO buying from Topcon, and CNH buying from Trimble.

to costs of production and competitive advantage for the farm machinery industry is the impact of labor laws that promote or dissuade union activity.

5.6.1 Safety Laws

In the US, safety regulations imposed by the federal government have had limited impacts on the industry (IBISWorld 2009). One of the few exceptions to this is safety regulations requiring rollover protection (ROPS) and/or enclosed cabs, which have increased fixed costs for tractor production, but also saved the lives of customers (Keast 2009). In 1975, the Occupational Safety and Health Administration (OSHA) issued a regulation stating that all tractors manufactured in the US after October 1976 must be equipped with a seatbelt and ROPS. Contrary to popular thought, this regulation was imposed on the customer, not the manufacturer or dealer (Keast 2009). The dealer or manufacturer ultimately are responsible, however, and have faced numerous lawsuits related to accidental injury as a result of operating a tractor without ROPS (Keast 2009)[36]. Shortly after the law was imposed, tractor manufacturers worked with the American Society of Agricultural Engineers to develop structural integrity requirements for ROPS, which were also adopted by OSHA (Keast 2009). In the following years, several states also adopted ROPS requirements making the equipment standard on all tractors over 20 horsepower (15 kilowatts) sold in the US today (Keast 2009).

In the European Union, safety regulations have had a more profound impact on the Big Three, forcing them to make extensive product changes to meet laws for cabs, lighting, and braking systems (McMahon and Wehrspann 2010). These modifications often mean that

[36] In 1982, International Harvester was sued by an operator who was injured when the skid steer he was operating lacked side shields for rollover protection. Despite the fact that the machine was sold to the farm owner without the ROPS, at the owner's request, International Harvester was still liable because the ***operator*** did not ask for the ROPS to be removed from the machine (Keast 2009).

production facilities in the US that produce tractors for export to Europe do so in dedicated batches (J. Daniels, pers. comm.). This impacts competitive advantage and restricts economies of scale usually achieved by long product runs. On the whole, however, safety regulations, imposed by the US federal or foreign governments have only had minor impacts of competitive advantage for the Big Three.

5.6.2 Environmental Laws

Environmental laws, imposed by the government, are often an impetus for firms to become more innovative, as was observed by Porter and Takeuchi (1999) in reference to air conditioner manufacturers' response to Japanese energy conservation laws. Porter and van der Linde (1999) stated that, "How an industry responds to environmental problems may, in fact, be a leading indicator of its overall competitiveness" (221). This is very true for the Big Three. Perhaps the largest impact on competitive advantage to be experienced by the farm machinery industry in over 200 years is the imposition of emissions laws designed to reduce the production of NOx and PM produced by diesel-powered farm machinery (Mowitz 2010a). The costs of R&D to meet Tier IV interim emissions regulations have been profound for the Big Three and have been passed to the consumer in the form of higher machine prices. Higher costs are not the only outcome, however. As a first mover to develop new green technology, AGCO has seen an increase in its brand recognition and market power. It is the industry leader in promoting SCR technology. Deere, on the other hand, continues to use cEGR technology, even though it recognizes that it will eventually need to develop its own SCR engines to meet Tier IV final regulations (Deere and Company 2010a). The slowness with which JD has developed the technology to meet standards will have serious impacts on its competitive advantage in the future as farmers are becoming less brand loyal and unwilling to wait for companies to catch up to the front of the product life cycle (Lessiter 2011).

Emissions laws have not all been negative for the US farm machinery industry. Part of what drove the upsurge of the industry in 2008 was government incentives for producers to adopt cleaner running machines (Grooms 2010b). The Carl Moyer Memorial Air Quality Standards Attainment Program, for example, offers grants to farmers in California to adopt Tier IV compliant on-road and off-road machines (Grooms 2010b). Federal rebates amounting to 50 percent of replacement costs, offered to farmers buying new tractors and other self-propelled machines as long as the equipment being replaced was destroyed, as a part of the Environmental Quality Incentives Program, were also included in the 2008 Farm Bill to help farmers buy new tractors and combines with lower emissions engines (Grooms 2010b). All of these government programs stimulated farm machinery sales for the Big Three.

Additionally, regulations imposed on California farmers by the California Air Resources Board (CARB) will stimulate demand for Tier IV-compliant machines in the near future. California farmers must have a majority of machines in their fleet outfitted with low emissions engines (D. Mowitz, pers. comm.). While CARB had suggested to the construction industry, which were subject to these fleet laws much earlier than the farm machinery sector, that retrofitting existing tractors was possible, most research has found the retrofitting process to be cost prohibitive. Industry analysts expect to see California farmers buying new tractors in record numbers in the coming years (Grooms 2010b). On the whole, EPA emissions regulations have had widespread impacts both positive and negative for competitive advantage in the farm machinery industry.

5.6.3 Economic Policies

In addition to the incentives offered for farmers to adopt cleaner running tractors and combines, the farm machinery industry has been impacted by other types of economic policy generated by various levels of government. Throughout time tariffs, levied by foreign governments against the Big Three, have greatly impacted global manufacturing location decisions for the firms ("Letter to A.R. Hauschel from Leon Clausen" 1 Sept. 1938, Library-Archives, Wisconsin Historical Society, Mss 1021). At other times, tariffs imposed against foreign competitors have helped protect the industry, although that protection is practically nonexistent today (IBISWorld 2009).

Other economic policies that have benefited the Big Three include corporate income tax abatements to the companies and farm subsidies that allow farmers to buy new machines. Corporate income taxes for the farm machinery industry vary between 15 and 35 percent, depending on the firm, but have been suspended from time to time to help a firm meet payroll and prevent widespread layoffs, as was the case for JD in 1984 and again 1988 (Greenhouse 1984; Associated Press 1988). Local and state governments have also been known to place moratoriums on property taxes to encourage the development of new facilities (Fox and Murray 1990).

Farm subsidies and government stimulus plans have also encouraged the industry. Farm Bill 2002 indirectly helped the Big Three by increasing crop subsidies to farmers in some of the largest producing areas of the US. With these increased payments, many farmers were able to update machinery and expand operations (IBISWorld 2009). When farmers fear that subsidies will be reduced or repealed, however, the sales of machinery decline (Wayne 1996). Economic stimulus packages also help the Big Three. In 2008, the Farm Security and Rural Reinvestment

Act provided farmers with extra income that was invested in new farm equipment. Much of this new equipment was purchased from US manufacturers (IBISWorld 2009). In all these ways, economic policies, instituted by governments of all levels, have had profound impacts on competitive advantage for the farm machinery industry.

5.6.4 Labor Laws

The US farm machinery industry has long struggled with labor problems, union tensions, and periodic strikes. The infamous Haymarket Square Massacre in 1886 in Chicago started out as a strike outside a McCormick-Deering (a predecessor company of CNH) plant (Marsh 1985). Senator Joseph McCarthy's famous hunt for communists actually began as an investigation into union activities and the penetration of the Communist Party into the West Allis, Wisconsin plant of the Allis-Chalmers Corporation (Petersen 1978). At the time, the President of Allis-Chalmers had been attempting to appease the workers with promises of profit-sharing and other benefits in an effort to prevent a strike that would cause daily production losses of up to 375,000 dollars (Allis Chalmers: Preliminary Report on Profit Sharing, ca. 1940, Library-Archives, Wisconsin Historical Society, Mss718; Allis Chalmers: Letters to Employees, ca. 1946, Library-Archive, Wisconsin Historical Society, Mss718).

Throughout the history of the Big Three, strikes have being very costly events. In the 1970s, the Tractor and Implement Division of Ford Motor Company had extensive contingency plans in the event of a strike, which included shipping parts to factories that were less likely to strike, holding containers from global factories in port facilities, and even ramping up production of tractors at other plants in England and the Netherlands (Division Contingency Plans, ca. 1970, Benson Ford Research Center, the Henry Ford, Accession 1929). Union bargaining and strikes continue to be a problem for the Big Three. Deere, in the last 30 years, has faced numerous shutdowns as a result of strikes (Associated Press 1986), as well as prolonged negotiations with the United Auto Workers, who represent most workers in union facilities owned by JD (Associated Press 1988; 2003). Overall, much like the Detroit automakers, unionization is a serious cost concern for the US farm machinery industry.

The ability to locate a manufacturing facility in a state with right-to-work legislation can be an advantage for firms that want to reduce production costs. This is why there has been a movement of manufacturing to the South in recent years (Kalafsky 2006). By looking at the location of the Big Three's manufacturing and assembly plants in relation to right-to-work laws (Figure 5.58), an interesting pattern begins to emerge. Over two-thirds of JD's plants are located in states with right-to-work legislation, which should give it competitive advantage in labor costs. However, in 1986, only one of its plants was not unionized (Associated Press). Given the emphasis that JD continues to place on legacy costs impacting its profit margins (Deere and Company 2009), it is not surprising that the company still is heavily unionized today. The costs of retirement packages and health insurance for retirees continue to be of concern for JD.

Both AGCO and CNH have a more even distribution of plants between states with right-to-work laws and those without, with approximately 50 percent of each. Estimates by CNH place union membership for the company at less than ten percent of the labor force (Wenzel 2004), giving it a competitive advantage in labor costs. In examining press releases for AGCO over the past few years, it appears that AGCO may have even less union penetration in its facilities, reducing its labor costs. Although, AGCO periodically mentions legacy costs as a cause of concern for future profits (Wall Street Journal Staff 2009). Overall, given the focus that JD places on legacy costs, created by unionization, and the high price of labor, even given the advanced nature of farm machinery manufacturing, AGCO and CNH may be in a better position to achieve competitive advantage based on their labor costs.

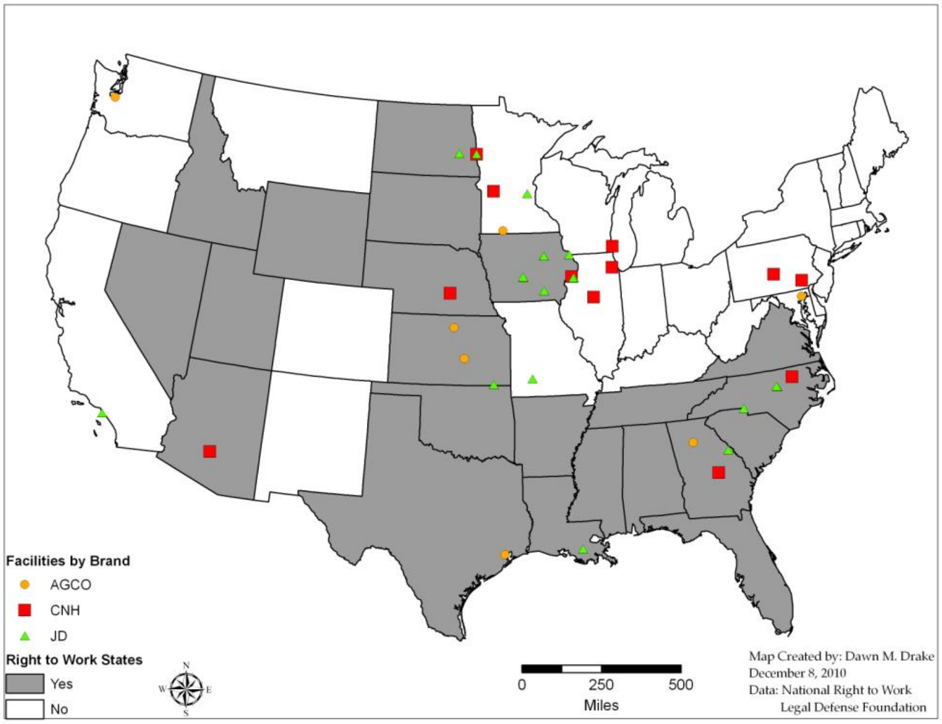

Figure 5.58: Manufacturing facilities for the Big Three compared to states with right-to-work legislation.

5.7 Chance

The farm machinery industry is one of several sectors of US manufacturing that is constantly faced with the impacts of chance on its profits. Because farming itself is a game of chance against the weather, farm machinery producers are often left in an uncertain position from year-to-year to predict profits (Wall Street Journal Staff 2009). For the US farm machinery industry, chance has often manifested itself in moments that seemed irrelevant to the sector at large, but led, for example, to the development of pneumatic tires for use on farm tractors and the establishment of Mahindra and Mahindra as a major farm machinery producer. Moments of chance including serendipitous friendships, combined with poor decisions on the part of others, and production shifts as a result of wars have led to competitive changes in the US farm machinery industry.

Farm tractors may not have had pneumatic tires nearly as early in their history if not for a chance friendship between Harvey Firestone and the general manager of the Allis-Chalmers Corporation, Harry Merritt (Gaines 2010a). Firestone was also friendly with Henry Ford and had approached him first with the idea for pneumatic tire technology to improve fuel economy and operator comfort, as well as to increase traction. Ford, however, was much more focused on developing options to convert Fordson tractors to track machines (Petersen 1978). So, Firestone offered the technology to Allis-Chalmers. In 1933, an Allis-Chalmers "U" became the first tractor ever tested at NTTL with rubber tires (Figure 5.59). Allis-Chalmers then set forth on an aggressive advertising campaign to promote the technology to farmers, staging tractor races at local county fairs with the Allis-Chalmers tractor being driven by noted racecar driver, Barney Oldfield (Gaines 2010a). From this moment of chance and a missed opportunity on the part of Ford, Allis-Chalmers opened up a new segment of the market. By the time of World War II, most farm tractors were sold with rubber tires as standard equipment (Petersen 1978).

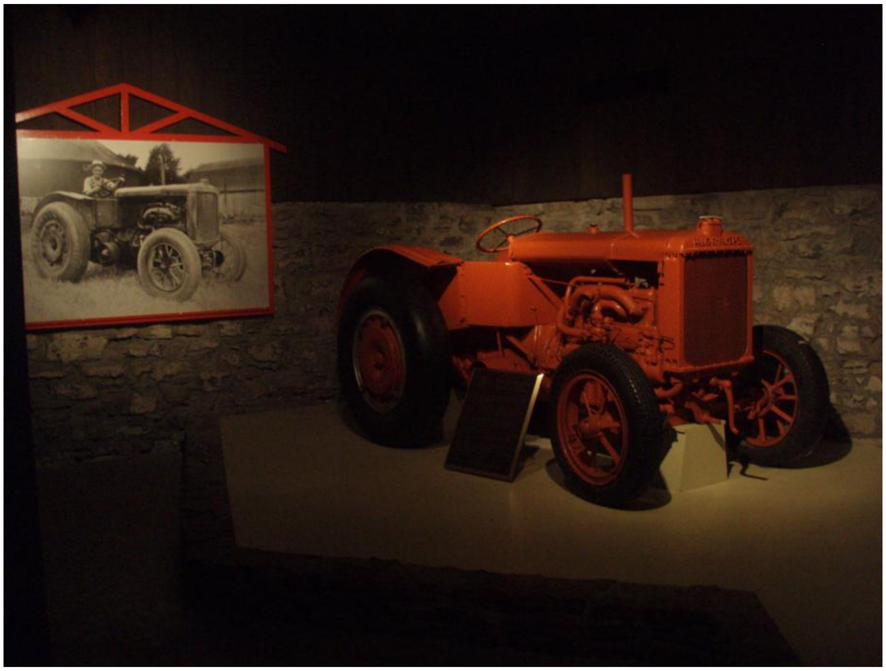

Figure 5.59: The first Allis-Chalmers tractor with pneumatic rubber tires, a 1933 "U", on display at the Wisconsin State Agricultural Museum in Cassville, WI (picture taken by author).

World War II provided another moment of chance in the farm machinery sector; one that brought the Big Three's largest international competitor into the farm machinery industry. Without the shift in production by many of the US farm machinery manufacturers from tractors and implements to artillery during World War II, Mahindra and Mahindra would not have such an established foothold in the farm machinery industry today. The Minneapolis-Moline Company, another predecessor company of AGCO, as a part of the war effort, developed and manufactured Willy's jeep for the US military (Gee 2008). In order to facilitate the delivery of the jeeps to the front in Northern Africa and the Pacific Theatre, Minneapolis-Moline contracted with Mahindra and Mahindra, a small automobile firm in India, to assemble kits that were shipped from the US (Gee 2008). In the years following the war, Minneapolis-Moline, as well as International Harvester, continued to contract with Mahindra and Mahindra, having it assemble farm machinery for sale in Europe and parts of Asia (Gee 2008). When Minneapolis-Moline went bankrupt in the early 1970s and International Harvester broke off contracts with Mahindra and Mahindra, the company decided to establish India's own domestic farm machinery industry, using the machinery and knowledge gained through 30 years of involvement with the US farm machinery industry (Gee 2008). Today, Mahindra and Mahindra is the fourth largest farm machinery producer and world's largest seller of tractors, mostly because of a moment of chance as a result of a war. This has greatly impacted the competitive climate and the global markets in which the Big Three participate today.

CHAPTER VI
SYNTHESIS

6.1 Porter and the US Farm Machinery Industry

After carefully examining the US farm machinery industry through Porter's model of competitive advantage (1990), this chapter will synthesize the findings from the case studies of the Big Three to empirically test the model's elements[37]. Table 6.1 lists all the sites evaluated for the Big Three and the findings of the analyses. From this table, competitive advantage of the locations can be compared, based on the individual point analyses in Chapter V, and questions can be raised about whether Porter's model is correct 20 years after it was conceived. Most of the industry-level empirical analyses of Porter's theory, in advanced economies, have found agreement between the tests and Porter's model in many, but not all facets (e.g. Boasson and MacPherson 2001; MacPherson and Boasson 2004). Empirical tests of competitive advantage in the US pharmaceutical industry, for example, have demonstrated that many variables that should be relevant do not demonstrate statistical significance (Boasson and MacPherson 2001). My qualitative research similarly indicates that the model and the empirical findings are not always in line with one another. In some cases, the double diamond model, proposed by Moon et al. (1995) for explaining competitive advantage in developing countries with high levels of FDI proved a better fit. Previously it was believed that the Moon et. al (1995) model was not relevant for mature manufacturing in developed economies where Porter's model was supposedly a better fit (Yetton et al. 1992).

[37] Appendix A lists all the evidence that was used to arrive at these findings.

Table 6.1: Synthesis of findings from Chapter V

Firm	Location	Function	F1	F2	F3	D1	S1	S2	S3	R1	R2	G1
AGCO	Duluth, GA	Admin/R&D	Y	Y	N	NA	Y	Y	Y	Y	NA	NA
AGCO	Beloit, KS	Manu	Y	Y	N	NA	NA	NA	N	Y	N	Y
AGCO	Hesston, KS	Manu	Y	Y	Y	Y	NA	NA	N	N	N	Y
AGCO	Jackson, MN	Manu	Y	Y	N	Y	NA	NA	N	P	N	N
AGCO	DuPont, WA	Assem	Y	N	Y	N	NA	NA	Y	P	N	N
AGCO	Edgewood, MD	Assem	Y	Y	Y	N	NA	NA	Y	Y	N	N
AGCO	LaPorte, TX	Assem	Y	Y	Y	N	NA	NA	Y	Y	N	Y
CNH	Burr Ridge, IL	R&D	Y	Y	Y	Y	NA	Y	Y	Y	NA	NA
CNH	Belleville, PA	Manu	Y	Y	N	NA	NA	NA	Y	Y	N	N
CNH	Benson, MN	Manu/ R&D	P	Y	P	NA	NA	N	N	N	N	N
CNH	Dublin, GA	Manu	Y	Y	Y	NA	NA	NA	Y	Y	Y	Y
CNH	Fargo, ND	Manu/ R&D	P	Y	Y	Y	NA	N	Y	N	N	Y
CNH	Goodfield, IL	Manu/ R&D	Y	Y	Y	NA	NA	Y	N	Y	NA	N
CNH	Grand Island, NE	Manu	Y	Y	Y	Y	NA	NA	Y	P	N	N
CNH	New Holland, PA	Manu/ R&D/Admin	Y	Y	P	Y	N	N	Y	Y	N	N
CNH	Racine, WI	Manu/Admin	P	Y	P	Y	Y	NA	Y	Y	Y	Y
CNH	Whitakers, NC	Manu	Y	Y	Y	NA	NA	NA	Y	Y	NA	Y
CNH	Davenport, IA	R&D	N	Y	Y	Y	NA	N	Y	Y	NA	NA
CNH	Stotonic, AZ	R&D	Y	Y	Y	Y	NA	N	N	Y	NA	NA
JD	Cary, NC	Admin	Y	Y	Y	NA	NA	NA	Y	Y	NA	NA
JD	Coffeyville, KS	Manu	N	Y	N	NA	NA	NA	N	N	NA	Y
JD	Coon Rapids, MN	Manu	Y	Y	Y	NA	NA	NA	N	Y	NA	N
JD	Des Moines, IA	Manu	Y	Y	Y	NA	NA	NA	Y	N	N	Y
JD	Dubuque, IA	Manu	Y	Y	Y	NA	NA	NA	Y	Y	Y	N
JD	East Moline, IL	Manu	Y	Y	Y	Y	NA	NA	Y	Y	Y	N
JD	Fargo, ND	Manu	Y	Y	Y	NA	NA	NA	Y	N	NA	Y
JD	Grovetown, GA	Manu	Y	Y	Y	NA	NA	NA	Y	Y	Y	Y
JD	Moline, IL	Admin/R&D/Manu	P	Y	Y	Y	NA	N	Y	Y	Y	N
JD	Ottumwa, IA	Manu	Y	Y	Y	NA	NA	NA	N	N	N	Y
JD	Springfield, MO	Manu	Y	Y	Y	NA	NA	NA	N	N	NA	N
JD	Thibodaux, LA	Manu	N	Y	Y	NA	NA	NA	N	N	N	Y
JD	Torrance, CA	Manu	N	Y	Y	NA	NA	NA	Y	Y	NA	N

Table 6.1: Continued

Firm	Location	Function	F1	F2	F3	D1	S1	S2	S3	R1	R2	G1
JD	Urbandale, IA	Manu	N	Y	Y	NA	NA	NA	N	N	NA	Y
JD	Valley City, ND	Manu	Y	Y	Y	NA	NA	NA	N	N	N	Y
JD	Waterloo, IA	Manu	Y	Y	Y	Y	NA	NA	Y	N	Y	Y
JD	Charlotte, NC	R&D	Y	N	Y	NA	NA	Y	Y	Y	NA	NA
JD	Morrisville, NC	R&D	Y	Y	Y	NA	NA	NA	Y	Y	NA	NA

F1: Educational attainment
F2: Research connections
F3: Transportation connectivity
D1: Market distance
S1: Headquarters location
S2: R&D location
S3: Rivals
R1: Related industries
R2: Supporting industries
G1: Right-to-work legislation

Y: Analysis favorable
N: Analysis negative
P: Analysis inconclusive
NA: Analysis not relevant

6.1.1 The Allis-Gleaner Corporation

When analyzing AGCO's sites, the headquarters in Duluth, Georgia should be very competitive, especially given its location in the middle of both the new farm machinery cluster and the "new automobile corridor." This allows AGCO to make research connections with companies both inside and outside the sector, including BMW, Mercedes, SAME Deutz-Fahr, and Volvo Trucks (*PR Newswire* 2000; AGCO 2009). By locating in the Atlanta MSA, which has experienced unprecedented growth in headquarters concentration in the last ten years (Gong and Wheeler 2007), AGCO can be much more competitive for both administration and R&D. This fits the findings of Porter (2000a), who stated that companies that locate headquarters in clusters of administrative activities are the most competitive. Being at such a distance from headquarters for other domestic firms in the same sector is unusual (Strauss-Kalm and Vives

2007), but is less of a concern for AGCO given the related industries and international farm machinery companies it can work with in the Atlanta MSA.

The AGCO assembly plants near Baltimore and Houston also appear to be very competitive with their locations in major ports, cancelling out the negative externalities of distance from demand markets and suppliers. The Tacoma, Washington facility is also connected, but if AGCO produces the majority of the kits in Brazil and Europe, and not Asia, that are assembled in Tacoma (AGCO Corporate 2007), is it a disadvantage for the kits to travel such great distances on their way to Tacoma? Are AGCO's transportation costs higher at this facility than the other two assembly facilities? Do reduced distribution costs to dealers west of the Rocky Mountains cancel this out? This is a case where a double diamond model (Moon et al. 1995), which accounts for both local conditions, in one diamond, and global conditions, in another diamond, may be a more appropriate method of analysis; such a model may better explain competitive advantage for AGCO's assembly plants.

The manufacturing facilities that AGCO has maintained over the years present another interesting test of competitiveness. As AGCO formed itself through over 24 separate acquisitions from 1990 to present[38], it has selected which factories to close and which to keep operating. The facility in Jackson, Minnesota came as part of the acquisition of Caterpillar's agricultural operations in 2002 (Shepherd 2002), while the Hesston, Kansas plant was acquired along with Hesston Hay Tools from CNH in 1999 (*Implement & Tractor* 1999). The Beloit, Kansas plant came with the acquisition of Sunflower in 2002. Despite the fact that AGCO had the opportunity to pick and choose the facilities to keep open, the analysis seems to indicate that

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[38] Despite the fact that AGCO was warned by the Justice Department about anti-trust violations and has claimed to be shifting company focus from acquisitions to technology, in early 2011, it was allowed to acquire 50 percent of Wil-Rich and Amity Technology to expand its air-seeding tool and tillage lines (*Farm Industry News* 2011a).

none of them is very competitive. The Jackson, Minnesota plant, which produces AGCO's largest and heaviest tractors, as well as its sprayers, is disconnected from transportation networks. All three plants are distant from competitors and suppliers, making resource and knowledge sharing difficult, even with the headquarters and R&D, which are located in Duluth, Georgia.

On the whole, it would appear from the analyses of Porter's model that, based on its location decisions, AGCO should be struggling to keep up with the rest of the industry. It continues, however, to grow and gain market share as compared to CNH that has labored to recover from economic downturns and a sell down of excess inventories (Tita 2011). In the long run, however, it would not be surprising for AGCO, with its increased global focus, to shutter some or all of these US manufacturing plants and move operations overseas or to the better-connected assembly plants. Given that Gleaner combines (which make up the majority of those sold by AGCO) are up to 7,000 pounds (3,182 kilograms) lighter than competitors, shipping is less of a concern than for other manufacturers that need to maintain a location in the heart of their demand markets.

Similar to how AGCO's assembly plants could be better explained by the double diamond model proposed by Moon et al. (1995), the same model may better explain AGCO's overall level of competitive advantage. Given AGCO's global connections and market dominance outside of the US, it can access benefits of local conditions, but also global advantages. This contradicts with most other empirical tests of Porter (e.g. Moon et al. 1998; Bowen and Leinbach 2006) that have recommended the double diamond model only in developing economies with high levels of FDI (Moon et al. 1995). In this case, AGCO is located in a developed economy and the US farm machinery industry has low levels of FDI (IBISWorld

2009), yet the double diamond model is most useful for explaining AGCO's competitive advantage.

6.1.2 Case New Holland

For CNH, the analyses indicate that some facilities are more competitive than others. Among those that are marginally uncompetitive, according to the analyses, are the facilities in Fargo, North Dakota and New Holland, Pennsylvania. The Fargo plant is lacking in related and supporting industry connections and is less well-suited for its manufacturing functions, but appears competitive for R&D of CNH's largest tractors. The New Holland plant is well-suited for its position as the majority producer of hay and forage tools, but appears to be less competitive for its other functions (R&D and headquarters).

The split headquarters and the distributed R&D strategies that CNH continues to pursue are impacting competitive advantage for the second largest farm machinery firm in the world. Both of these decisions are contrary to the literature and would seem to indicate opportunities for CNH to alter its firm structure, strategy, and rivalry to increase competitiveness. If CNH could streamline operations to be more like AGCO and JD with just one major headquarters and fewer R&D facilities, in more competitive locations, the firm could gain market share on JD and stop losing ground to AGCO.

The CNH facility that is most troublesome, in these analyses, is the Benson, Minnesota sprayer plant. In addition to being a poor location for its R&D function in terms of transportation connectivity and educational attainment rates, it ranks favorably in very few of the evaluations of its location for manufacturing. This is a plant that manufactures self-propelled sprayers (Figure 6.1). If it cannot compete on costs, due to its poor location, it may lose market share. Although, given the fact that AGCO also produces its sprayers in a sub-optimum location (Jackson, Minnesota), it may be a moot point, for now. Both companies could face competition from JD that manufactures sprayers in Des Moines, Iowa, foreign competitors, or short-line companies that specialize in sprayers, such as Apache of Mooresville, Indiana.

Figure 6.1: A Case IH Patriot sprayer, manufactured in Benson, MN, on display at 2010 Farm Progress in Boone, IA (picture taken by author).

The majority of CNH's facilities appear to be competitively located, for their functions, based on these analyses. This includes manufacturing facilities in Grand Island, Nebraska; Belleville, Pennsylvania; and Whitakers, North Carolina, R&D facilities in Burr Ridge, Illinois; Stotonic, Arizona; and Davenport, Iowa, and a combined manufacturing and R&D facility in Goodfield, Illinois. All of these facilities were favorably evaluated in multiple map analyses. This is not necessarily the whole story, however, as a recent *Wall Street Journal* article pointed to CNH's excess manufacturing capacity and stockpiled inventories as sources of competitive disadvantage compared to JD and AGCO (Tita 2011).

The analyses of CNH's site locations did not always produce accurate findings, however. The manufacturing plant in Racine, Wisconsin appears to be an ideal location for CNH in terms of competitiveness, yet this was a plant that Fiat targeted for closure when it acquired Case IH in 1999 (*Implement & Tractor* 2000). Obviously this never happened, so perhaps Fiat was able to discover the advantages of the site, such as appropriate levels of educational attainment, and proximity to related and supporting industries and rivals.

More disconcerting for the correctness of Porter's model, the compact tractor assembly plant in Dublin, Georgia appears to be well-situated for its function. On January 31, 2011, however, CNH announced that it would close this plant do to its misalignment with prevailing market conditions and lack of competitiveness in the industry (Tita 2011). This was not indicated by the analyses and may point to a missing piece of Porter's model that can explain the lack of competitiveness of the Dublin, Georgia plant. Since this plant was dedicated primarily to the assembly of tractor kits that were shipped from Turkey, India, and Japan (J. Daniels, pers. comm.), the double diamond model, proposed by Moon et al. (1995), is a better fit for explaining competitive advantage for this one site in CNH's US manufacturing network. The double diamond model examines not only local conditions, but also global conditions that impact competitive advantage. While the analysis of local demand looked favorable, there may be a competitive disadvantage in the global diamond.

Closing inefficient sites, like those in Benson, Minnesota (which has not been proposed by CNH) and Dublin, Georgia can help CNH. Also, not duplicating efforts by maintaining both the New Holland and Case IH brands as full lines of equipment will help to streamline operations. Since 90 percent of machines leaving New Holland, Pennsylvania are painted as New Holland equipment because of New Holland's hay tool reputation, then sell all hay tools as New Holland and reduce paint schemes, product literature, and advertising budgets. Similarly, since 90 percent of combines leaving Grand Island, Nebraska are painted as Case IH Axial Flow combines, sell all combines as Case IH and again reduce redundancy in paint schemes, literature, advertising, and dealer training. This will greatly help CNH to compete in the global farm machinery industry by streamlining operations and reducing redundancy.

Another way to streamline CNH would be to reduce the number of sites for higher level R&D and administrative functions. Given the fact that CNH's R&D facility in Burr Ridge, Illinois is so well-suited, based on factor conditions and nearness of both rivals and related industries, this should be one of the sites that CNH considers for moving most of its R&D activities. Streamlining R&D, to use only the most competitive sites, like Davenport, Iowa and Burr Ridge, Illinois, while maintaining the Stotonic, Arizona site for intensive, high-stress testing, will improve competitive advantage for CNH. Porter and Stern (2001) suggested that competitive advantage in R&D is maximized by selecting locations that are not necessarily the most cost effective, but are most likely to stimulate innovation. Burr Ridge, Illinois, in the Chicago MSA, is the most attractive option for this among those currently available to CNH, based on its positive factor conditions and nearness to rivals and related industries. If CNH would also move all of its headquarters activity to the location in Racine, Wisconsin, which is most well-suited to administrative functions, this would additionally allow CNH to co-locate headquarters and R&D in near proximity. This co-location should increase competitiveness (Vernon 1979).

6.1.3 Deere and Company

The analyses of JD demonstrate many more uncompetitive sites than CNH. That being said, JD also has a number of sites that are well-suited to their functions. The dense cluster of manufacturing sites in northern Illinois and Iowa, including those in Moline and East Moline, Illinois; Dubuque, Iowa; and Waterloo, Iowa, coupled with JD's headquarters and R&D facilities, are very competitive, not only because of their locations, but, according to Fox and Murray (2000), also because of the clustering of multiple functions for a single firm[39]. Although not immediately located in the cluster, the manufacturing plant in Coon Rapids, Minnesota is also competitively located, according to the analyses. The facility in Des Moines, Iowa, which manufactures cotton harvesters and self-propelled sprayers, is also favorably located.

Another location that is well-suited for JD's operations is Fargo, North Dakota. While this was a less than optimum location for CNH, because JD is manufacturing high-end electronics at this site, whereas, CNH is building heavy four-wheel drive articulated tractors, the necessary factor conditions are different enough to make Fargo competitive for JD, but not CNH. The type of manufacturing also makes JD's site in Torrance, California competitive. Because this is the home of Greenstar, JD's precision agriculture division, this is an ideal location that can tap into human capital resources and knowledge spillovers from Aerospace Alley and Silicon Valley.

All of JD's North Carolina locations also have competitive advantage, according to the analyses. These facilities are well-connected for higher order functions like R&D and administration. They can tap into the deep pool of high-skilled human capital in the Research

[39] Technically, this should also make New Holland, Pennsylvania competitive for CNH, but JD has the advantage of not only having multiple functions in this cluster, but the locations are suitable for these multiple functions, which New Holland is not.

Triangle Park region. Locating near a second-tier city, like Charlotte, also can provide competitive advantage by eliminating the negative externalities of a large city (congestion, high land rents) while preserving positive externalities such as a deep labor pool and specialized services (Gong and Wheeler 2007).

Deere's Grovetown, Georgia assembly plant also appears to be favorably positioned according to the analyses. Given that the facility performs similar operations to that of CNH's Dublin, Georgia plant, however, one might be suspicious of these findings. Deere recently issued warnings about flat revenues in the landscaping and turf grass division (Deere and Company 2011), making this a plant to watch and may be one that JD considers closing in the near future. Similar to CNH's Dublin plant, competitive advantage may be best analyzed for this site using a double diamond model, as proposed by Moon et al. (1995), examining both local and global conditions.

Two of JD's manufacturing sites appear marginally uncompetitive from these analyses, but have other advantages, not considered within Porter's framework. Springfield, Missouri is home to JD's remanufacturing operation, where used engine blocks and transmissions are repaired and retooled for resale and reuse. Given the specialized nature of this operation, its competitive needs are not the same as other manufacturing facilities. The lack of related and rival companies may not be as important as at other JD facilities. Similarly, the sugarcane harvester plant in Thibodaux, Louisiana appears to be unfavorable, but is located in the heart of its US demand market with easy access to shipping facilities to move the rest of the new equipment to Brazil and other parts of South America, where the specialty machines are in high demand.

Among the sites that appear uncompetitive, according to the analyses, many are also the oldest in the JD organization. The Coffeyville, Kansas manufacturing plant was built in the 1930s, with limited resources to conduct an exhaustive site search (Gibbard 1998). Holl (2004) has suggested that when companies have limited resources, they may select a site that is familiar. Coffeyville, Kansas was the home to the Coffeyville Plow and Implement Manufacturing Company, whose owner was also a member of the Board of Directors of JD in the early 1900s and contributed to the decision to locate there (Gibbard 1998). Another uncompetitive site, in Ottumwa, Iowa, was acquired as part of a merger with Dain Manufacturing in 1911, which transformed John Deere Plow Works in Deere and Company (Mills 1986).

The two sites that JD should be most concerned about, in the analyses of competitive advantage, are those in Urbandale, Iowa and Valley City, North Dakota. Given that the Urbandale plant is manufacturing advanced electronics for Greenstar, the lack of highly skilled labor and nearby rivals or related industries is most disconcerting. Whereas the Torrance, California and Fargo, North Dakota plants that also manufacture advanced electronics, are well-situated for resource sharing and knowledge spillovers, the Urbandale location appears isolated and uncompetitive. JD may consider moving this operation to one of its other electronics facilities to improve competitive advantage.

Valley City, North Dakota was once a mini-cluster of farm machinery manufacturing, with not only the JD plant, but also a CNH component manufacturing site. After Fiat began to streamline CNH, however, its Valley City plant was closed (*Implement & Tractor* 2000). Deere continues to manufacture air seeders in this town, however, despite the poor indicators for competitive advantage. Air seeders (Figure 6.2) are being used more in traditional US agriculture as the incidence of strip tillage and no-till systems increase, but the main market continues to be the Canadian Prairie Provinces (R. Kleinsasser, pers. comm.). The technology was also developed and perfected in the region around Saskatoon, Saskatchewan, which is where the majority of short-line manufacturers, producing air seeders, are located today (R. Kleinsassser, pers. comm.). While North Dakota has similar farming conditions to the Canadian Prairie Provinces, if JD has to export the majority into Canada, it might be easier to seek a more competitive location in a higher demand area.

Figure 6.2: Case IH air seeders awaiting delivery at the plant in Saskatoon, Saskatchewan (picture taken by author).

6.1.4 A Note About Inertia

The preceding synthesis looked at individual locations as if they all function as discrete units when they are, in fact, part of a larger network for each of the manufacturers. Many of these facilities were built 50 to 100 years ago when factor conditions were very different. Transportation systems have changed greatly in the last century. These changes can make facilities that once were favorable appear unfavorable today. Also, older facilities face costs of inertia. While more competitive locations might exist for the Big Three, the costs and the organizational will to move to new locations and build new infrastructure outweigh the competitive disadvantage the firm experiences by staying in the current location.

6.1.5 Revisiting Porter

An empirical test of Porter, using the Big Three as case studies, indicates some problems and incidences where location decisions and the model do not agree. The findings are consistent with the current picture in the industry, but do little to explain the seeming future trajectory of US manufacturers. Based on the analyses, since approximately half of AGCO's facilities are uncompetitive, while less than one-third of JD and CNH's are, it is not surprising that AGCO is number three in domestic and international market share. Momentum seems to be on AGCO's side, however, as the leader in green technology and a consistent award winner for innovations[40]. This may be a reflection of the benefits of locating in the new farm machinery cluster in the Atlanta MSA or the complacency that JD appears to be displaying about advertising innovations that it continues to make and developing solutions to meet Tier IV final emissions regulations. It also points to the need to consider Moon et al.'s (1995) double diamond model for certain parts of the US farm machinery industry, despite previous applications of the double diamond only in developing economies with high levels of FDI.

Therefore, in the case of the farm machinery industry, competitive advantage can be partially explained by Porter (1990), or Moon et al. (1995), but geography alone is not enough.

[40] In 2010, AGCO won eight AE50 Awards (most of which were for tractors and combines), given by the American Society of Agricultural and Biological Engineers for the best 50 new products in agricultural, biological, and food science in a given year. In that same year, CNH won nine (most of which were for implements) and JD won nine (most of which were for turf grass systems) (ASABE 2011). Also in 2010, AGCO won three FinOvation Awards from *Farm Industry News*, while JD won two, and CNH won one (McMahon and Wehrspann 2011). In 2011, the Fendt 828 Vario was named Tractor of the Year by journalists at Europe's EIMA farm show (*Farm Industry News* 2011b)

Much of the future of the US farm machinery industry is going to be predicated not only on geographic decisions (especially in terms global markets), but also non-geographic strategic decisions based on innovations and marketing. The inclusion of other models in the organizational studies literature, such as headquarters and R&D siting, creative class talent, product life cycle theory, and green technologies are critical to understanding the competitive position and geography of the US farm machinery industry now and in the future.

6.2 Product Life Cycle Theory and the US Farm Machinery Industry

If place-based product life cycle theory (Vernon 1979) holds for the US farm machinery industry then only the most advanced and newest technology should be produced by the Big Three in the US and other advanced market economies. Yet, in looking at the types of manufacturing occurring in the US (Appendix E), this is not the case. The most advanced manufacturing for the Big Three, representing the best opportunity for gaining competitive advantage in the global marketplace, is green technologies. Yet, only JD manufactures its Tier IV-compliant engines in the US (at plants in Coffeyville, Kansas and Waterloo, Iowa). Case New Holland's SCR engines are built by a sister company, FPT, at factories in Bulgaria and Romania (E. Guzman, pers. comm.). E_3 Sisu SCR engines were developed in Nokia, Finland and are built by AGCO in plants in Finland, Russia, and Brazil (J. Rogers, pers. comm.). This embodies findings by Hirsch (1967) that certain countries can capitalize on high educational attainment and low labor costs to specialize in high-end manufacturing. If Friedman (2008) is correct and US manufacturing is to regain competitive advantage through the development and manufacturing of green technologies, one would expect AGCO and CNH to manufacture their SCR engines in the US. Instead, much of the farm machinery produced in the US is standardized and not particularly innovative. With the exception of precision guidance systems and engine technology, most patents issued to the farm machinery industry today are incremental changes to standard equipment (United States Patent and Trademark Office 2009; United States Patent and Trademark Office 2010a, b). Manufacturing of this type does not fit the pattern anticipated by Vernon (1979). Given the importance of mechanized farm machinery to the pervasive vision of the US as a region comprised of amber waves of grain (Lopez 1989), product life cycle theory may be overridden by simple nationalistic pride where the Big Three believe that American farmers will only farm with American-made machines.

While product life cycle theory is important to understanding competitive advantage in the US farm machinery industry, the increasing impacts of globalization on labor and transportation costs require some modifications to the model. Just as second-tier cities are important for headquarters and R&D functions, second-tier countries, that can provide high-skilled labor at low wage rates, will increase in importance for advanced manufacturing. Also there needs to be some accommodation for industries that are integral to a country's image and therefore less likely to relocate to lower cost areas despite opportunities to gain competitive advantage. Modifications of these types can improve existing theory and help explain the situation in the US farm machinery industry.

CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

This empirical analysis of Porter's Theory of Competitive Advantage (1990), using case studies from the US farm machinery industry, has resulted in some new and interesting findings. A theory-elaborating case study methodology informed by Eisenhardt (1989) that employed archival data, publically available documents, trade show reconnaissance, and plant tours, coupled with map and content analysis, has highlighted how geography matters to competitive advantage in general and the US farm machinery industry in specific. The research questions posed by this dissertation can largely be answered as a result of the findings.

1). Does location play a role in the operations, competitive issues, performance, and competitive advantage of US farm machinery firms?

Location clearly plays a role in the operations, competitive issues, performance, and competitive advantage of US farm machinery firms, although not always in ways that can be explained by Porter's model alone. The inclusion of literature on headquarters and R&D siting, creative class issues for labor, and product and industry life cycle theories also contribute to an understanding of the sector. Additionally, despite prior findings that the single diamond model proposed by Porter (1990) was suitable for analysis of mature manufacturing industries in advanced economies (Yetton et al. 1992), the double diamond model proposed by Moon et al. (1995), appears to better explain the continued growth of AGCO and the struggles of CNH and JD's Georgia assembly facilities.

One of the clearest examples of how geography matters to competitive advantage in the US farm machinery industry is the establishment of a new industry cluster in the Atlanta MSA. The opportunities for resource sharing and knowledge spillovers between AGCO and many of its international competitors could signal a shift in power in the sector. Many empirical tests of Porter have found interfirm rivalry to be one of the most important drivers of innovation and competitive advantage (e.g. Porter and Takeuchi 1999; MacPherson and Boasson 2004). In the long run, locating AGCO's headquarters in Duluth, Georgia may be the most important decision AGCO ever makes to benefit its own competitive advantage.

The research also found, on the other hand, that geography alone could not explain the operations, competitive issues, performance, and competitive advantage of the US farm machinery industry. The immediate future of the industry is going to be driven by the ability of firms to innovate and market that innovation to farmers around the world. Green technologies are the future of competitive advantage for the farm machinery industry. Given AGCO's advantage in being the first to adopt new technology to meet EPA emissions regulations, it could see its competitive advantage and market share in the sector grow in coming years. Conversely, JD's seeming inability to market its own technological advances could cause the market leader to lose position to not only CNH and AGCO, but also to international firms like Mahindra and Mahindra.

2). Do the performance and competitive issues of the US farm machinery industry conform or contradict the assumptions of Porter's Theory of Competitive Advantage (1990)? What potential modifications could be made to Porter's Theory of Competitive Advantage based on the findings of the case studies in this research?

The performance and competitive issues of the US farm machinery industry do conform to many of the tenets of Porter's Theory of Competitive Advantage (1990). Case New Holland, that has the most locations with negative conditions, is also the one that has struggled the most in recent years (Tita 2011). Positive conditions have benefited the US farm machinery industry as well. All three firms utilize close connections with institutions of higher learning to train workforces and develop new technology (see section 5.2.3). This is going to be an increasing source of competitive advantage for both farm machinery manufacturers and US agriculture in general as shrinking state budgets in agricultural states often make cuts to institutions of higher education, including land grant schools[41] (Shupp Espenshade 2011). The importance of rivals in the Atlanta MSA has positively impacted competitive advantage for AGCO (see section 5.4.2). Close relationships with related industries such as construction equipment and heavy-duty truck manufacturers have helped the Big Three develop new traction technology and meet EPA emissions standards (see section 5.5.1).

That being said, Porter's model alone cannot account for the continued growth and success of AGCO. Despite the findings of other empirical tests of Porter's model for mature manufacturing in advanced economies (e.g. Yetton et al. 1992), AGCO is more easily explained using the double diamond model proposed by Moon et al. (1995). In prior studies, the double

[41] The Commonwealth of Pennsylvania is facing a 52.4 percent cut in the budget of the Pennsylvania State University, which would profoundly impact the School of Agriculture and encourage more partnerships between the University and private companies (Shupp Espenshade 2011).

diamond has been used to explain competitive advantage in developing economies with high levels of FDI and global connections (e.g. Bowen and Leinback 2006). Given the fact that AGCO has the most global connections of the Big Three, exporting more than 60 percent of its US production and manufacturing the majority of its equipment in Brazil and Europe, this makes sense when compared to the global strategies of CNH or JD. As industries in the developed world continue to globalize and attract FDI, it may be necessary to modify Porter's theory (which accounts for local conditions) to include the second diamond, proposed by Moon et al. (1995), to account for global conditions contributing to competitive advantage.

3). Are there under-researched or undiscovered geographical characteristics of the organizational studies literature that pertain to the US farm machinery industry?

Eisenhardt's (1989) theory-elaborating case study methodology is designed to illuminate gaps in the theory related to the analysis of a firm or industry. In the course of this research, it became apparent that product life cycle theory, as it exists today, needs further research and modification to accommodate the impacts of globalization and high-speed transportation and communication networks. Vernon (1979) would not have predicted that AGCO could competitively price tractors that are imported from Brazil and Europe to compete against JD and CNH's domestic production. He also would not have predicted that the most advanced technology on those tractors – namely low emissions engines – is produced outside of the US. To properly account for this geography, research needs to return to the findings of Hirsch (1967) and focus on second-tier countries that provide high-skilled labor at relatively low prices. These locations are going to continue to be attractive for manufacturing operations, much in the same way that second-tier US cities continue to attract administrative and R&D functions for manufacturing as suggested by Gong and Wheeler (2007).

Another geographical anomaly that this research has revealed is the perseverance of relatively lower-order manufacturing operations locating domestically for the US farm machinery industry, despite the high price of labor in the Upper Midwest. I believe that this trend continues, despite the findings of place-based product life cycle theory (Vernon 1979), partially because of inertia, but also because of the pervasiveness of farming as a part of the American imaginary (Lopez 1989). Food security and the ability to feed oneself are important issues for many countries around the world. There is a reason that amber waves of grain and fruited plains appear in the lyrics of patriotic songs in the US. American farmers feel the pride of feeding the country and the Big Three tap into that with their marketing (Figure 7.1), knowing that US farmers are more likely to buy a tractor from them than an international competitor. This does not fully explain, however, why the Big Three continue to manufacture standardized equipment, like hay tools and tillage equipment, in high costs areas of the US. It is likely related to some sort of nationalistic fervor, however. Research into the importance of nationalistic feelings as they relate to manufacturing can help to modify product life cycle theory to better account for not only the US farm machinery industry, but also the experiences of the Detroit automakers. If we can better understand the impacts that these nationalistic feelings of manufacturing pride have on day-to-day business decisions for US firms, product life cycle theory may be amended to better explain the US farm machinery industry.

Figure 7.1: Signage in Case IH's display area at 2010 Farm Progress in Boone, IA pointing to the need for high-horsepower machinery to feed the growing world population (pictures taken by author).

This empirical analysis of Porter's Theory of Competitive Advantage (1990), using case studies of the US farm machinery industry has highlighted the importance of place in organizational studies models to evaluate operations, competitive issues, performance, and competitive advantage for mature manufacturing in advanced economies. It has demonstrated the need to employ Moon et al.'s (1995) double diamond model to understand firms that are increasingly globalized, despite producing mature products in advanced economies. It also confirmed many of prior findings of Porter (1990). Additionally, it discovered new areas of geographic research related to product life cycle theory.

7.2 Limitations of Findings

There are a few limitations to the findings of this research. The findings would be strengthened by data from archives and plant tours of JD. Additionally, without direct input from the Big Three, there remains some uncertainty about the synthesis of the individual analyses. By speaking directly to the companies, I can uncover how different segments of Porter's model (1990) are weighted by the firms. This research assumed that each segment of model receives equal weight in site location decisions for the Big Three. This may not be the case. The firms could, in fact, give so much weight to one aspect of the model that other areas do not matter. Future research will need to address this issue to truly evaluate competitive advantage for the US farm machinery industry.

7.3 Future Research

There remains much research to be completed on competitive advantage in the US farm machinery industry. Interviews with industry analysts, dealers, end users, and executives from the Big Three can further shed light on the industry and advance this analysis, providing the necessary weighting of the elements of Porter's model. Longitudinal content analysis of more SEC filings, annual reports, and letters to shareholders, issued by the Big Three, can establish whether there have been long term shifts in strategy by AGCO, CNH, or JD. Further analysis of the impacts of technology, especially green technology and precision agriculture, may uncover the future of competitive advantage for the sector.

Perhaps the most promising area of future geographic research regarding the US farm machinery industry is further examinations of the new cluster in the Atlanta MSA. Is AGCO the driver of this cluster? Why did AGCO decide to locate in this region when JD and CNH have stayed in the center of the older Midwest cluster? Has JD and CNH stayed in the Midwest due to the costs of inertia? Was the development of this cluster an accident, or did local economic development planners in the region actively pursue this sector? All of these questions deserve answers, not only to better understand competitive advantage for the farm machinery industry, but also to seek information that could be relevant to other industries. Sectors in the waning days of their life cycles may be able to reinvent themselves based on the findings related to the new farm machinery cluster. Also this research of the Atlanta cluster should include case studies of foreign farm machinery firms as additional empirical tests of competitive advantage.

The methodology utilized in this research is generalizable to other industries to evaluate competitive advantage and geographic applications of organizational studies models. Future research might further examine the ability of a double diamond model to explain competitive advantage in other mature sectors of the economy in the US. Following the example of AGCO may provide certain waning firms new life and ability to compete against entrenched rivals.

Continued research into product life cycle theory is also necessary. The impacts of second-tier countries, returning to the work of Hirsch (1967) and the importance of nationalism in manufacturing decisions present future avenues of research for understanding mature manufacturing and competitive advantage.

Finally, trade show reconnaissance and photo content analysis are fairly new techniques in economic geography research. Future work employing these methodologies and data sources can demonstrate its effectiveness to the discipline.

7.4 The Future of the US Farm Machinery Industry

Will JD remain the top firm in the farm machinery industry or can another company steal its market share and loyal following? Given the long and comparable history of the US farm machinery industry and the automobile industry, it is appropriate to draw parallels between the two. When this research began, JD appeared to be most like Toyota, with a history of organic growth and leading innovation. By the end of the study, however, JD appears more and more like the old General Motors – content to rest on its laurels and profits, innovating only as necessary and assuming reputation and historic inertia will allow the company to persevere. Given its lack of innovation in green technologies and the lack of advertising of other innovations, it is the firm most at risk for future declines and lost market share to CNH and AGCO, as well as foreign competitors. That is not to say JD is disappearing any time soon. It still has historical momentum, due to its persistent location in Moline, Illinois over the last 200 years. This inertia will propel JD into the future, but it will remain vulnerable if existing patterns do not change.

Ironically, at the beginning of this research CNH looked a lot like Chrysler[42], lacking innovation and advanced thinking and languishing under duplicated efforts of multiple product lines and total lack of understanding of the demands of the market. With the introduction of SCR engines by FPT and the development of new technologies to keep pace with AGCO, CNH now looks more like an industry stalwart, comparable to Ford. Case New Holland still faces challenges, however. Duplicated efforts of managing two separate brands, as if they were separate companies, are going to continue to have an impact on competitiveness for CNH. The number of R&D facilities that the company maintains is also a concern. What CNH needs to be most aware of, however, are the actions of parent company, Fiat. Twice since Fiat acquired Chrysler, it has used CNH to try to bolster the fortunes of the languishing automaker. First, Fiat considered selling CNH to generate revenues to invest in Chrysler (Bertacche and Cinelli 2009). More recently, Fiat has been actively tying the fortunes of Chrysler to Case IH by offering incentives to farmers who buy Dodge trucks and Magnum tractors or Axial Flow combines

[42] This is ironic because at the time, Fiat did not own Chrysler and much of what has revitalized Chrysler are management changes made by Fiat since the purchase in 2009.

(Figure 7.2) and forcing Case IH dealers to convert fleets of service trucks to Dodge. Case New Holland needs to ensure that Fiat does not make Chrysler into an albatross that negatively impacts its competitive advantage in the future.

Figure 7.2: Displays at the 2011 Ag Connect Expo in Atlanta, GA promoting the connections between Dodge and Case IH, including a Ram truck in Case IH's display area (pictures taken by author).

The future of AGCO is bright, largely due to its geographic advantages. As the only firm that mentions competitive advantage on its website[43], AGCO has the clearest focus for growth. From its history as the Allis-Chalmers Corporation, this company has always been an also-ran in the farm machinery industry, but now it is gaining. At the beginning of this research, the company looked like General Motors – a multi-headed hydra of brands that were difficult to manage and lacked innovation. In the last three years, however, the firm has transitioned to look more like the Asian automakers by leading the way in fuel efficiency and emissions compliance.

[43] Among the human dimensions of AGCO's business values, the firm states that, "Using speed, quality, and innovative behavior we expect to achieve competitive advantage" (AGCO 2011f).

Growth in emerging markets like South America and Asia will continue to propel AGCO ahead and may allow them to take market share from JD and CNH. Its position in the new farm machinery cluster also will have continued positive impacts on its competitive advantage.

In the near future, the Big Three are going to have something larger than each other and EPA regulations to worry about. Mahindra and Mahindra is continuing to grow and expand. While it may be a long time before it makes significant inroads into the US market for high-horsepower tractors and combines, its ability to manufacture low technology, cheap tractors that better fit the needs of farmers in the developing world is going to continue to give it a competitive advantage and allow it to grow its market share internationally. Mahindra and Mahindra represents the single largest threat to the US farm machinery industry's continued domination of the global marketplace and will be the firm to watch in the future. If Mahindra and Mahindra continues to grow, the geography of the US farm machinery industry could greatly shift, leaving JD and CNH in a inferior position relative to players (including AGCO) in the new cluster, centered on the Atlanta MSA.

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APPENDIX

APPENDIX A

Table A.1: Data used to reach conclusions for each company in each analysis in Chapter V

Analysis	**Data Used For Each Firm**			
	AGCO	**CNH**	**JD**	**Other**
FACTOR CONDITIONS				
Raw Materials and Manufacturing Inputs	A,G, N,W	A,G, N, T, W	G, N,W	NA
Educational Attainment of Labor Force	M	A, M, T	M	NA
Research Connections	A, M, P	M, N	M, P, W	NA
Transportation Connectivity	M	M, T	M, W	NA
DEMAND CONDITIONS				
Sophisticated Consumers	N	P	N	NA
Market Distance	M, N	A, M, P	M	NA
Customer Support	N, P, W	N, P, T, W	N, P, W	NA
FIRM STRUCTURE, STRATEGY, & RIVALRY				
Agglomerations	M	M	M	NA
Global Strategies	P, I, R, W	P, R, T, W	P, R, W	NA
Headquarters	A, M, P	M, T	M	NA
R&D	A, M	M	M	NA
Manufacturing Locations	A, M, N, W	M, N, P, W	M, N, W	NA
Precision Farming Technology	N, P, R, W	P, R, W	N, P, W	NA
Green Technology	C, G, I, N, P, R, W	C, I, N, P, R, W	C, N, P, R, W	NA
Innovation Marketing	P, W	P, W	N, P, W	NA
Manufacturing Technology	N, W	N, T	N	NA
Rivals	M, N	A, M, N	M, N	M
RELATED & SUPPORTING INDUSTRIES				
Construction Machinery	M, N	M, N	M, N	NA
Heavy-Duty Trucks	M, P	I, M, R	M	NA
Suppliers	A, I, M	A, I, M, T	M	NA
GOVERNMENT				
Safety Laws	N	N, T	N	NA
Environmental Laws	I, N	I, N	I, N	NA
Economic Policies	A, N	A, N	A, N	NA
Labor Laws	A, G, M, N, W	A, G, M, N, W	G, M, N, W	NA
CHANCE				
Pneumatic Tires	A, N	A	NA	NA
Mahindra	NA	NA	NA	N, W

A = archives
C = company literature
G = annual reports
I = informal interviews at trade shows
M = map analysis
N = newspapers and trade publications
P = trade show pictures
R = trade show reconnaissance observations
T = plant tours
W = websites
NA = not analyzed

APPENDIX B

Table B.1: Identified archives of the Big Three

Facility	Location	Archives Available (Company that firm belongs to today)
Benson Ford Research Center	Dearborn, MI	Ford Motor Company – Tractor and Implement Division (CNH); New Holland Farm Machinery (CNH)
Wisconsin Historical Society	Madison, WI	Allis-Chalmers Corporation (AGCO); J.I. Case Farm Machinery (CNH); International Harvester (CNH); McCormick-Deering (CNH)
Minnesota Historical Society	St. Paul, MN	Minneapolis-Moline Company (AGCO)
Floyd County Historical Society	Charles City, IA	Oliver Farm Equipment (AGCO)
Racine Heritage Museum	Racine, WI	J.I. Case Company (CNH)
Milwaukee County Historical Society	Milwaukee, WI	Allis-Chalmers Corporation (AGCO)
Rock Island County Historical Society	Moline, IL	Deere & Company
Deere & Company Library	Moline, IL	Deere & Company
University of Guelph Library	Guelph, Ontario	Massey-Harris (AGCO); Massey-Ferguson (AGCO)

APPENDIX C

Table C.1: Selected farm machinery trade shows

Show Name	Location	Geographic Focus	Relative Size
Agritechnica	Hanover, Germany	International	Extra Large
World Ag Expo	Tulare, California	International	Large
SIMA	Paris, France	International	Large
Ag Connect Expo	Orlando, FL & Atlanta, GA	International	Medium
National Farm Machinery Show	Louisville, KY	National	Extra Large
Farm Progress	Boone, IA & Decatur, IL	National	Extra Large
Western Canada Farm Progress	Regina, Saskatchewan	National	Medium
Canadian International Farm Show	Mississauga, Ontario	National	Medium
Husker Harvest Days	Grand Island, NE	Regional	Medium
Sunbelt Ag Expo	Moultrie, GA	Regional	Medium
Mid South Farm & Gin Show	Memphis, TN	Regional	Small
Keystone Farm Show	York, PA	Regional	Small

APPENDIX D

Table D.1: Publically offered plant tours for the Big Three

Manufacturer	Name	Location	Function
AGCO	Hesston Facility	Hesston, KS	Hesston, Challenger, and Massey Ferguson Hay and Forage, Gleaner, Massey Ferguson, and Challenger Rotary Combine, and White Planter Manufacturing
CNH	Belleville Plant	Belleville, PA	Hay and Forage Manufacturing
CNH	Benson Works	Benson, MN	Sprayer, Floater, Cotton Picker Manufacturing/ Self-Propelled Sprayer and Floater R&D
CNH	Dublin Works	Dublin, GA	Compact Tractor Manufacturing
CNH	Fargo Plant	Fargo, ND	Tractor Manufacturing/ Tractor R&D
CNH	Goodfield Plant	Goodfield, IL	Tillage Manufacturing/ Tillage R&D
CNH	Grand Island Works	Grand Island, NE	Combine Manufacturing
CNH	New Holland Operations	New Holland, PA	Hay and Forage Manufacturing/ Hay and Forage, Combine, Cotton Picker R&D
CNH	Racine Works	Racine, WI	Tractor and Component Manufacturing
JD	Harvester Works	East Moline, IL	Combine and Front-End Equipment Manufacturing
JD	Waterloo Works	Waterloo, IA	7000, 8000, and 9000 Series Tractor Manufacturing

APPENDIX E

Table E.1: US Locations of the Big Three (CNH 2007; Deere and Company 2007; United States Securities and Exchange Commission 2007; AGCO Corporate 2009)

Corporation	Name	Location	Function
AGCO	Corporate Headquarters	Duluth, GA	Administration
AGCO	Beloit Facility	Beloit, KS	Sunflower Tillage and Seeding Manufacturing
AGCO	Hesston Facility	Hesston, KS	Hesston, Challenger, and Massey Ferguson Hay and Forage, Gleaner, Massey Ferguson, and Challenger Rotary Combine, and White Planter Manufacturing
AGCO	Jackson Facility	Jackson, MN	Challenger Tractor (270 to 570 horsepower), RoGator, Terra-Gator, and Spra-Coupe Self-Propelled Sprayer Manufacturing
AGCO	Baltimore Assembly Plant	Edgewood, MD	Tractor Assembly
AGCO	Houston Assembly Plant	LaPorte, TX	Tractor Assembly
AGCO	Tacoma Assembly Plant	DuPont, WA	Tractor Assembly
CNH	North American Headquarters – Case Agriculture	Racine, WI	Administration
CNH	North American Headquarters – New Holland Agriculture	New Holland, PA	Administration
CNH	Case Agricultural Equipment Engineering	Burr Ridge, IL	Tractor, Compact Tractor, Ag Loader, Planter, and Engine R&D
CNH	Belleville Plant	Belleville, PA	Hay and Forage Manufacturing
CNH	Benson Works	Benson, MN	Sprayer, Floater, Cotton Picker Manufacturing/ Self-Propelled Sprayer and Floater R&D
CNH	Dublin Works	Dublin, GA	Compact Tractor Manufacturing
CNH	Fargo Plant	Fargo, ND	Tractor Manufacturing/ Tractor R&D
CNH	Goodfield Plant	Goodfield, IL	Tillage Manufacturing/ Tillage R&D
CNH	Grand Island Works	Grand Island, NE	Combine Manufacturing
CNH	New Holland Operations	New Holland, PA	Hay and Forage Manufacturing/ Hay and Forage, Combine, Cotton Picker R&D
CNH	Racine Works	Racine, WI	Tractor and Component Manufacturing
CNH	Consolidated Diesel Company	Whitakers, NC	Joint Operation with Cummins Diesel to Manufacture Off-Road Diesel Engines
CNH	Mount Joy Facility	Davenport, IA	Combine R&D
CNH	Sacaton Testing Center	Stotonic, AZ	Tractor Testing
JD	John Deere Worldwide Headquarters	Moline, IL	Administration
JD	John Deere Worldwide Commercial and Consumer Equipment Division	Cary, NC	Administration
JD	John Deere Coffeyville Works	Coffeyville, KS	Power Systems Manufacturing

Table E.1: Continued

Corporation	Name	Location	Function
JD	John Deere Cylinder Division – Minneapolis	Coon Rapids, MN	Hydraulic Cylinder Manufacturing
JD	John Deere Des Moines Works	Des Moines, IA	Cotton Harvesting, Sprayer, Tillage, and Planting Manufacturing
JD	John Deere Dubuque Works	Dubuque, IA	Harvester and Harvester Head Manufacturing
JD	John Deere Harvester Works	East Moline, IL	Combine and Front-End Equipment Manufacturing
JD	Phoenix International	Fargo, ND	Electronics Design and Manufacturing
JD	John Deere Commercial Products	Grovetown, GA	Compact Utility Tractor Manufacturing
JD	John Deere Cylinder Division	Moline, IL	Hydraulic Cylinder Manufacturing
JD	John Deere Seeding Group	Moline, IL	Planter and Seeder Manufacturing
JD	John Deere Ottumwa Works	Ottumwa, IA	Baler, Mower Conditioner, Windrower, Mowing, and Raking Manufacturing
JD	ReGen Technologies L.L.C.	Springfield, MO	Engine Remanufacturing
JD	John Deere Thibodaux, Inc.	Thibodaux, LA	Sugarcane Harvester Manufacturing
JD	NavCom Technology, Inc.	Torrance, CA	GPS and Wireless Communications Manufacturing
JD	John Deere Ag Management Solutions	Urbandale, IA	Production Ag Equipment Technology Manufacturing
JD	John Deere Seeding Group	Valley City, ND	Air-Seeding Equipment Manufacturing
JD	John Deere Power Systems & John Deere Engine Works	Waterloo, IA	Power Systems Manufacturing
JD	John Deere Waterloo Foundry	Waterloo, IA	Gray and Ductile Iron Casting Manufacturing
JD	John Deere Waterloo Works	Waterloo, IA	7000, 8000, and 9000 Series Tractor Manufacturing
JD	John Deere SouthEast Engineering Center	Charlotte, NC	R&D
JD	Moline Technology Innovation Center	Moline, IL	R&D
JD	John Deere Training Center	Morrisville, NC	R&D

APPENDIX F

Emissions Regulations and Technology in the Farm Machinery Industry

EPA emissions regulations to reduce the release of nitrogen oxides (NOx) and particulate matter (PM) by both on-road and off-road engines have been becoming increasingly stringent over the last 20 years (Wehrspann 2010c). This gradual step down process began for off-road applications in 1996, impacting tractors from 50 to 750 horsepower (37 to 560 kilowatts). Tier II of the process began in 2001 and mandated a 50 percent reduction in PM and 20 percent decrease in NOx. Tier III, which lasted from 2006 through 2008 mandated a further 40 percent reduction of NOx outputs over Tier II. On January 1, 2011, the farm machinery industry entered interim Tier IV, which mandated a reduction in PM by 90 percent and NOx by 50 percent for all engines, except those under 75 horsepower (55 kilowatts) (Deere and Company 2010a). With these new sweeping reductions, the EPA estimates that, since 1996, the regulations have made emissions reductions equivalent to taking 35 million cars off the road (Mowitz 2010a).

Tier IV interim standards represent the largest shift in technology for the industry since the 1800s (Mowitz 2010a). A recent statement by the CEO of Caterpillar said that R&D expenditures by the construction firm to meet Tier IV standards were greater than any other R&D expenditures ever made by Caterpillar – a firm that developed the first tractors that operated on a track system, and perfected diesel engines for agricultural and industrial applications (Mowitz 2010a). Estimates by JD place the cost of innovation at the firm at 2.5 million dollars a day, much of which, in recent years, has been dedicated to meeting Tier IV interim standards (Mowitz 2010a).

Tier IV interim is also the first tier where changes by the farm machinery manufacturers have become readily apparent to the farmers themselves (Mowitz 2010b). Depending on the method that is employed to meet Tier IV standards, farmers now face issues of greater engine heat deflection or the addition of a fuel treatment additive. Also, this is the first tier that has caused widespread increases to the cost of the machinery, with estimates for price increases ranging from three to seven percent among the Big Three (Mowitz 2010a). Tier IV interim is not the end of EPA emissions regulations either. On January 1, 2014, the industry will enter the final stage of emissions regulations, Tier IVB, which requires another 80 percent reduction in NOx over interim Tier IV regulations, as well an appreciable decrease in PM for tractors under 75 horsepower (55 kilowatts) (Deere and Company 2010a). There are provisions in EPA laws for an additional three tiers of emissions regulations in the future, which will likely focus on the reduction of carbon dioxide and other greenhouse gases (Mowitz 2010a).

Under Tier IV interim regulations, there are two methods for achieving the mandated emissions standards for off-road diesel engines. These are cooled exhaust gas recirculation (cEGR), which is a thermal treatment process, and selective catalytic reduction (SCR), which is a chemical treatment solution (Wehrspann 2009b). Each of these processes has its benefits and drawbacks and one or both have been adopted by each of the Big Three to achieve Tier IV standards. Most industry analysts believe that to achieve Tier IV final standards, manufacturers will have to use a combination of the two technologies (Xinqun et al. 2010). This is because NOx and PM are opposing emissions created in a tractor. If an engine reduces NOx production, then PM production will increase and vice-versa (CNH America 2010b). This is known as the NOx-PM trade-off (Xinqun et al. 2010). The cEGR system is efficient at reducing NOx, but must employ an external system to meet PM standards (Mowitz 2010a). On the other hand, SCR very efficiently reduces PM through maximum fuel burn, but must use additional systems to reduce NOx (Mowitz 2010a). Combining the two systems will be the only way to fully achieve the near zero emissions tractors that will be required in 2014.

The premise behind cEGR is that by passing a certain percentage of cooled, re-circulated exhaust gas through the engine, it will reduce the combustion temperatures and the natural oxygen content of the air passing into the cylinders (Mowitz 2010a). The exhaust gas is cooled in most cEGR engines by passing it through a heat exchanger that uses coolant from the engine (Xinqun et al. 2010). Reducing engine combustion temperatures and the natural oxygen content of engines helps to reduce NOx production, but also leads to a poorer level of fuel burn-off (Deere and Company 2010a). Fuel that is not burnt completely forms soot particles, increasing the level of PM sent to the exhaust system (Mowitz 2010a). Therefore, cEGR engines must also have an extensive exhaust system to remove PM. Particulates are removed from cEGR engines by replacing the traditional muffler with two additional systems – a diesel oxidation catalyst (DOC), which functions much like a catalytic converter in an automobile, and a diesel particulate filter (DPF), which is a porous substrate designed to catch any remaining PM (Mowitz 2010a). This is the most visible change to a tractor equipped with a cEGR engine. The muffler unit is now three times the size it was in past generations of equipment (Wehrspann 2010b) (Figure F.1). Companies utilizing cEGR believe that the DOC and DPF will last the useful lifetime of the tractor without needing to be changed (Mowitz 2010a). On the whole, cEGR is the less popular of the two methods for managing emissions and only JD and SAME Deutz-Fahr are currently using it in agricultural applications (Mowitz 2010a).

Figure F.1: The cEGR exhaust system on several JD tractors on display at the 2011 National Farm Machinery Show in Louisville, KY. On the left, exhaust, laden with PM is funneled from the engine into a DOC. On the right, the much larger exhaust system needed for Tier IV engines to accommodate the DOC and DPF (pictures taken by author).

The science behind SCR is largely a balancing act where engines burn hotter to achieve maximum fuel usage and reduction in PM (Mowitz 2010a). Hot engine temperatures, however, lead to increased levels of NOx production that must be neutralized as well. Exhaust from the engine is dosed with a fine spray of a fuel treatment know as diesel exhaust fluid (DEF) or AdBlue, as it is called in Europe, to begin a chemical reaction that turns NOx into harmless nitrogen and water vapor in a catalytic chamber (Mowitz 2010a) (Figure F.2). A tank adjacent to the fuel tank stores the DEF for use by the engine (Figure F.3). The amount of DEF necessary to neutralize the NOx varies depending on the load the tractor is under, and is automatically controlled by the tractor’s computer systems. The two main components of DEF are 32 percent urea and 68 percent de-ionized water. Once NOx has been neutralized in the catalytic chamber, the exhaust passes through a very small DOC to guarantee that all PM is removed as well.

Figure F.2: A cutaway view of the exhaust muffler for a Case IH SCR engine. At the top is the catalytic chamber where DEF is introduced and at the bottom is the DPF (picture taken by author).

Figure F.3: SCR fuel tanks (left to right) of a Massey-Ferguson and Case IH tractor. The blue cap is on the tank for DEF and has a smaller filling neck to prevent introduction of diesel fuel (pictures taken by author).

One major drawback of the SCR system is the additional costs of DEF (Mowitz 2010a). In general, however, given the fact that SCR maximizes fuel burn, leading to higher fuel efficiencies, the added cost of DEF is often negated[44]. Access to the fluid is also not an issue since SCR is the chosen technology of most heavy-duty trucks and many farm machinery manufacturers (Mowitz 2010a). General Motors' 2011 Duramax diesel-equipped pick-up trucks also have a DEF tank (Mowitz 2010b). For these reasons, the fluid can be obtained at most truck stops and fuel centers as well as directly from the dealer (AGCO 2011b).

Another drawback that is often pointed to with DEF is that it freezes at temperatures below 12 degrees Fahrenheit and has been known to degrade at temperatures above 90 degrees Fahrenheit. To manage freezing, SCR systems are designed to automatically heat DEF when temperatures are low and DEF does not ever freeze solid (L. Bose, pers. comm.). It simply turns to a slush that defrosts quickly. Given that temperatures above 90 degrees are often rare in a fuel storage area, most industry experts believe DEF is very stable and has long shelf-life compared to other fuel additives (L. Bose, pers. comm.).

Another drawback that is cited by AGCO, but not other companies using SCR, is that the engine cannot withstand prolonged use of biodiesel blends higher than B5 (five percent biodiesel and 95 percent traditional diesel fuel) given the current level of refining that occurs in the US biodiesel industry (J. Rogers, pers. comm.). The heavy metals and other contaminants present in higher biodiesel blends lead to damage of the catalytic chamber (J. Rogers, pers. comm.). Therefore, AGCO will not warranty a SCR engine that is run on more than B5 blends. While AGCO is the only firm that admits to this issue, "fueled by biodiesel" stickers, that were once

[44] AGCO estimates that for every 25 gallons of diesel fuel that a tractor burns, it burns one gallon of DEF, which costs approximately the same as diesel fuel in the US (Wehrspann 2010c).

very prevalent on machinery at trade shows (Figure F.4), have disappeared as more firms are using SCR engines. Case IH has recently also stated that it will only continue to warranty its machines for B100 if the owner follows all Case IH maintenance procedures (Wehrspann 2009a).

Figure F.4: Biodiesel stickers (clockwise from left) on a New Holland combine, Challenger tractor, and Case IH tractor on display at the 2010 National Farm Machinery Show in Louisville, KY (pictures taken by author).

One requirement for either SCR or cEGR systems is ultra-low sulfur diesel fuel. Sulfates in diesel fuel create a large proportion of the PM (Xinqun et al. 2010). By reducing the amount of sulfates in the diesel fuel, there are fewer particulates for the engine to handle. Additionally, sulfur in diesel fuel has corrosive effects on the catalytic chamber of SCR engines and the DOC in cEGR engines (Xinqun et al. 2010). Much like the process that removed lead from gasoline to allow for the effective use of catalytic converters on automobiles in the 1970s, the proportion of sulfur in diesel fuel has been decreased to accommodate the new engine technology in trucks and tractors (Xinqun et al. 2010).

APPENDIX G

Table G.1: List of abbreviations used in the dissertation

Abbreviation	**Term**
ACE	Ag Connect Expo
AGCO	Allis-Gleaner Corporation
BRIC	Brazil, Russia, India, China
CARB	California Air Resources Board
Case IH	Case International
cEGR	Cooled Exhaust Gas Recirculation
CEO	Chief Executive Officer
CIFS	Canadian International Farm Show
CNH	Case New Holland
CVT	Continuously Variable Transmission
DEF	Diesel Exhaust Fluid
DPF	Diesel Particulate Filter
DOC	Diesel Oxidation Catalyst
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FDI	Foreign Direct Investment
FPT	Fiat Powertrain Technologies
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GPS	Global Positioning Systems
IVT	Infinitely Variable Transmission
JD	Deere and Company
JIT	Just-in-Time Manufacturing
KHD	Klochner-Humboldt Deutz Ag
MSA	Metropolitan Statistical Area
NFMS	National Farm Machinery Show
NOx	Nitrogen Oxides
NTTL	Nebraska Tractor Test Labs
OSHA	Occupational Safety and Health Administration
PM	Particulate Matter
R&D	Research & Development
ROPS	Rollover Protection System
SCR	Selective Catalytic Reduction
SEC	Securities and Exchange Commission
SEDAAG	Southeastern Division of the Association of American Geographers
TYM	Tong Yang Moolsan
US	United States
USDA	United States Department of Agriculture
V2V	Vehicle-to-Vehicle
WCFP	Western Canada Farm Progress
WCM	World Class Manufacturing

VITA

Dawn Drake completed a Ph.D. in the Department of Geography at the University of Tennessee in Knoxville, Tennessee. The research focused on location decisions made by the Big Three US farm machinery producers (AGCO, Case New Holland, and John Deere), using Michael Porter's Theory of Competitive Advantage as a model. Prior to this degree, Dawn earned a B.S.ed in social science secondary education from Indiana University of Pennsylvania. As a part of this degree, she completed an honors thesis that delimited culture regions using barns as indicators. Dawn served as a substitute teacher in high schools in western Pennsylvania before entering the Masters program at the University of Delaware where she completed a M.S. in geography in May 2008. Her Master's thesis examined climate impacts on mastitis incidence in grazing Holstein cattle in Northampton County, Pennsylvania. Through the course of her education, Dawn served on the Executive Committee of Gamma Theta Upsilon as Student Representative and Student Representative on the Board of the Rural Geography Specialty Group. She also was the first Student Representative to the Steering Committee of the Southeastern Division of the Association of American Geographers (SEDAAG) and served on the Local Arrangements Committee for the 2009 SEDAAG Meeting in Knoxville, Tennessee.