The Role of Formalized Education in Agricultural Production: An Analysis of Heartland Region Corn Yield, Farm Earnings, and Off-farm Labor Mobility, 1970-2000.

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Abstract: Education’s role in agricultural production is commonly underestimated when compared to other sectors of the economy, yet the economical implications of formalized schooling on the farm have long been studied. In this thesis it is suggested that educational attainment has, indeed, long been a contributing factor in farming output, earnings, and labor mobility. More specifically, knowledge and skill have been instrumental dynamics of the differentiation amongst output, income, and transferability. The supply of educated farm youth and the demand for their labor have shifted throughout the twentieth century as they have been shaped by institutional support and technological advancement. The last thirty years of the century in America’s most prolific farming region, the Heartland, reveals a landscape where formalized education, while universally offered, maintains specific value on and off the farm. However, a notable contradiction may exist between the respective roles of secondary and tertiary schooling, and all relationships involving any level of educational attainment are prone to changes over time.

Key words: Education, Agricultural Production, Farm Labor, Human Capital
The failure to treat human resources explicitly as a form of capital, as a produced means of production, as the product of investment, has fostered the retention of the classical notion of labor as a capacity to do manual work requiring little knowledge and skill, a capacity with which, according to this notion, laborers are endowed about equally.

-Schultz, “Investment in Human Capital”
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ABSTRACT

Education’s role in agricultural production is commonly underestimated when compared to other sectors of the economy, yet the economical implications of formalized schooling on the farm have long been studied. In this thesis it is suggested that educational attainment has, indeed, long been a contributing factor in farming output, earnings, and labor mobility. More specifically, knowledge and skill have been instrumental dynamics of the differentiation amongst output, income, and transferability. The supply of educated farm youth and the demand for their labor have shifted throughout the twentieth century as they have been shaped by institutional support and technological advancement. The last thirty years of the century in America’s most prolific farming region, the Heartland, reveals a landscape where formalized education, while universally offered, maintains specific value on and off the farm. However, a notable contradiction may exist between the respective roles of secondary and tertiary schooling, and all relationships involving any level of educational attainment are prone to changes over time.
CHAPTER 1
INTRODUCTION

Educational attainment has been quantitatively measured, qualitatively debated, and systematically theorized for quite some time. The multitudes of socioeconomic effects which stem from education are collectively tremendous yet individually navigable. It is this thesis’ ambition to offer supported conclusions regarding the value of education through the analysis of three specific connections within American agricultural production.

1.1 Goals of the Study

In his book *Corn and Capitalism: How a Botanical Bastard Grew to Global Dominance*, notable Mexican anthropologist, Arturo Warman, professed, “Marginalization threatens the American farmer, the most outstanding product of the U.S. democratic ideal.”¹ Farming as a profession accompanied the promise of land and sustenance for many Americans prior to the twentieth century. Yet with the vast accumulation and extension that has typified agricultural production throughout the United States, even post-1900, have also come inequality, exclusion and attrition. Certain comparative advantages have long been recognized in agricultural production, though these factors have never been impenetrable to socioeconomic imbalances. Just as race (i.e. Native Americans, blacks), descent (i.e. migrant workers) and income (i.e. rural poor) have defined groups of marginalized people in agricultural production, education and skill have similarly categorized success and survival.

The intent of this thesis is to highlight human capital’s role in American agricultural production by viewing education as it relates to agriculture’s structural shifts and output.

differentials throughout the late twentieth century as well as earnings disparity on the farm and the propensity to seek employment off the farm. The role of human capital is indeed a vast and complex one with many shifting parameters and landscapes. With this in mind, any aggregated ideology typifying groups of people, eras of time, or regions of practice comes with unavoidable assumptions. Nevertheless, the concept of formal education as a personal asset and a functional input is believed to be sound. Therefore, a review of the historical trends in educational attainment is appropriate in order to conceptualize the worth of such capital accumulation. This thesis will first discuss the rise and stagnation of educational attainment in the agricultural sector and collective economy as a precursor to more particular analysis. Such a voluminous narrative is the thesis’ first objective in an overall aspiration to understand the significance of formalized schooling in the agricultural sector. Yet, to gain a more meaningful and specific understanding of how education correlates with production and personal labor success, a thorough empirical look into one geographical region’s patterns of educational attainment is undertaken. Specifically, this thesis will conduct an original statistical analysis of county-level data in the Heartland region of the United States over the final three decades of the twentieth century. Essentially, the Heartland region is selected to provide a disaggregated vantage from the nation as a whole to which several questions are to be assessed.

The primary inquiries of which the aforementioned analysis correspond to are multifold. First, the notion of education as a production input is pondered to evaluate how the Heartland region farmers’ educational backgrounds factor into the production of corn over a thirty-year period. The intent is not to make a claim about the production prowess of the region as a whole, but to explore the differences among and within counties. Educational attainment, in combination with other traditional inputs like land and labor, is believed to constitute the tangible discrepancies in output. As the most bountiful crop in the region, corn
is used in the analysis as a representational indicator of production, rather than an aggregated “basket” of crops that would require significant estimation assumptions and conversion proxies. The primary intent is not to signify corn as an unordinary production good in regards to education, but to facilitate an accurate depiction of Heartland region production. Second, the concept of education as a personal investment in real earnings is evaluated in determining the disparity in per-capita farm income amongst the counties of the Heartland region. While a traditional study of earnings is often on the single “firm” level, the county-aggregated data is again used in this thesis to explore the concept of congruence between counties of monetary wealth and of those boasting higher averages of human capital attainment. Third, the idea of education as a transferable asset is tested by reviewing the decisions of farmers to mobilize off-farm. Again, Heartland region county-level data is used to illustrate the aggregated trends in off-farm labor mobilization and to test the link between educational attainment averages and off-farm mobilization, which is believed to stem from relatively higher useful skills and broader aspirations.

Finally, as particularly relevant to the latter portion of the twentieth century, the division of educational attainment between secondary and tertiary levels is made to allow for contrasting results in the three inquiries just discussed. County-level percentages of ‘high-school and higher’ and university graduates are compared to test the notion that counties with larger higher-education shares fall victim to relatively lower output and earnings caused by a disinterest in agricultural production that is attached to tertiary degrees.

1.2 Social Importance and Academic Relevance

While the complete breadth of human capital is seemingly impossible to tabulate, the components of and the applications that extend from the stock are undoubtedly integral in pointed and successful analyses. To discount the education, experience and knowledge that people possess within any class, culture or landscape is to ignore the characteristics that
shape these very groups. Similarly, a view of labor markets ignorant of key skill components wrongly likens labor inputs to the physical capital variety. This thesis focuses on the role of human capital – notably formal education – in agricultural production for an array of motives, socially appealing, academically relevant or sometimes both. The fact that agricultural production is wholly performed on soil and accompanied by animal feed and crop fertilizer does not exclude it from the discussion of the value of knowledge and skill. Industrialized and service-based sectors of economies have long been dissected by social scientists aiming to quantify and qualify the evolution of laborer education and experience as they relate to the growth of the sector. As stated, similar analyses specific to agricultural production throughout the United States have been completed; nevertheless, a disproportionate share of research has been dedicated to the sector.

### 1.2.1 Education’s Significance to Society

Agriculture’s historical significance to American economic aggregate growth and personal opportunity can be traced back centuries. The prevalence of the personal farm in an individual’s or family’s list of assets and resources was practically omnipresent throughout the first 150 years of the nation’s existence. Although farming as a profession quickly declined throughout the twentieth century the means for income and utility and the consideration of educational variables in production all remained. As was just referred to, the wide-scale transformation of agricultural production throughout the United States is considerable and provides another justification for the analysis of the role of human capital. In 1950 the total farm population amounted to just over 23 million people, about 15.3% of the total population, and there were approximately 5.65 million farms. Fifty years later the farm

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3 Farm population consists of all persons living on farms in rural areas. Data prior to 1960 are based on self-identification by respondents to census material as to whether they live on a farm. The USDA Census of
population had shrunk to around 3 million and the total number of farms, 2.1 million, was less than half of the 1950 total.\textsuperscript{4} At the same time increased productivity has steadily driven overall output throughout the twentieth century. Total Factor Productivity (TFP) measured 0.447 in 1950, 1.068 in 2000 and averaged 1.51\% growth during the fifty year period.\textsuperscript{5} Such dramatic changes in farm quantity, labor and productivity provide an ideal scenario for the study of education amidst transformation. Finally, agricultural production is a unique sector by the relatively high percentage of laborers and proprietors seeking additional wages from non-farm opportunities. Non-farm labor is often sought to provide supplemental income and overall financial invariability from season to season. The distinction between farm-specific and general education and skill is increasingly blurred due to the propensity for dual employment.

1.2.2 Human Capital’s Academic Application

In addition to the social considerations of this thesis mentioned above, there are also a number of relevant academic motivations for such a topic. Considering the volume of notable studies on education’s role in agricultural production, the very fact that precedence exists for such a subject justifies the consideration of further analysis. In his 1964 seminal work, \textit{Transforming Traditional Agriculture}, Schultz offered a salient proclamation of education’s value, “In modern times, the most pervasive force disturbing the equilibrium of agricultural communities is the advance in knowledge useful in agricultural production.”\textsuperscript{6} There exists a progression of literature concerning knowledge and skill since the 1960s which remains highly relevant. Likewise, the quantification and charting of educational attainment and its


correlation with other socioeconomic variables conveys a logical precursor to the discussion of the qualification of schooling. The apparent difficulty of interpreting the distinctions amongst educational accomplishments and job-based experiences, farm-specific or otherwise, does not preclude the quantification of them. Just as production factor advances - in land, machinery and technology – are commonly measured, the calculation of education is equally appropriate.

1.2.3 Family and Location: Agricultural Attributes

Also noteworthy is the substantial geographical link between education and farming. Many pioneering states in the support and availability of secondary education were prominent farming locales. These regions, such as the North Central part of the United States, also feature a majority share of public tertiary institutions. Historically these “prairie states” were progressive, wealthy and accurately taxed. Throughout the expansion of the “high school movement” graduation rates in this region were often in the range of 25-50% higher than the national average. Furthermore, from a non-geographical aspect, education has traceable direct benefits to agricultural proprietors and laborers. Specifically, farmers have often been accountable for the comprehension of progressive farm journals, knowledge of animal inoculation, possession of engineering abilities in response to machinery maintenance, knowledge of a spectrum of crop varieties and the practice of modern accounting and other business practices.

Considering the tradition of familial ownership of farms throughout the United States the study of knowledge and skill is highly germane to the generational gap(s) in educational attainment. The continual increase in the aggregate level of educational attainment from one generation to the next throughout the twentieth century is widely publicized. Educational

differences specific to farm families may reveal even more meaningful correlations between knowledge and productivity. Finally, the agricultural sector in the United States has been plagued by income inequality and poverty for much of the second-half of the twentieth century. In 1960, 45.7% of all farm family heads were below the poverty line, compared to only 15.8% of non-farm family heads. This gap has steadily decreased over recent decades, yet the decline of poverty does not by rule equate to the eradication of inequality. Education is synonymous to ability; increased ability for some can contribute to uneven earnings for an overall sector. Poverty maintains an endemic presence in agriculture due to the gap in human capital – both farming-specific and general. The study of educational attainment is also highly pertinent to this aspect of agricultural production.

1.2.4 Spotlight on Corn and the Heartland Region

This thesis’ specific analytical focus on corn production in the Heartland region merits explicit academic motivations, as well. First, the region’s dominant landscape is, historically and presently, farm-based. Additionally, the geographical distinction of the relative educational success of the region is noteworthy, as already mentioned. Admittedly, the emphasis on corn is less pertinent. Corn is unique in terms of its variety of uses – for food, feed and industry – and is considered by many the backbone of American agriculture. The demand for corn as a livestock feed constitutes the majority use for the grain and shows no signs of slowing down despite the increases in alternative uses for the crop such as high-fructose corn syrup, industrial alcohol and fuel ethanol. Overall corn production has experienced steady growth since the 1950s, fueled largely by the parallel rise in productivity.

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11 Currently, corn accounts for 94.9% of all U.S. feed grain production. “ERS/USDA Briefing Room – Corn: Background,” http://www.ers.usda.gov/Briefing/Corn/background.htm (accessed 2010-03-08).
yield. Highly exposed to improvements in technology (seed varieties, fertilizers, pesticides), mechanization and production practices (reduced tillage, crop rotation), corn production has been an indicator of the agribusiness style of farming now dominant throughout the country. All that said corn is specifically studied here due in large part to its abundant production in the Heartland region, making its characteristics valid representations of prototypical farming in the region.

Corn seems to transcend time, concurrently boasting discoveries via colonization and of technological improvements made contemporarily. Corn, while relatively less labor-intensive than many crops – due to the corn kernels’ firm attachment to the cob – and notably successful rate of hybridization, attracts a wide spectrum of labor participants. The differentiation of education and skills possessed by laborers are significant to the production of the crop and the wealth of the proprietor. Referring back to the Heartland region, these states have always produced the bulk of American corn (*see figure 1*). Yet variation in landscape, climate and socioeconomic background always exists amongst a region of such size. A magnified study into county-level differences between educational attainment and corn production is decidedly relevant.

### 1.3 Thesis Outline

This thesis presents an analysis of the presence and value of formalized education in the United States. Chapters 2 begins with an overview of the notable research completed in the fields of human capital investment, economic productivity, technological advancement, labor mobility, and the marketplace for skill. Furthermore, a discussion of the theories relevant to the research questions is delivered in chapter 3, making note of particular theoretical associations to the three variables hypothesized as being corollary with human capital attainment: productivity, earnings, and labor mobility. Chapter 4 presents a lengthy examination of education’s historical pattern of development in the rural regions of the
United States. The expansion of formalized schooling in the early- to mid-twentieth century and subsequent slowdown in the growth of skill supply later in the century is richly reviewed because of its significance to the economic valuation of human knowledge and skill. Particular attention is paid to Claudia Goldin and Lawrence F. Katz’s sampling and analysis of the 1915 Iowa State Census. Also included, via chapter 5, is an independent review of educational trends in the aggregate economy during the twentieth century that provides an essential look into the shifting attitudes toward education and how the agricultural sector coalesced with such trends. Moreover, many farmers’ decision to mobilize toward off-farm employment opportunities is discussed in chapter 5 to express the magnitude of transferable skills and the degree of rurality in the farming sector.

Figure 1. Corn Production

Note: The Heartland Region includes Illinois, Iowa, Indiana, eastern portions of South Dakota and Nebraska, western Kentucky and Ohio, and the northern two-thirds of Missouri. Source: USDA NASS QuickStats.
Chapters 6 and 7 describe the methodological approach and specific statistical models employed in the thesis. In chapter 6 data sources, formats, characteristics, and construction are detailed to present an accurate representation of the parameters of the study. A summary of the cross-sectional and panel regression models, the primary statistical methods used, are portrayed in chapter 7. Specific explanation is made to distinguish the three separate dependent variable analyses executed. Finally, the analytical limitations of the thesis are described to clarify all possible results, illustrate all potential model errors, and dismiss any correlative assumptions. All econometric results are summarized in chapter 8; a thorough analysis of all variable relationships and panel trends is provided. Additionally, all results are connected to relevant theories and evaluated against the thesis’ hypotheses. A careful discussion of the meaning of all econometric results is completed to integrate the original study with the multifaceted history of education in rural America. Just as chapters 4 and 5 provide a meaningful look at education’s historical trends throughout rural America, the thesis’ original statistical results described in chapter 8 are treated as a continuation of the shifting value and role of formalized schooling. A concluding chapter is offered to summarize the primary goals, pertinent themes, and statistical results of the thesis. Lastly, the appendices provide previous econometric result tables, maps of relatable geographical districts and regions, and all original econometric results via several key tables.
CHAPTER 2
PRIOR LITERATURE

Chapter 2 summarizes some notable previous studies in the fields of human capital and agricultural economics. Particular attention is paid to the spectrum of education’s classification – from production function to personal investment to quality agent – and the different focuses of various analytical studies on education’s value in production and labor mobility.

2.1 Investment and Production

A wealth of research on the economic function of human capital and the agricultural production model has been offered dating back to the late 1950s. Schultz initiated a modern view of the productivity potential of the agricultural sector, one that equated human capital to the oil that fueled such an engine. In chapter 1 of the aforementioned *Transforming*, Schultz dismisses prior doctrines in the field as the result of “physiocratic and classical legacy”.\(^1\) Schultz prescribed a fresh consideration of farm land to mean the natural landscape (simply the endowment) plus the capital formation on the natural landscape (investment in the land). Even more significant, he declared that the capital formation on the land was increasingly substitutive of the land itself; the production process was ultimately manmade.\(^2\) It was mandatory to update and realign the factors of agricultural production in order to transform to a modern profitability model. Schultz stated that only human ability and technological change would propel future growth.

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\(^1\) The classical economists represent “those writers on economic theory who worked in England during and after the time of Malthus and before the time of John Stewart Mill.” Schultz took this phrase from William J. Baumol’s *Economic Dynamics* (1951). Marx and Marshall are also mentioned to have misjudged the similarity of cost conditions between agriculture and manufacturing. Schultz, *Transforming*, 10.

Zvi Griliches, a contemporary and friend of Schultz, provided valuable research on the agricultural production function. Perhaps most notably, Griliches labeled “the changing quality of the human agent” as an elusive concept largely influenced by improvements in the level of formal education received by potential farm laborers. He later reaffirmed education’s place in the agricultural production function by likening educational attainment to a quality measure to be coupled with a quantifiable labor input measure. John Kendrick’s “Productivity Trends: Capital and Labor”, from 1956, first credited educational investment and personal technical knowledge, collectively termed “cultural capital”, as the source of efficiency improvements to immaterial capital accumulation. Micha Gisser’s “Schooling and the Farm Problem” tackled the labor surplus problem in farming, having declared that “the net effect of more schooling would be to increase income in rural farm areas in addition to encouraging more farm outmigration.”

In 1970, Finis Welch’s “Education in Production” was published. The article continued the trend of thought praising education as a factor of production and form of investment. Throughout the 1970s and -80s, Wallace E. Huffman, a prolific author of several studies on the dynamic role of human capital, advanced Welch’s premise of education’s twofold contribution to production, the “allocative effect” and “worker effect”. He emphasized the allocative effect’s importance to agricultural production due to the sector’s inherent disequilibria. Additionally, Huffman analyzed the positive relationship between educational attainment and off-farm labor supply of farmers by county in a 1980 article, one of the first to study this relationship. Finally, Huffman penned a few comprehensive analyses

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of education’s role in agricultural productivity in response to structural and policy-based shifts in the sector.  

2.2 Technological Change and Mobilization

Three inspiring statistical analyses published in different decades and based on varying geographic scopes are: Rodgers (1994), Wallace and Hoover (1966), and Oluwole and Findeis (2001). Rodgers reviewed some long-term national farming trends before offering some detailed findings on general versus farming-specific human capital fitted to Cartesian quadrant planes. Wallace and Hoover analyzed the effects of technological change on 1959 state-level agricultural labor markets, allowing for age and education influence variables. Oluwole and Findeis studied individual farm households’ off-farm labor participation from 1977 to 1998 using education as a primary independent variable. All three studies indicated education’s significance in agricultural productivity and labor. Additionally, Jamison and Lau’s Farmer Education and Farm Efficiency (1982), a highly-recognized empirical handbook of agricultural human capital worth, provided countless production function and regression models germane to the statistical goals of this thesis.

Farm labor’s mobilization to off-farm employment was the subject of many essential studies. Articles by Hathaway (1960), Bryant (1964), Waldo (1965), and Hathaway and Perkins (1968) represented early empirical reviews of agricultural population trends and labor patterns, all with a keen focus on the spectrum of supply and demand factors which

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influenced such mobilization throughout the 1940s, 1950s, and early 1960s. These factors ranged from socioeconomic characteristics of laborers to the economic and innovative push and pull factors of the farming and non-farming sectors, respectively. Analyses by Sumner (1982), Barkley (1990), Mishra and Sandretto (2002), and Nehring, et al (2005) featured econometric analyses of the relationships between off-farm labor supply and farmer income, age, education, land size and other independent variables.

2.3 The Race
The resultant polarity between technology and education was made relevant by Goldin and Katz. Their numerous publications explored the complex relationship between educational attainment (supply), employer-driven skill utilization (demand), and the summative wage and labor equilibrium. Their most comprehensive study was the 2008 pseudo-compendium of previous works, The Race between Education and Technology. In it, they tracked the rise and stagnation of formalized education in America, and coupled its course with the shifting presence of skill-biased demand throughout different industries. Specific to the agricultural sector, “Education and Income in the Early Twentieth Century: Evidence from the Prairies” (2000) provided a remarkable look into the 1915 Iowa State Census, and investigated the connections between educational attainment and farm wages and productivity. Goldin and


Katz have developed a most valuable blend of historical narrative and theoretical formulation; their vast work was a chief inspiration for this thesis.¹²

CHAPTER 3
RELEVANT THEORY

Chapter 3 provides a methodical outline of the theories most pertinent to the concepts of this thesis. Subsections 3.1 to 3.4 present theories of educational value in the production function, while subsection 3.5 discusses the return to education and the market for skill. Subsections 3.6 to 3.9 relate to the transferability of education from farm to non-farm activities.

3.1 Education as a Factor of Production

To this day, Transforming serves as a roadmap to understanding the dynamics of the world’s oldest production activity. Furthermore, Schultz skillfully identified the distinct differences between traditional agricultural communities and those which have transformed. Such a transformation hinges on proper investment into agriculture and acknowledgment that it is a means of economic growth. Most important to Schultz’s beliefs is the recognition of human capital as a factor of production. He wrote, “The knowledge that makes [the] transformation possible is a form of capital whenever it is an integral part of the material inputs farmers use and whenever it is a part of their skills and what they know.”

Schultz clarified that a simple increase in supply of capital – human or material – does not serve to alter agriculture; rather, the proper application and handling of such capital is critical to profitable advancement.

Despite Schultz’s study of agricultural production taking place on a national level, his work has been cited numerously in all types of analyses. In fact, this thesis recognizes that county-level discrepancies may be similar to those circumstances defining a country as either traditional or otherwise. For, what is most central to the advancement of production, regardless of size of the area, is manmade. Human agents present key differences in the level

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1 Schultz, Transforming, 3.
of acquired capabilities, often with the ability to overcome natural endowment factors. With focus on technology’s role in transformation, Schultz posited, “A technology is always embodied in particular factors and, therefore, in order to introduce a new technology it is necessary to employ a set of factors of production that differs from the set formerly employed.”

Technological advancements provide further incentives to invest in useful capital inputs, but also validate the reduction in non-productive inputs. Schultz argued that factor proportionality, more than farm size, was most critical to agricultural transformation.

3.2 Skill and Land

In chapter 10 of Transforming, Schultz characterized modern agriculture as developing “reproducible services” like material inputs and human knowledge. He made the distinction between the two by pointing out that material inputs may be continually improved, but knowledge is advanced only via investment in people. A further disparity between material and human capital is material inputs’ inability to be universally applied due to climatic and biological circumstances. Knowledge, however, is pervasive enough to exist anywhere; it can also assist in the application of material inputs in varying settings. In general, Schultz argued that human capital is the basis for productivity growth in modern agriculture rather than traditionally valued land. The significance of skill and knowledge combined with the proper allocation of input factors is the force behind transformation. Without the necessary skills and knowledge, modern material inputs are deemed irrelevant and a notable production imbalance results.

This thesis values Schultz’s contributions to the concepts of agricultural productivity and human capital valuation. Particularly, skills and knowledge are appreciated as proper factors of agricultural production. Yet, human capital as it directly relates to agricultural

\[\text{Footnotes:} \]

2 Ibid., 132.
3 Ibid., 111.
4 Ibid., 146.
5 Ibid., 175.
production has often been studied on a national basis so that shifts in the industry’s structure can be considered. A primary example is the decline of agriculture’s economic importance as a country develops. A simple review of the long-term employment and GDP-share trends in the United States supports this notion.

### 3.3 The Two Effects of Education

Finis Welch, in his influential paper, “Education in Production”, portrayed education as a factor of production in addition to a personal investment. Thus when considering the ascent of the average amount of schooling attained through the twentieth century the counteractive growth in demand for education is believed to have been accompanied by the growth in demand for the factor of production that education represents. Welch explained that,

> Growth in total revenue is necessary for growth in the demand for factors used by an industry. If growth rates in total revenue resulting from differential rates of neutral technical change are positively related among industries to the share of skilled labor, changing technology will increase the demand for skilled relative to unskilled labor.⁶

Education, as a factor of production, presents a two-fold effect on labor. The “worker effect” simply represents the increased output resulting from education, yet the “allocative effect” implies the change in existing factors and/or the introduction of new factors achieved by increased education.⁷ Welch posited that the value of education in agricultural production, due to a constant differentiated set of duties largely based on commodity prices and climatic restrictions, is more associated with the “allocative effect” than in most industries. Moreover, job complexity as it relates to educational differences is relatively unclear in farming. The dynamic state of agricultural production presents an ideal environment for the usefulness of allocative ability. Traditional agricultural production allowed farmers to rely on word of mouth for critical methodological knowledge; however, the transformation farming has experienced in the twentieth century has mostly precluded generational information sharing.

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⁷ See Huffman, “Decision Making,” for a relevant analysis of education’s “allocative effect” regarding the introduction of nitrogen fertilizers from 1959-64.
Therefore, in such a dynamic setting the ability to acquire, apply and, adapt to new input factors is considered a major part of the return to education itself.\(^8\) Although Welch’s statistical analysis proved telling only for college graduates, the analysis completed in this thesis considers the “allocative effect” of education to be highly valid as it relates to the production function.

### 3.4 Farmer’s “Adaptive Ability” in Production

Huffman has provided a wealth of literature on the subject of human capital in agricultural production. His primary theory almost goes without saying – labor productivity is a function of human capital. Regarding Welch’s division of education’s return, Huffman advanced his sentiment that the “allocative effect” of education is a chief factor of agricultural output. In his 1985 article, Huffman referred to this effect as “adaptive ability”; such ability is distributed to farmers quite unevenly and thus serves as the basis for productivity disproportions.\(^9\) Farmers face constant uncertainties regarding price, production, and technological innovation. Huffman stressed the importance of adaptive ability, “Because of the heterogeneity of new technologies and their interactions with heterogeneous land and local agroclimatic conditions, farmers continually face decisions about which technology is best for their farm-specific conditions.”\(^10\)

In an earlier article Huffman made the further connection between farmers possessing allocative ability and the interpretation and utilization of any available information. This can be likened to education’s value in applying commonly available knowledge in addition to its role in discovering embedded information.\(^11\) Huffman labeled allocative ability as an acquired trait learned in formal schooling and through experiences searching for information.

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\(^8\) Welch, 55.
\(^10\) Ibid., 431.
\(^11\) Huffman, “Decision Making: The Role of Education,” discusses government extension services as an example of such information.
This ability provides farmers potential returns on their personal investment in obtaining pertinent skills, and thus, farmers are cognizant of the opportunities to gain such returns.\textsuperscript{12}

\section*{3.5 Educational Supply and Demand}

Goldin and Katz are prolific authors of historical examination of and theoretical contributions to the value of education in regards to economic growth, labor productivity, income disparity, and technological advancement. Through numerous publications they describe education as a converse force of technology, pitting the two in a “race” that determines the socioeconomic returns to education and the wage premium that may result. Moreover, modern economic growth, characterized by technological innovation and human capital, has made the twentieth century the “American Century”.\textsuperscript{13} Goldin and Katz stress the importance of education’s supply growth through the first three-quarters of the twentieth century, and label this ascent as the most critical push toward income equality, higher productivity, and labor-skill alignment. Equally, the last-quarter of the twentieth century has been marred with heightened income disparity, productivity sluggishness, yet continued technological advancement. The common thread between these recent trends is a palpable slowdown in the growth of educational supply. It is with the decade of the 1970s that Goldin and Katz divide the American Century into two eras, demarking the rise and stagnation of formalized education in the United States.

\subsection*{3.5.1 Skill-biased Technological Change}

Goldin and Katz’s supply-side theory of the socioeconomic dynamism experienced throughout the twentieth century does not entirely discount the demand-side effects. They describe the phenomenon of “skill-biased technological change” as an explanatory force of wage structure change stemming from “rapid secular growth in the relative demand for more-

\textsuperscript{12} Huffman, “Allocative Efficiency: The Role of Human Capital,” 61.
skilled workers”\textsuperscript{14}. It is commonly accepted that the overall occupational distribution of employment in the United States swung in favor of more-educated workers throughout the century; skill-specific demand has long been substantial.

Much research has suggested that long-run change in the distribution of earnings is shaped by a race between the demand for skill, driven largely by industrial shifts and technological advances, and the supply of skill, altered by changes in educational investments, demographics, and immigration.\textsuperscript{15}

An imperative point that Goldin and Katz make, though, is that skill-driven demand has been a part of the general economy for many decades, and is not simply an accompaniment of computerization. Consequently, the sizeable shifts in educational supply are more noteworthy in constructing and interpreting the value of education.

### 3.5.2 Specific Returns to the Agricultural Sector

Goldin and Katz admit that a sizeable void of data has caused many unknowns concerning the stock of educated workers in the first-half of the twentieth century. However, one exception, the 1915 Iowa State Census, became the subject of some of their most renowned analysis. Chapter 4 of the thesis further details some of their findings from the state census. Germene to this thesis are education’s returns to the agricultural sector, exemplified by the census sample studied. The following excerpt from Goldin and Katz’s census study summarizes formal education’s importance in predominant farming regions:

> The prairie states were populated by progressive farmers at a time when running a farm increasingly required knowledge of chemistry, botany, accounting, electricity, and other tools of modern science…And although many farmers would have preferred that their children remain on the land, most knew it would prove impossible. The best they could do was to endow them with education to be mobile.\textsuperscript{16}

Supported by the results found in their study of the 1915 Iowa State Census, Goldin and Katz infer that positive returns to post-common-school existed in the farm sector, and that productivity gains resulted from increased educational attainment. Their analysis on the relationship between education and productivity was completed on a county-level basis for


\textsuperscript{15} Ibid., 24.

multiple time points, and served as a principal motivation for the statistical analyses completed in this thesis.

3.6 The Harris-Todaro Model

Two distinct models that hypothesize outmigration of farm labor are the Harris-Todaro model and Cochrane’s ‘treadmill model’, which is reviewed in subsection 3.7.\(^{17}\) The Harris-Todaro model characterizes rural-urban migration as the result of increasing opportunity cost of agricultural labor based on the urban-rural differences in expected earnings. In other words, potential rural migrants make decisions in order to maximize expected utility.\(^{18}\) Education increases the function of expected urban income in a way where the more educated are more likely to migrate to off-farm employment. The most polarizing aspect of the Harris-Todaro model is the ignored relationship between education and agricultural productivity; such education can only promote off-farm labor mobility and urban production increases. This thesis argues that human capital indeed has a positive correlation with farm-labor productivity and thus an exodus from farming can have a harmful effect on farm-labor productivity. Wallace Huffman’s work supported this notion and is reviewed in subsection 3.8. The Harris-Todaro model posits that as the average level of education amongst the residual group of laborers on the farm decreases from off-farm migration, aggregate farm output decreases and farm-output prices increase as a response.\(^{19}\)

3.7 Cochrane’s “Treadmill Model”

W. W. Cochrane’s treadmill model presents an alternate view on education, focusing on farm-specific knowledge and experience that is directly attributable to farm productivity and a critical aspect of rural-urban migration. Cochrane spends very little explanation on specific

\(^{17}\) See Rodgers, “Differential Human Capital,” for a concise summary and comparison of these models.


\(^{19}\) Rodgers, 6.
knowledge processes; rather, he centers on the advantage in adopting technology certain knowledge brings. These fortunate farmers benefit from the rise in commodity worth and proceed to expand their operations by purchasing more land, often adjacently held by struggling farmers.\textsuperscript{20} Non-innovative farmers are presumed to quit the industry as each round of technology adoption occurs. The treadmill model is entirely policy-oriented and lacks statistical model support, yet the concept of knowledge-based technology adoption can help show the correlation between education and productivity. While this thesis’ hypotheses do not specifically mirror the Harris-Todaro model or Cochrane’s ‘treadmill model’, particular elements of each (e.g. transferability of general knowledge, technology adoption’s affect on productivity) are exceptionally pertinent.

3.8 Off-Farm Reallocation of Skills

In addition to Huffman’s analysis on education’s return to agricultural productivity, he also stressed the importance of human capital on farmers’ decisions to mobilize off-farm. In a county-level analysis using data from the 1964 Census of Agriculture he concluded that “raising the education level of farmers…increase[s] the off-farm labor supply of farmers. This implies that part of the return to education in agriculture arises from its effect on the reallocation of farmers’ labor services between farm and nonfarm labor markets.” In the study, Huffman summarized education’s effect on farmers’ off-farm labor supply as two-fold. The direct relationship simply relates to an increased desire and qualification for off-farm employment; though, the indirect effect encompasses the causal chain of increased farm output, market price reduction, price-induced reduction in supplied output, and reallocation of a share of farm labor to off-farm work.\textsuperscript{21}

\textsuperscript{21} Huffman, “Farm and Off-farm Work Decisions,” 22.
3.9 Education as a Transferable Tool

Dale E. Hathaway, wrote much concerning farm labor mobility and the effects on income distribution. In his writings, Hathaway penned a few notable theories of labor movement that are highly relevant to this thesis. Referring to the magnitude of labor migration and mobility from farm to off-farm, Hathaway stressed the heterogeneity of the migrants as well as the economic conditions in which they lived in. The path of mobilization was not repeated throughout time and space, making for even more useful social analysis of the labor movements. Hathaway stated, “We know, however, that human resources in agriculture are not homogenous, so that who migrates from agriculture has an effect beyond the mere numbers involved upon both agriculture and the receiving sector of the economy.” He made the point that the characteristics of migrants have historically changed based on the economic state of non-farm areas and the aggregate increase in educational levels in rural areas, a thought that this thesis aims to evaluate from the panel data constructed.

Despite the pliable nature of labor movements during the twentieth century, specific skills held by those succeeding in labor reallocation were evident. Moreover, those laborers lacking favorable employee traits were often the victims of misinterpreted skill supply and deficient aggregate labor demand off the farm. By means of Social Security data analysis Hathaway concluded “that the characteristics which determine an individual’s earnings in agriculture are likely to have a similar effect in nonfarm employment.” Formal education is an ideal measure to exemplify Hathaway’s conjecture since it stands independent from industry-specific job experience or training. The belief that the typical curriculum of formal secondary education provides students with an ability to apply knowledge to a wide array of employment opportunities is pertinent. Naturally, industry preparation and experience has a compounding effect on future off-farm employment. However, the majority of farmers,

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22 Hathaway, 382.
23 Hathaway and Perkins, 352.
particularly in prior generations, lacked such training and relied only on their education. Hathaway’s writings still remain valuable in studies of labor transfer and income variation.

3.10 Conclusion

Although representing a diverse cross-section of theoretical topics, the concepts presented in chapter 3 all relate to the overall valuation of educational attainment, specifically its role in the production function and as a transferable tool. The thesis will consider these theories when recounting the historical narrative of education’s role in agrarian and general society and when performing its novel statistical study of the Heartland region counties. Educational attainment has certainly been considered a valuable input on its own, but also as a capable augmenter of other inputs. Likewise, education has long been praised as significant differentiator in terms of labor skills and aspirations.

3.11 Hypotheses

Upon review of the relevant theories, as completed in subsections 3.1 to 3.9, it is appropriate to briefly outline the thesis’ primary hypotheses. Hypothesis A states that a positive correlation exists between average educational attainment percentage and output of corn, as measured on the county level in the Heartland region. This hypothesis is based on the belief that education is a production function input, similar to other forms of traditional capital. Hypothesis B posits that a positive correlation exists between average educational attainment percentage and per-capita income earned by farm laborers, as measured on the county level in the Heartland region. Hypothesis B regards education rather as an investment that provides a return via personal earnings. Hypothesis C states that a positive correlation exists between average educational attainment percentage and the off-farm employment percentage of farmers, as measured on the county level in the Heartland region. Hypothesis D stipulates the previous hypotheses by stating that the correlative relationships between average educational
attainment percentage and the dependent variables are not continuously measured. Specifically, tertiary educational attainment may result in opposite correlations with output and earnings than secondary educational attainment.
Chapter 4 describes the maturation of formalized schooling in rural America throughout the first-half of the twentieth century, from the one-room school of traditional practice to the modern pedagogical methods adopted under the influences of more-progressive urban regions. Goldin and Katz’s sampling and analysis of the 1915 Iowa State Census is used as a primary source of empirical data. The last section, 4.3, in the chapter discusses the subsequent second-half slowdown of educational advancement throughout the United States.

4.1. The One-Room School

“An efficient social institution is one that allows people to accomplish their goals in the least costly way, given resources available to accomplish those goals.”¹ This quote by the American economist William Fischel offers a practical point of view of formal education in much of American history. The analysis of American schooling prior to around 1940 is characterized largely by distaste. Much of what embodied education during those times has been deemed counterintuitive to social progress. However, the rural landscape many Americans considered home validated such antiquated practices based on the “given resources” which Fischel refers to.

Plainly, the divide between rural and urban was significant in the pedagogical methods of educating youths. The nineteenth century one-room schools that were ubiquitous in the United States prior to the “high school movement” and massive school district consolidation effort in the early twentieth century persisted in the majority of rural regions

long after they disappeared in urban zones. The reasons centered on the necessitude to accommodate for farm families’ way of life, or rather, not to disrupt this livelihood. One-room schools offered the flexibility of unmeasured curriculum and noncompulsory attendance. It was quite common for children to remain absent from school for weeks or months at a time to provide their labor on family farms. The lack of a graduated system of schooling allowed children to leave and return to school as their families permitted them to without the consequence of being held back a grade. Children simply picked up where they had left off in their individual lesson books regardless of age. Furthermore, these one-room schools typically featured summer and winter terms to allow children to remain on family farms during the harvest times of spring and autumn. Two additional aspects of the rural landscape which supported the one-room school system were the relatively low-density of people and the complete lack of transportation. One-room schools were logically placed in the center of a community so that children of all ages (and both sexes) could walk to and from school.²

It is worth reiterating the practice of what many would consider “opportunity cost analysis” by children and their families. Upon the point that students considered their time outside of school more valuable than their time at school they simply stopped attending. As mentioned, it was common that some children would return to school at later times because of the forgiving nature of the system. Fischel aptly describes the educational structure, “Its ungraded pedagogy allowed children to acquire increments of skills and knowledge while meeting their families demands for their labor.”³ Yet, during the twentieth century, families’ demands for their children’s labor transformed into demands for their children’s future.

² Children were not expected to walk more than 2 miles to school considering the conditions of the terrain and, perhaps more importantly, the expectation to complete farm chores at home. Ibid., 37.
³ Ibid., 65.
4.1.1 Rural Development

Two trends that swept rural living in the twentieth century paved the way for the modernization of formal schooling. First, the increased mobilization of families, particularly rural to urban migration, affirmed new qualifications for success relevant to parents and children. Specific to children was the ability to translate prior knowledge to urban formalized school systems, commonly in the form of qualification exams. One-room school system’s vulnerabilities were suddenly revealed when evaluated in the aggregate. Even more significant was the recognition of the need for proper and transferable education for all of America’s children. In an agricultural setting this marked the initial societal demand for education that further progressed throughout the twentieth century in the forms of specialized labor, tertiary schooling and skill-biased technological change. Second, the mechanization of farming practices lowered families’ dependence on their children for labor. The opportunity cost of education was subsequently lowered, as well, and the demand for formal education grew. A non-farming specific example of mechanized change that also shaped rural schooling in the twentieth century was the advent of the school bus. Coupled with vast improvements to the road infrastructure, the school bus made consolidation possible in several farm regions.

The durable features of formal education like grade-based learning and common calendar adherence that accommodated labor mobility and urban population growth throughout the country in the early twentieth century became specifically relevant to rural regions soon thereafter. The school district consolidation movement was composed almost entirely of the transformation of several rural one-room schools into a larger grade-based school congruent with national standards. Upon considerable efforts toward conversion the one-room school effectively died out by 1972.⁴

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⁴ One-room schools still accounted for almost half of all school districts in 1960, yet immense school consolidation occurred throughout the mid-twentieth century. For example, the 9,459 districts of Illinois in 1948 were reduced to 3,413 in just four years. Ibid., 69.
4.2 The 1915 Iowa State Census

As detailed in the previous subsection, the pedagogical methods relied upon in rural education fueled a noted disparity between rural and urban learning. This inequality eventually led to the rural pedagogical conformity to accepted urban practices and consolidated school buildings and districts. It is worth considering the consequences of the variance in educational attainment – both the quantity and quality – amongst different regions of the United States. Unfortunately due to a sizeable void in records specific educational statistics are not available prior to 1950 with two noteworthy exceptions. The 1915 Iowa State Census remarkably inquired about educational attainment twenty-five years before any national census did so. Additionally, Iowa asked for information concerning current schooling, occupational income, total wealth, unemployment, church attendance and several other topics, making it the most unique and comprehensive census ever taken.

4.2.1 Educational Attainment – Rural versus Urban

In “Evidence from the Prairies”, Goldin & Katz constructed a sample from the 1915 Iowa State Census of sixty-thousand individuals to analyze correlations and differences amongst the state population. Table 1 shows years of schooling by type of institution for various demographic groups of 25- to 59-year olds. Most relevant to this section are the numbers in bold font highlighting the near opposite composition of primary education between the rural and urban population. The average rural-based 25- to 59-year old in 1915 Iowa obtained an average of almost six years of primary school (with a maximum of eight years) from “common” schools, acknowledging the review of the rural one-room school in the previous section. Although, the older cohort sampled in table 1 plainly describes people whom

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5 Iowa and South Dakota inquired about educational attainment in their respective 1915 State Censuses; however only Iowa’s Census inquired about income earned by occupation making it possible to analyze the value of education. For this reason, plus the fact that all 2 million separate index cards from the census survived and were subsequently microfilmed by the Genealogical Society of Salt Lake City, the Iowa Census is deemed the one of notable value between the two. Goldin & Katz, The Race, 73.
attended primary school prior to the turn of the century, thus making these results far from surprising. Maybe more unexpected is the fact that the average total years attained is almost identical for rural and urban populations, raising the distinction between quantity and quality of schooling.

<table>
<thead>
<tr>
<th>Years of Schooling by Type of Institution, Iowa 1915</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Entire Sample</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>Native-born</td>
</tr>
<tr>
<td>Iowa-born</td>
</tr>
<tr>
<td>Foreign-born</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Arrived &gt; 19 yrs</td>
</tr>
<tr>
<td>Urban Sample</td>
</tr>
<tr>
<td>Rural Sample</td>
</tr>
</tbody>
</table>

Notes: “Total, Truncated” sums the years in each column but truncates the sum of common and grammar school at nine years and high school at four years. "Arrived > 19 yrs" means that the individual came to the United States at age 20 or more. "Urban Sample" represents 26,768 records from the cities of Davenport, Des Moines and Dubuque. "Rural Sample" represents 33,305 records from ten counties not containing a city with more than 25,000 people.

Source: Transferred from Goldin and Katz, "Evidence from the Prairies," 792; in which data was compiled from the 1915 Iowa State Census.

While resources such as the 1915 Iowa State Census account for statistical measurements of education, the qualification of learning is exponentially more difficult to calculate. Though the differences between one-room school pedagogy and the formalized grade-based curriculum have become understood via migration accounts, school district transformation efforts and increases in the demand for edification change, more modern discrepancies within schooling and skill acquisition are less obvious and subsequently less studied. This thesis will not consider in detail the qualification of educational attainment.
amongst different groups or regions; however a specific analysis of the quantification of educational attainment seems like a logical precursor or accompaniment to any non-numerical study. As an interesting aside, modern contemplation of the race between technology and education rests squarely on the quality of schooling. Considering that technological progress is widely believed to unanimously increase wage premiums, and that educational resources are effectively limited in number, then the quality of such institutions could have an ameliorating effect on skill-based earnings inequality.

Table 2

<table>
<thead>
<tr>
<th>Occupation, Males and Females 20- to 64-Years Old</th>
<th>Common or Grammar School</th>
<th>Some High School</th>
<th>High School Graduate</th>
<th>Some College Plus</th>
<th>Mean Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>All employed</td>
<td>71.9</td>
<td>10.0</td>
<td>7.6</td>
<td>10.5</td>
<td>8.63</td>
</tr>
<tr>
<td>Blue Collar, Service</td>
<td>83.3</td>
<td>8.8</td>
<td>4.5</td>
<td>3.4</td>
<td>7.80</td>
</tr>
<tr>
<td>Craft</td>
<td>76.8</td>
<td>10.2</td>
<td>7.7</td>
<td>5.3</td>
<td>8.32</td>
</tr>
<tr>
<td>White Collar</td>
<td>37.0</td>
<td>15.2</td>
<td>19.1</td>
<td>28.8</td>
<td>10.80</td>
</tr>
<tr>
<td>Professional</td>
<td>15.1</td>
<td>12.1</td>
<td>16.0</td>
<td>56.9</td>
<td>13.00</td>
</tr>
<tr>
<td>Managers, Proprietors</td>
<td>55.2</td>
<td>13.6</td>
<td>14.1</td>
<td>17.1</td>
<td>9.62</td>
</tr>
<tr>
<td>Clerical, Sales</td>
<td>40.2</td>
<td>17.9</td>
<td>23.5</td>
<td>18.5</td>
<td>10.29</td>
</tr>
<tr>
<td>Farmers</td>
<td><strong>87.0</strong></td>
<td><strong>7.0</strong></td>
<td><strong>1.7</strong></td>
<td><strong>4.3</strong></td>
<td><strong>7.82</strong></td>
</tr>
</tbody>
</table>

Notes: Only those with positive occupational earnings for 1914 and legibly written occupations are used. Blue-collar occupations include those in craft, operative, service, and laborer occupations (codes 300 to 988 using the 1940 occupational classification). White-collar occupations include those in professional, semiprofessional, managerial (excluding farming), clerical, and sales occupations (codes 1 to 45, and 100 to 299 using the 1940 occupational classification). Education categories represent the highest grade, or year in a type of school, completed.

Source: Transferred from Goldin and Katz, "Evidence from the Prairies," 794; in which data was compiled from the 1915 Iowa State Census.

The highlight of table 1’s depiction of schooling by type of institution is the rural versus urban contrast. Yet, according to the sample compiled by Goldin and Katz, the designation of “rural” should not be defined as strictly agrarian. As indicated in the notes section of table 1 non-farming families could have certainly been captured in the rural group. In order to view the differences in educational attainment by occupation we must refer to table 2. The numbers in bold font reveal that 87% of farmers in 1915 Iowa had not received
any high school education and on average had received three fewer years of education than a typical white-collar worker. Table 2 helps reveal a more telling account of the educational shortcomings in agricultural production. While Iowa was arguably twenty-five years ahead of the country in educating its citizens, the relative learning achievements for farmers were still lacking.

4.2.2 Returns to Education among Farmers

Education, although persistently disparate in quantity and quality amongst regions, universally claims some level of meaning and return. Such a return is naturally dependent on the particular stage of aggregate educational development in a region or country. For example, the value of a primary education alone was far higher in the nineteenth century than in much of the twentieth because of increasing collective educational attainment and the associated labor market demand for higher-educated individuals. So though educational attainment was comparatively lower amongst agricultural production workers in 1915 Iowa (and likely all of the United States), the return to schooling was alternatively substantial. Table A1 (see appendix A) “depicts estimates for the return to years of formal education from a standard log annual earnings function augmented to allow the returns to vary for different types of schooling.”

Columns 3 and 6 reveal significant returns to a year of post-elementary schooling for those working in farming occupations. Specifically, the returns to a year of high school are 11.4% and 13.2% for all those employed in farming occupations and explicitly those 18- to 34-years old, respectively. Remarkably high returns exist for a year of college as well, though the meaning of college education was quite different one hundred years ago considering that some students studying in colleges lacked a high school education. Nevertheless, these substantial returns to high school and college education signify a highly

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7 Among male farmers 18- to 65-years old with positive earnings, about 13% had at least either a year of high school or of college. Goldin and Katz, “Evidence from the Prairies,” 798.
pertinent value in such an agriculturally-dominated state. The rise in demand for secondary education applied to those on the farm and for town and city dwellers alike. For farm families the presence of a local high school likely had two effects. The first was that their children had easier access to a competitive education without leaving the farm community. Secondly, a greater portion of such educated farm youth ultimately abandoned farming in search of alternative employment opportunities.\(^8\) Contrarily, those educated youths choosing to stay in the farm community are posited to have become more skilled farmers.

### 4.2.3 Education and Agricultural Productivity

The preceding subsection reviewed the returns to education in the form of farmer income; this subsection will expand the concept of educational returns to the rate of production. The role of education in agricultural productivity has been broadly studied throughout the twentieth century; the importance of productivity measurements is level with income premiums in the exploration of individual and regional success.\(^9\) Continuing with Goldin and Katz’s work with the 1915 Iowa State Census sample, the aggregation of information into county sets allowed them to correlate such educational data with crop values and input levels, like the number of acres and value of machinery and implements per farm, from the national agricultural censuses of 1910 and 1920. Such a breadth of information provided them the opportunity to analyze cross-sectional data to investigate the correlation between high school education and agricultural productivity and also time-series data to explore the correlation within variable movements. A basic Cobb-Douglas production function was used to estimate logs for each of the ninety-nine counties in Iowa in 1915 and 1925. The equation used is shown below\(^{10}\):

\[\text{Output per farm} = (\text{Q/L}), \text{ a function of machinery per farm} = (\text{K/L}), \text{ and land per farm} = (\text{T/L}), \text{ each raised to the appropriate elasticity} = (\beta, \gamma). \text{Education} = (E), \text{ as given by the fraction of adults (older than 20 years) with at least a high school education.} \]

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\(^8\) Ibid., 801.

\(^9\) See Schultz, *Transforming Traditional Agriculture* for theoretical concepts; and Huffman, “Structural and Productivity Change,” and Huffman, “Allocative Efficiency,” for a more statistical review.

\(^{10}\) “Output per farm, (Q/L), is a function of machinery per farm, (K/L), and land per farm, (T/L), each raised to the appropriate elasticity (β,γ). Education (E), as given by the fraction of adults (older than 20 years) with at least a high school education.”
\[(Q/L) = A \cdot (K/L)^\beta \cdot (T/L)^\gamma \cdot \exp^{\delta E + \sum \lambda_i S_i}\]

The results of their analysis are shown in table A2, columns 1 and 2 (*see appendix A*). In both years the educational variable’s coefficients are positive and statistically significant. The positive correlation between the fraction of adults in a county who attended any high school or college and crop value holds true for 1915, 1925 and for the difference comparison form (*column 3*).

The methods used in the analyses summarized by tables A1 and A2 are essential in considering the valuation of educational attainment. Specifically, the two frameworks – individual census sample (table A1) and county aggregation (table A2) – offer unique considerations of income and productivity differentiation. The results displayed by tables A1 and A2 support the principle that higher-educated farmers were more able to adopt and maintain technological processes that lead to increased productivity and higher earnings potential. Education’s role in productivity and earnings is most often complementary; the interaction between knowledge and various new inputs such as chemical fertilizers, hybrid seed and machinery is paramount to a modernizing agricultural environment.\(^{[11]}\) The state of agriculture in 1915 Iowa was that of a progressive, skill-driven sector. Individual farmers possessing some secondary and/or tertiary education were shown to earn higher wages, and counties boasting higher collective educational attainment were more productive. Furthermore, the results from the 1915 Iowa State Census reviewed in this chapter support the idea that the advancement of knowledge and the application of new input factors don’t evolve exogenously.

Iowa was not the benefactor of some arbitrary evolution of skill; rather they developed institutional sources of knowledge to exploit human capital in the form of a

---

production function. Regrettably, in 1915 educational success in such a dominantly agrarian region like Iowa was rather atypical. Figure 2, taken from Goldin and Katz’s “Evidence from the Prairies”, depicts high school enrollment and graduation rates for the United States and the West North Central census division.\textsuperscript{12} For much of the first half of the twentieth century the WNC boasted higher enrollment and graduation rates than the national average, indicating that educational attainment is not a static or spatially level phenomenon. Although attainment levels varied throughout the nation the value of schooling – in the form of a wage premium – was omnipresent. However, markedly reduced returns to education resulted from the expansion of educational access during the first half of the twentieth century. Education’s role and value in the latter half of the century is reviewed in the following subsection.

4.3 Educational Slowdown and Rising Inequality

Much of the twentieth century was characterized by educational advancement and aggregate economic growth. It was no coincidence that the United States, the nation that made the largest investment in formal education, quickly became the world’s leader in per-capita income. Obviously economic growth was not purely the result of educational attainment, but considering the governmental makeup, property rights, and market persistence evident in the United States, the correlation between education and growth is sound. Perhaps the most telling aspect of the nation’s educational growth was the rapidness of the pattern. For population cohorts born from 1870 to around 1950, every decade revealed an increase of 0.8 years of education.\textsuperscript{13} The pace of educational advancement slowed for those born after the 1950s, rising inequality pervaded, and the increase in productivity was largely tempered.

\textsuperscript{12} The West North Central census division includes Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota.

\textsuperscript{13} Goldin and Katz, \textit{The Race}, 4.
Table 3 reveals the progression of educational attainment throughout the twentieth century for the United States and Iowa. As mentioned in the earlier section, Iowa and other historical farming states enjoyed an advantage in average years of schooling attained over the balance of the country for much of the twentieth century; however, as indicated in table 3 this advantage had disappeared by 1980. The fundamental facet of these trends is that areas that once experienced monumental advances in educational attainment eventually plateaued. The farming regions in the United States experienced a similar trend, just one that occurred a bit later than urban and suburban areas. In fact, rural counties experienced reductions in the
## Table 3
Educational Attainment of the Workforce, 1915 to 2005

<table>
<thead>
<tr>
<th>Fraction, by years</th>
<th>United States</th>
<th>Iowa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean years</td>
<td>7.63</td>
<td>9.01</td>
</tr>
<tr>
<td>0-8</td>
<td>0.756</td>
<td>0.522</td>
</tr>
<tr>
<td>9-11</td>
<td>0.129</td>
<td>0.174</td>
</tr>
<tr>
<td>12</td>
<td>0.064</td>
<td>0.185</td>
</tr>
<tr>
<td>13-15</td>
<td>0.028</td>
<td>0.061</td>
</tr>
<tr>
<td>16+</td>
<td>0.026</td>
<td>0.058</td>
</tr>
</tbody>
</table>

*Notes*: Samples are restricted to those 16 or older and exclude those who were in the military or institutionalized. The workforce in each year from 1940 to 2005 consists of those who are employed at the survey reference week. The workforce in Iowa in 1915 includes those reporting occupational earnings for 1914; each individual is weighted according to the number of months worked in 1914. Sampling weights are used for all samples.

*Source*: Transferred from Goldin & Katz, *The Race*, 32; in which data was compiled from the 1915 Iowa State Census; 1940, 1960 and 1980 Census IPUMS; and the 2005 CPS MORG samples.
percentage of persons 25 and older without a high school degree up until 2000. The supporting evidence for these patterns again hinged on supply and demand theory. Comprehensive public education access and economic realignment toward services continued to permeate the rural landscape post-1950.

4.3.1 Rural Specifics of Relative Supply Decrease

Two distinct red flags associated with the quantitative rise in educational attainment throughout rural America existed, though. The first was the natural process of younger age cohorts replacing older ones, which ultimately resulted in higher average educational attainment rates. Table 4 depicts the breakdown of educational attainment by age cohort in the year 2000. Highlighted in bold are the percentages of non-metro 55- to 64-years old and 65+ age cohorts’ without a high school degree. A stark contrast is obvious when these percentages are compared to those in younger age cohorts. Yet, particularly pertinent to the construal of overall educational attainment patterns in non-metro areas is the parallel amongst 25- to 34-, 35- to 44-, and 45- to 54-years old age cohorts’ level of education in 2000. The most telling interpretation of table 4 is that the percentage of the non-metro population not graduating high school did not decrease from 1970 to 2000, meaning that any aggregate statistical improvements simply reflected age cohort replacement. The supply of education in rural America had clearly leveled off in the last quarter century.

The second alarming aspect of the role of education in predominantly farming areas was an effect of formalized schooling. It became increasingly more difficult for farming communities to educate their children and continue to insulate them in the periphery. Educated youth became more and more willing to explore alternative employment and continued educational opportunities in urban areas. Metro areas offered higher returns on

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14 The decreases in population share without a high school degree from 1970 to -80, -80 to -90, and -90 to 2000 in rural counties (based on 1993 ERS metro/non-metro classification) were all between 25 and 26%. “ERS/USDA Briefing Room – Rural Labor and Education: Nonmetro Education,” http://www.ers.usda.gov/Briefing/LaborAndEducation/education.htm (accessed 2010-02-28).
secondary, and particularly tertiary, education mainly due to greater costs of living and larger demand for high-skill workers. In contrast, job-seekers without a high school degree were faced with similar challenges whether in a rural or urban setting. In other words, those more likely to leave the farm were higher-educated, often resulting in “brain drain” throughout agricultural regions.

![Table 4](Image)

Educational Attainment by Age and Metro/Non-metro Status, 2000

<table>
<thead>
<tr>
<th>Education Level</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65+</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-metro:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>13.1</td>
<td>13.0</td>
<td>13.0</td>
<td>21.5</td>
<td>35.9</td>
</tr>
<tr>
<td>High school graduate</td>
<td>40.5</td>
<td>42.9</td>
<td>39.1</td>
<td>42.1</td>
<td>36.5</td>
</tr>
<tr>
<td>Some college</td>
<td>28.7</td>
<td>27.6</td>
<td>27.2</td>
<td>21.4</td>
<td>16.6</td>
</tr>
<tr>
<td>College graduate</td>
<td>17.7</td>
<td>16.6</td>
<td>20.7</td>
<td>15.1</td>
<td>11.0</td>
</tr>
<tr>
<td><strong>Metro:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>11.6</td>
<td>11.1</td>
<td>10.3</td>
<td>17.0</td>
<td>28.5</td>
</tr>
<tr>
<td>High school graduate</td>
<td>28.0</td>
<td>31.3</td>
<td>29.0</td>
<td>34.3</td>
<td>35.1</td>
</tr>
<tr>
<td>Some college</td>
<td>28.3</td>
<td>27.8</td>
<td>28.1</td>
<td>22.7</td>
<td>18.8</td>
</tr>
<tr>
<td>College graduate</td>
<td>32.0</td>
<td>29.8</td>
<td>32.6</td>
<td>26.0</td>
<td>17.6</td>
</tr>
</tbody>
</table>

Source: Transferred from “ERS/USDA Briefing Room - Rural Labor and Education: Nonmetro Education.” The data were compiled from the U.S. Census Bureau, Census of Population.

The second half of the twentieth century revealed a slowdown of educational supply in rural America, perhaps one that was inevitable in light of the revolution of formalized schooling that began earlier in the century. Chapter 5 will briefly review some of the aggregate trends that shaped the country’s supply and demand for educated workers. The revolutionary expansion of formalized education, both in urban and rural regions, was accompanied by sweeping shifts in the value of education. Commercial productivity, personal earnings power, income inequality and industry-based employment distribution were all impacted considerably.
4.4 Conclusion

Such a detailed account of formalized schooling’s developmental track has provided important background to the more modern considerations of education. Subsections 4.1 and 4.2 satisfied the thesis’ ambition of presenting a comprehensive review of the trends of educational supply and skill premium that occurred during the first-half of the twentieth century. The Goldin and Katz analyses summarized in tables A1 and A2 remain significant to the concepts and patterns formed by data representing more modern time periods, such as those depicted by tables 3 and 4 in subsection 4.3. This bridge from early to late twentieth century analysis is central to the thesis’ primary statistical objectives presented in chapter 7. The link between the historical patterns of attainment discrepancies, productivity increases, wage premiums, and labor mobilization, and the more recent movements in such functions is paramount to the realization of educational value.
CHAPTER 5
AGROECONOMIC TRENDS AND FARM TO OFF-FARM LABOR MOBILITY

Chapter 5 concludes the review of historical trends and secondary analyses by presenting a look at education’s changing role nationally - not simply on the farm. Subsection 5.1 offers an agro-economic perspective to stress the dynamic exchange of labor and goods between the farm sector and the rest of the economy. Accordingly, subsection 5.2 reviews the specifics of rural-to-urban labor movements and the role of educational attainment.

5.1 National Trends in Education and Earnings

While the focus of this thesis remains solely on the agricultural sector, an aggregate view provides perspective into how the nation’s attitudes about education changed over time. Moreover, it is no secret that farm and non-farm regions boast a symbiotic relationship where assets – material and human – are transferred continuously. For instance, technological advancements in the non-farm arena may spillover to the farm profession at the same time as labor may migrate from farms to urban centers. Off-farm labor migration is a remarkable trend amongst American farmers with a twofold effect. First, out-migration reduces the level of labor inputs in agricultural production, and subsequently increases per-farm and per-capita incomes, farm size and overall labor productivity. Second, the migration from farm areas makes a significant contribution to the growth of the non-farm labor force and signifies a large transfer of human capital.

5.1.1 Early Supply Side Shifts

Formalized schooling began to take shape in the United States as early as 1880 when the standard calendar convergence began. The mostly localized movement facilitated itself much
more swiftly in urban areas than in the broad agrarian landscape. The shape of high school also quickly morphed from a resource offered to the few and privileged to an expansive network of learning facilities available to the masses. Goldin and Katz describe the change as follows:

High schools at the turn of the century were elite institutions that prepared the children of the wealthy and the fortunate for occupations in offices and for those that required a college degree. The restricted number of individuals who could potentially enter office jobs around the turn of [the] century gave rise to the notion that they were members of a ‘non-competing group.’

The decline of certain non-competing groups marked the beginning of the supply side shift in American education. In particular, the growth of educated laborers in the early twentieth century, combined with a larger division of labor in many industries, resulted in a decreased wage premium for the higher educated.

5.1.2 Early Demand Side Responses

Coupled with these supply side shifts was the noted advancement of technological innovations. With technological progress came lower costs for information services and the increased demand for complementary skilled workers; competition rather than deskilling was the predominant force. Such demand shifts can be categorized as either inter-sector, where labor movement stemmed from changing product demand patterns and factor input cost and availability, or intra-sector, a much more elusive phenomenon to describe. Table 5 illustrates the inter-sector shifts in employment in the United States from 1910 to 1940. Most striking is the pattern of growth of those sectors which employed disproportionally more high-school workers – sales, clerical, managerial and professional. The aggregate economy was changing as laborers migrated from the farm to the office. High-ability workers earned higher wages

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1 Fischel, 32.
3 A male office worker in 1914 earned 1.7 times what a male production worker did, but only 1.1 times in 1926. Ibid., 4.
4 White collar employment (professional, managerial, clerical and sales) increased from 17.6% of total employment in 1900 to 31.1% in 1940. Ibid., 26.
and sectors which employed more high-ability workers paid higher average wages. Thus, the inter-sector demand shifts in the first half of the twentieth century contributed to the rise in education’s wage premium.

Table 5

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>Occupational Distribution, Males and Females</th>
<th>Fraction H.S. Graduate</th>
<th>Fraction ≥ 10th Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900</td>
<td>1910</td>
<td>1920</td>
<td>1930</td>
</tr>
<tr>
<td>Professional</td>
<td>0.043</td>
<td>0.047</td>
<td>0.054</td>
</tr>
<tr>
<td>Managerial</td>
<td>0.058</td>
<td>0.066</td>
<td>0.066</td>
</tr>
<tr>
<td>Clerical</td>
<td>0.030</td>
<td>0.053</td>
<td>0.080</td>
</tr>
<tr>
<td>Sales</td>
<td>0.045</td>
<td>0.047</td>
<td>0.049</td>
</tr>
<tr>
<td>Craft</td>
<td>0.105</td>
<td>0.116</td>
<td>0.130</td>
</tr>
<tr>
<td>Operative</td>
<td>0.128</td>
<td>0.146</td>
<td>0.156</td>
</tr>
<tr>
<td>Laborer</td>
<td>0.125</td>
<td>0.120</td>
<td>0.116</td>
</tr>
<tr>
<td>Service, private</td>
<td>0.054</td>
<td>0.050</td>
<td>0.033</td>
</tr>
<tr>
<td>household</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service, other</td>
<td>0.036</td>
<td>0.046</td>
<td>0.045</td>
</tr>
<tr>
<td>Farmer</td>
<td><strong>0.199</strong></td>
<td><strong>0.165</strong></td>
<td><strong>0.153</strong></td>
</tr>
<tr>
<td>Farm Laborer</td>
<td><strong>0.177</strong></td>
<td><strong>0.144</strong></td>
<td><strong>0.117</strong></td>
</tr>
<tr>
<td>All Occupations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-agricultural</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The fraction of high school graduate is that with 12 or more years of schooling in the 1940 PUMS; ≥ 10th grade is fraction with 10 or more years of schooling in the 1940 PUMS.  
Source: Transferred from Goldin and Katz, “The Decline of Non-Competing Groups,” 11; in which data were compiled from Kaplan and Casey’s *Occupational Trends in the United States, 1900 to 1950* (1958) and the 1940 IPUMS.

Intra-sector demand shifts, much more difficult to quantify, have often been treated as residual shifts in wage premium analyses. These shifts are linked to the term “skill-biased technological change” in which only groups possessing certain skills benefit from innovation and process-based advancements. Higher educated workers were in high demand in the early part of the twentieth century, predominantly in more dynamic industries. As a result, the value of a secondary-school education and the associated wage premium increased.

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5.1.3  Continued Technological Change and the Value of Education

Clearly, the demand for and the supply of educated labor act as separate forces in the realization of skill value and wage premiums, yet the interaction of the two is what defines the true meaning of the trends. If the increase in the supply of relatively higher-educated workers occurred without any significant demand-side response, wage premiums would eventually be reduced to an inconsequential level where wage inequality would exist only in the form of demographically discriminative forces. The return to a year of high school and college reached its valley around 1950; by then the rise of public schooling had made access to formalized education virtually universal. In this sense, the supply-side forces dominated the demand-side for much of the first half of the twentieth century, which kept wage premiums mostly on the decline. After 1950 the rise in demand, however, outweighed any supply-side increase due to the diffusion of technological innovations and their complementary need for skilled laborers. Figure 3 shows the evolution of the rates of return to a year of formal secondary and tertiary education from 1914 to 2005.

Based on the trends depicted in figure 3 something occurred around 1950 to reverse the wage premiums for educated laborers. Goldin and Katz explain this idea by comparing education or skill to a “good” using basic microeconomics – “If both the relative price and the relative quantity of a good (in this case, skill) increase, then the demand for the good (skill) must have been increasing at a rate greater than that of the supply of the good (skill).”\(^6\) Using their example, the “price” of skill is meant to represent the wages paid to skilled workers and the “quantity” is the level of employment achieved by skilled workers.

5.1.4  The “Baby Boom” and the Rise(!) of Wage Premiums

The Baby Boom generation’s maturation reached its tertiary stage of formalized schooling right around 1970. Appropriately, the supply of college-educated laborers increased

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\(^6\) Ibid, p.95
drastically and the college wage premium decreased throughout the decade (see table A3). The college wage premium’s modest increases throughout the 1950s and 1960s were offset by the shift in supply that occurred in the 1970s. Just as the “high school movement” of the early twentieth century created secondary educational access for much of the country’s youth, the development of the public university system, reaching its apex in the 1970s, provided higher education for the relatively larger cohorts of high school graduates. Moreover, as many of these students graduated from universities the labor market was flooded with a young, eager, and – most importantly – cheap labor force. Table A4 depicts the labor supply shifts for the 25-year period dominated by the Baby Boomers (see appendix A). It is quite apparent the cohorts containing female, highly-educated and inexperienced laborers made the most significant gains in the aggregate labor force during this time.

Figure 3. Return to a Year of School

![Graph showing return to a year of school](image)

Notes: “Young” means 0 to 19 years of potential work experience. “All” means 0 to 39 years of potential work experience. Returns to high school and college taken from 1915 Iowa State Census Sample, 1940 to 1990 IPUMS, 1990 and 1996 March CPS, and 1995 and 2005 CPS MORG.

Source: Goldin and Katz, The Race, 84-5.

7 The public sector of university education accounted for 70% of four-year students in 1970, its peak in the twentieth century. Furthermore, public college tuition costs, averaging 4% of median family income were relatively low compared to decades prior to and after the 1970s. Ibid., 278.
However, total reliance on the relative supply of educated laborers to determine the time pattern shifts in the wage premium is considered a bit audacious. While the Baby Boomer’s boost in the supply of educated workers plainly contributed to the assuagement of the wage premium throughout the 1970s, the time period immediately thereafter showed a stark divergence. Katz and Murphy touch on this topic in a 1991 paper,

Thus, when looking across [demographic] groups, differential supply growth alone seems like an unlikely candidate to explain the observed changes in relative wages for the entire period. These findings indicate that demand growth was an important component of the change in factor prices over the period as a whole and particularly during the 1980s.8

The relative supply of highly educated workers continued to rise post-1980, yet the premiums received by these workers rose at the same time, marking the difference between the 1970s and the decades since. Relative demand for highly-educated laborers grew at a faster rate for the period 1970-95 than in 1940-70. Relative supply mirrored this comparison, yet the acceleration in the secular growth rate of relative demand was markedly higher.9 These trends construct the notion of skill-biased technological change, where skilled employees are best suited to meet the need for applied knowledge, technical ability and problem-solving capacity. Goldin and Katz describe this increased utilization of skill:

A clear positive relationship has been found between the relative employment of more-skilled workers and measures of technology and capital, such as computer investments, the growth of labor computer use, R&D expenditures, the utilization of scientists and engineers, and increased capital intensity.10

The fractured pace of technological intensity and skill-upgrading across industries was critical to the creation of substantial skill-bias and wage premiums – phenomena the country has yet to reverse.

5.1.5 Adding it All Up

Based on the supply and demand shifts reviewed in subsection 5.1 a few conclusions can be made about the role of education in the aggregate economy. First, technological change

10 Goldin and Katz, The Race, 98.
played a critical role in determining the value of education amongst different labor markets. It is supposed that in the absence of steep skill-biased technological change educational wage premiums would have declined considerably through the mid-1900s and into the 2000s. As it stands, the comparison of the twenty-year periods 1960-80 and 1980-2000 reveals an extreme disparity in relative wage change (see table A.3). The latter period’s positive growth may have been tempered without the aid of skill-biased technological change. Second, the accessibility of public education has always influenced the quantity of skill present in the overall labor market. The “high school movement” and the expansion of public universities both resulted in noted declines in skill premium during the interwar period and the 1970s, respectively. Compression of wages was often the result of large cohorts progressing relative to the average group via attainment of education and skill.

Finally, and sequential to the first two conclusions, supply or demand shifts alone are misrepresentative of the changes in wages and quantity of labor. Technology and its complementary users – educated workers – did not act independent of other labor forces. Likewise, the results of formal education initiatives did not solely determine wage outcomes. Rather, the marriage of supply and demand-side forces consistently determined the role and value of education throughout the economy. The results have been far from consistent; however, the evolution of supply and demand changes can be traced accurately. The collective patterns and examples discussed in this subsection, despite not explicitly describing the agricultural labor economy, remain germane to this thesis.

5.2 The Decision to Mobilize

The previous subsection’s discussion of aggregate economic and educational patterns throughout the United States serves as a logical segue to this subsection’s topic. Increasingly, farmers have made the decision to mobilize away from the agricultural labor market toward the general economic environment surrounding many rural areas. Opportunity and necessity
have been recognized as conflicting forces behind such decisions. No matter what the basis for mobilization, the pattern is apparent: agricultural production laborers have become more reliant on off-farm wages over the last half of the twentieth century.

A theme central to the phenomenon of farm-to-nonfarm labor migration is the unpredictability of agricultural returns. “Fluctuations in farm output, commodity prices, and business cycles are major causes of farm income variability.”\(^\text{11}\) Additionally, the demand structure for crop staples like grain, cotton and soybean became less domestically weighted over the years and thus more vulnerable to foreign import policy shifts. Even still, the U.S. government has always maintained a dominant role in farming success through various policies to determine market prices for major agricultural commodities. The Food and Agricultural Act of 1965 largely reversed prior decisions to preserve food price stability via intergovernmental loan initiatives.\(^\text{12}\) The Act essentially opened the door to world exportation of U.S. agricultural goods and the collective invariability which accompanied such a large trade arena. Table 6 depicts the extreme variation in net farm income for most of the twentieth century and highlights the fact that this variation has not weakened in more recent decades. The other notable governmental policy introduced in the twentieth century was the Federal Agriculture Improvement and Reform Act of 1996 (FAIR). FAIR altered governmental support payments by removing their link with farm prices and allowing farmers to react to market forces rather than payment program constraints.\(^\text{13}\)

As evidenced by table 6, the returns to agricultural production are far from consistent. Consequently, many farmers turned to off-farm employment to increase total household income and to temper the effects of farm return variability. These two objectives align with the ‘necessity’ force mentioned in the beginning of this section. Many farmers found

\(^{11}\) Mishra and Sandretto, 209.
themselves in need of supplementary income that can only be earned off of the farm. The number of farmers reporting working off the farm more than doubled from 1944 to 1997.\textsuperscript{14} Parallel with such individual motives are collective trends that tend to “pull” laborers away from agricultural production. Income stability has also been a deciding factor in labor mobility. “Off-farm income appears to smooth out income flows because off-farm wages are generally less variable than on farm sources of income.”\textsuperscript{15} Independent from the ‘necessity’ force described is the ‘opportunity’ aspect of off-farm labor patterns. While this force is believed to be minor compared to the ‘necessity’ cause, specific socioeconomic variables can predict the propensity of farmers to try their hand at off-farm jobs. The following subsection will address these factors.

<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
<th>Average Yearly Variation in Real Net Income (Aggregate)</th>
<th>Average Yearly Variation in Real Net Farm Income (per Farm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>± Million Dollars ± Percentage</td>
<td>± Dollars ± Percentage</td>
</tr>
<tr>
<td>1933-38</td>
<td>Post-Depression recovery</td>
<td>8 784 ± 34</td>
<td>1 859 ± 34</td>
</tr>
<tr>
<td>1939-48</td>
<td>World War II</td>
<td>7 812 ± 12</td>
<td>994 ± 6</td>
</tr>
<tr>
<td>1949-59</td>
<td>Post-WWII boom, Korean War and postwar readjustment period</td>
<td>8 093 ± 12</td>
<td>1 157 ± 9</td>
</tr>
<tr>
<td>1964-73</td>
<td>Vietnam War</td>
<td>8 457 ± 16</td>
<td>4 183 ± 23</td>
</tr>
<tr>
<td>1979-84</td>
<td>Farm crisis period</td>
<td>12 159 ± 39</td>
<td>6 019 ± 47</td>
</tr>
<tr>
<td>1985-95</td>
<td>Post-farm crisis period</td>
<td>5 202 ± 12</td>
<td>3 538 ± 17</td>
</tr>
<tr>
<td>1996-99</td>
<td>Post-FAIR\textsuperscript{b} Act</td>
<td>7 034 ± 18</td>
<td>3 648 ± 21</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Selection of periods was made based on the landmark dates in American history, in terms of both agriculture and the economy as a whole.

\textsuperscript{b} Federal Agricultural Improvement and Reform Act of 1996.


\textsuperscript{14} According to agricultural census results, 27% of farmers reported off-farm work in 1944 compared to 58% in 1997. Mishra and Sandretto, 216.

\textsuperscript{15} Nehring, Fernandez-Cornejo, and Banker, 633.
5.2.1 Characteristics of Mobile Laborers

Farmers seeking off-farm employment for opportunistic reasons may evidence specific characteristics that contribute to one’s success more than those farmers making the shift out of necessity. Prior studies of off-farm labor movements have indicated some prevailing socioeconomic traits in those working away from the farm regardless of their motives. First, farm size has an inverse relationship with the share of off-farm income earned; large commercial farms have very little reliance on off-farm income.16 Another aspect of the physical farm land that is telling of the pattern of off-farm employment is the degree of specialization the farm boasts. It is understood that some farm types have higher labor and management requirements, such as dairy, egg, and melon producers. Conversely, general crop producers and cash grain operators tend to have higher off-farm income shares because their operations allow them to do so.17 Such producers are more easily able to work off-farm due to labor substitution on the farm. The opportunity cost of their labor mobility was diminished by the hired labor’s adaptability to general crop production practices.

A few characteristics which emphasize the heterogeneity of the agricultural labor force are age, education, and farming experience. Specific to the decision to seek off-farm labor, generally younger, less-experienced and higher-educated workers are more likely to mobilize and much more likely to succeed in doing so.18 The statistical analysis portion of this thesis will study the relationship between county-level education and the degree of off-farm employment to compare with earlier studies in the field.

16 Ibid., 647.
17 Mishra and Sandretto, 216.
5.2.2 Geographical Influence

“The prospect of low earnings in agriculture and the difficulties of becoming established in farming, along with the attractions of nonfarm employment and urban living, have caused a large out-movement of young adults from the farm population.”\(^{19}\) A final point imperative to labor mobility is the physical distance from farm to city. Increasingly, the general economic environment became influential to farm operators as off-farm income became more important to their well-being. This was particularly evident in more urban areas where access from periphery to center was more available and off-farm labor demand was present.\(^{20}\) For the first time, urban factors not directly related to farm production demand were an important variable in farm labor decisions. Accordingly, farm regions adjacent to urbanized areas were affected more than isolated regions throughout the country.

5.3 Conclusion

Throughout this chapter education has been described as a shifting phenomenon with substantial ties to social, economic, and industrial variables in the United States. Starting with the diminution of the one-room school in the beginning of the twentieth century, the function of education in society prevailed. Formal schooling was quickly recognized as a means for labor preparation and social transferability, progressions typically made from rural to urban. Moreover, for many farm-based children the opportunity cost of formal schooling decreased due to the rising value of knowledge and skill in the general economy. Following grade-based curriculum’s replacement of the one-room school’s forgiving pedagogical structure, school consolidation efforts were made to replicate scholastic achievements in farming regions with those in urban areas. The second half of the twentieth century marked a considerable slowdown in educational attainment, even in rural areas. As younger age cohorts replaced

\(^{19}\) Waldo, 1239.
\(^{20}\) Nehring, Fernandez-Cornejo, and Banker, 648.
older groups, the average educational attainment in non-metro counties increased through the end of the century; however, high school graduation percentages were virtually unchanged for new cohorts in the last thirty years.

Education’s progression throughout rural America, while interesting in its own right, is more noteworthy when associated with production and labor trends. This chapter has highlighted the major patterns and characteristics of formalized education in farming regions, but has also reviewed some remarkable correlations involving educational attainment. Formalized schooling has been found to correspond with increased productivity, higher earnings and inequality, and increased propensity to mobilize. Analyzing school effects in agricultural regions is particularly compelling due to its bi-regional reach. First, a rise in educational attainment can promote increased agricultural productivity and a more prominent farm wage premium. Additionally, increased schooling has been attributed to the mobilization of traditionally farm-based laborers toward off-farm employment, often in urban areas. This dynamic relationship has historically made associated research highly insightful and academically relevant. The studies discussed in this chapter exemplify this notion with no exception. In such dynamism lies the link between the historical accounts told and the analysis of more recent time periods to be accomplished in this thesis. The thesis’ intensified study to be performed on the Heartland region represents an accurate means for the continued examination of human capital in a predominant farming area. While national supply and demand trends would have predictable merits, a regional county-level analysis should highlight material differentiation amongst county success and the distance of education’s socioeconomic reach into agricultural.
CHAPTER 6
DATA AND MEASURES

6.1 Introduction

As has been stated throughout, the objectives of the thesis are to explore the relationships between educational attainment and agricultural productivity, farmer earnings, and off-farm labor mobility; and fitting such objectives to the proper statistical model is a critical process. Essentially, the thesis includes three distinct data sets, each associated with one of the three primary statistical objectives defined. The three data sets, however, share the same time and space dimensions, specifically the years 1970, -80, -90, and 2000, and the United States counties of the Heartland agricultural region.¹ A set of measurements that applies to a case at different periods of time is considered a time series; and a set of measurements that applies to different cases at a single period of time is referred to as a cross-section. Yet, data sets like the three used in this thesis combine cross-section and time series data to form what are known as panel data sets.²

The advantages of panel data sets, as briefly summarized below, are numerous. A continuation of the merits and characteristics of panel data can be found in chapter 7. Via the combination of time series and cross-section observations, panel data give “more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency.”³ In short, panel data are representative of the dynamics of change over time and

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¹ Up to this point the number of counties has been defined as 539. However, prior to the start of any quantitative analysis it was vital to assess any deficiencies in the county-level data. Due to missing information eleven counties were eliminated from the case set. These counties are: Brown, IN; Crawford, IN; Floyd, IN; Ohio, IN; Switzerland, IN; Camden, MO; Crawford, MO; Dallas, MO; Linn, MO; Montgomery, MO; and Washington, MO. Therefore, as will be indicated forward, the case set includes 528 counties.
between cases. The objectives of the thesis justified, at minimum, a cross-sectional analysis of the role of educational attainment. Nonetheless, the availability of county-level data (cross-section) at various time periods warranted the expansion of quantitative study to a panel data analysis, thus incorporating the influence of time on education’s role in productivity, earnings, and mobility. This is not to say that panel data modeling is without considerable estimation and inference problems. One way to think of the modeling risks is to consider the additive nature of the inherent flaws in cross-section and time series dimensions. Panel data are subject to both types of problems.

The scale of the thesis’ data sets – county-level – is the result of conscious consideration of the analytical significance of and the accessibility to data. Consistent and representative cross-sectional data was unavailable for years prior to 1969 for any case scale narrower than state-level. Additionally, individual farm data available via the Integrated Public Use Microdata Series (IPUMS) derived from federal censuses presented an unwanted degree of disaggregation. Wallace Huffman’s studies often utilized county-level data as opposed to individual farm records because:

[The] specification errors from fitting an economic model, which at best captures the effects of only the most important variables on individual firm behavior, to individual firm data may be larger than the aggregation bias resulting from fitting the model to county aggregate data. Furthermore, county aggregates are small units, and county averages have a relatively large amount of inter-unit variation…

Furthermore, it could be posited that production method and industry skill spillover is a more realized phenomenon on the individual farm-level, as opposed to the county-level. The time periods measured in the thesis result almost entirely by the availability of the data. It could be argued that a study of educational effects throughout the middle of the twentieth century could present more meaningful and disparate results considering the dynamic expansion of the formalized school system throughout the 1940s, -50s, and -60s. Nevertheless, the decades from 1970 to 2000 present a more level landscape of educational attainment in rural America

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making the output and income variations between counties more noteworthy than the
differences over time. This will be discussed further in chapter 7.

Subsection 6.2 details every variable employed in the three data sets. Data sources,
formats and constructions are explained so as to prevent any misrepresentation of the results.
As mentioned above, chapter 7 provides a comprehensive review of the statistical models
utilized in the study, and insight into how the models fit the quantitative objectives of the
thesis. All discussions of statistical results are reserved for chapter 8.

6.2 Data Descriptions

The data collected for this thesis was derived from a variety of government sources. It was
critical to the thesis’ hypotheses that data was compiled on a cross-sectional and time series
basis to allow for meaningful and unique quantitative analyses. The data set for this thesis is
comprised of 528 counties in the Heartland region, an area known for having the largest
percentage of farms in the United States, as well as the largest concentration of corn and
soybean acreage. Figure B1 depicts the nine agricultural regions and highlights a few key
facts about each (see appendix B). County-level data was collected for four consecutive time
periods; when available, the years 1970, -80, -90, and 2000 were used. However, all data
from the USDA censuses were taken from the most appropriate census year. For example, the
1992 USDA Census data was compared to any other data representative of 1990. Any further
data manipulations are described in the particular variable’s sub-subsection.

The three major statistical objectives are each associated with a unique data set, yet
some variables were used in more than one data set. The following data descriptions are
shown per the data set they appear in.

\footnotesize
\textsuperscript{5} The Heartland region is one of nine agricultural resource regions demarcated to generate specific geographic
areas that maintain homogeneity with regard to “resource and production activities”. Data on land characteristics
and commodity production are more easily classified because of these resource regions. The eight other regions
are: Northern Crescent, Eastern Uplands, Southern Seaboard, Mississippi Portal, Prairie Gateway, Northern
Great Plains, Basin and Range, and Fruitful Rim. Craig Gundersen and others, “A Safety Net for Farm
6.2.1 Education and Output

6.2.1.1 Output

Corn output was measured for all counties in the 1970, -80, -90, and 2000 time periods. All data was taken from the USDA’s National Agricultural Statistics Service (NASS), one of the two USDA agencies responsible for statistical reporting and agricultural economics research.\(^6\) Its largest statistics database, Quick Stats, provides a comprehensive online resource to query by commodity, geography and year. Corn output per-county was taken from Quick Stats and appears as the number of bushels produced per-county.\(^7\) These county estimations are assembled via quarterly and end-of-season surveys distributed each year, where expected sampling errors are unavoidable. The output variable appears in natural log form in the econometric model used.

6.2.1.2 Land

Land size data were measured for all counties by compiling data from the U.S. Census Bureau’s online database USA Counties\(^\text{TM}\). The data represents the total acres of farmland for each county. This USA Counties\(^\text{TM}\) data was originally collected via USDA censuses; therefore, USDA census years – 1978, -82, -92, and 2002 – were matched with the closest decade time points in the study. These land estimations are made by the USDA per their census surveys, completed on a wider scale than any additional annual surveys. Sampling errors are still a reality, however. The land variable appears in natural log form in the econometric model used.


\(^7\) A bushel of corn equals 56 lbs./25.4kg
6.2.1.3 Corn to Total Farm Land Ratio (%)

This simple ratio was calculated by dividing the area specifically harvested for corn (acres) for each county, as taken from NASS Quick Stats, by the total farm land (acres) for each county. Such a ratio provides an indicator of the level of concentration and dependency a county has on corn production versus all other crop and animal operations. This explanatory variable appears in percentage form in the econometric model used.

6.2.1.4 Agricultural Chemicals and Petroleum

Expenditures on fertilizer, lime and chemicals (agricultural chemicals) and petroleum products were measured for all counties in the 1970, -80, -90 and 2000 time periods. All data came from the Farm Income and Expenses section of the BEA’s Regional Economic Accounts database. The agricultural chemicals data represent money spent on fertilizers, lime and pesticides by all farms in a county during a given calendar year. The 1970 data set includes expenditures only on fertilizers and lime, as pesticides and other agricultural chemicals were not tracked prior to 1978. The petroleum products data represent the money spent on petroleum products by all farms in a county during a given calendar year. Together, these two expense categories were used as a proxy for a machinery and technology input estimate for each county. While they do not represent an actual measure of machinery used in each county, they provide a relevant indicator of modern farming practices used. Considering the dominant presence of corn production in the Heartland region, as well as the fact that corn boasts the highest fertilizing costs per-acre among major field crops, the data was not converted to estimate solely for corn production costs. This thesis was comfortable treating the BEA data as satisfactorily representative of corn production only, and did not opt for an estimated translation of the data gathered. All dollar amounts were adjusted for inflation and

translated to 1990 dollars using the Bureau of Labor Statistics (BLS) Inflation Calculator.\(^9\)

The chemical and petroleum expense variables appear in natural log form in the econometric model used.

6.2.1.5 Educational Attainment (\%)

Educational attainment data were measured for all counties in the 1970, -80, -90, and 2000 time periods. All data were taken from the USDA Economic Research Service’s (ERS) online county-level data sets. The ERS compiles educational completion percentage data from the U.S. Census Bureau’s records for each county and categorizes it into four groupings: “Less than high school”, “High school only”, “Some college”, and “College degree”.\(^{10}\) This classification scheme was altered to produce two significant education indicators capable of contributing more comprehensible statistical results. The two education variables are the percentage of county population with: (1) at least a high school degree (everyone that has graduated form high school), and (2) a university degree.

These educational attainment estimates represent entire county populations (persons twenty-five and older) and not simply farm proprietors or laborers. It is quite possible that estimates specific to agricultural production workers might present an alternative percentage breakdown; however, these are the only statistics available on the county-level. The ERS provides a vast amount of educational data showing the disparity between urban (metro) and


\(^{10}\) For 1970 and 1980, the share of adults with less than high school includes those who had not completed the 12th grade. In 1990 and 2000, the share includes those who did not receive a high school diploma or its equivalent (such as a GED). For 1970 and 1980, the share of adults with high school only includes those who completed 12th grade only. In 1990 and 2000, the share includes those who completed 12th grade and received a high school diploma or its equivalent (such as a GED), but did not report college experience. For 1970 and 1980, the share of adults with some college includes those who completed from one to three years of college. In 1990 and 2000, the share includes those who reported completing at least one year of college but did not receive a bachelor’s degree. For 1970 and 1980, the share of adults who are college graduates includes those who completed at least four years of college. In 1990 and 2000, the share includes those who received a bachelor’s or higher degree. “ERS/USDA Data – County-Level Education Data,” U.S. Department of Agriculture – ERS, [http://www.ers.usda.gov/Data/Education/](http://www.ers.usda.gov/Data/Education/) (accessed 2010-03-12).
rural (non-metro), yet the entirety of such information is categorized by county lines. Thus, the disparities reviewed are simply differences within the county data used in this thesis. Finally, a year-based interval scale of schooling attained would have been preferred in order to analyze the returns to education; nevertheless, this data was not available on the county-level.

6.2.1.6 Year

Binary dummy variables representing each time period that data was gathered for were created: 1970, -80, -90, and 2000. The reference variable used was 1970; the three other binary dummy variables were thus compared to the reference year.

6.2.2 Education and Earnings

6.2.2.1 Per-capita Farm Income

Farming income figures were measured for all counties in the 1970, -80, -90, and 2000 time periods. All data came from the Farm Income and Expenses section of the BEA’s Regional Economic Accounts database. Total Farm Labor and Proprietors’ Income represents the net income of sole proprietors, partners, and hired laborers; but excludes the non-family farm corporations’ income. All income is derived only from “the current production of agricultural commodities, either livestock or crops.” All income figures were adjusted for inflation and translated to 1990 dollars. Additionally, the income totals were divided by the total farm employees in each county. The creation of this ratio variable was key so that a per-capita filter could be applied to the income totals obtained. The income dependent variable appears in natural log form in the econometric models used.

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6.2.2.2 Age

Age data were measured for all counties in the years 1974, -82, -92, and 2002. All data were taken from USDA censuses. Such censuses utilize mail-out/mail-back data collection to reach all individuals and businesses associated with agriculture, based on prior censuses, Internal Revenue Service (IRS) administrative records, and existing USDA database records. The age data collected for this thesis represent the average age of farm operators in each county. Additional age details evidencing the number of operators in specific age groups were available for the 1992 and 2002 USDA Censuses; however, because such information was unavailable for all census years only the average age statistic was used. The data were matched with the closest decade time points in the study (e.g. 2002 USDA Census data with 2000 time point).

6.2.2.3 Rurality Indicator

Code-system data were taken from the USDA’s ERS classification scheme dedicated to measuring degrees of rurality. Based on 1970 U.S. Population Census data, the classification system was originally developed in 1975 and subsequently updated with each new decennial census. The current system, released in 2003, determines rurality based on 2000 U.S. Population Census data. The Rural-Urban Continuum Codes “distinguish metropolitan (metro) counties by the population size of their metro area, and nonmetropolitan (non-metro) counties by degree of urbanization and adjacency to a metro area or areas.” The classification system currently consists of nine – three metro and six nonmetro – groupings based on the official metro-nonmetro status announced by the Office of Management and Budget (OMB). The three earlier versions of the classification system contained ten groupings due to an additional metro county descriptor that distinguished counties with a population of at least one-million between “central” and “fringe”. See figure B2 in appendix B for detailed maps showing the 1993 and 2003 classification systems. “ERS/USDA Briefing Room –

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13 All farm operators are asked for standard information like crop acreage, quantities harvested, inventories, product values, land use, hired laborer use, and operator characteristics. Selected operators are asked to provide additional details on production expenses and farm-related income. First gathered as part of the 1840 U.S. Population Census and continuing as such through 1950, the separate USDA census began in 1954 and occurred every five years. There was a census taken in 1978 and then in years ending in “2” or “7” forward. The next census will occur in 2012. “Census of Agriculture – Publications,” U.S. Department of Agriculture – NASS, http://www.agcensus.usda.gov/Publications/1992/General_Information/index.asp (accessed 2010-04-13).
14 The classification system currently consists of nine – three metro and six nonmetro – groupings based on the official metro-nonmetro status announced by the Office of Management and Budget (OMB). The three earlier versions of the classification system contained ten groupings due to an additional metro county descriptor that distinguished counties with a population of at least one-million between “central” and “fringe”. See figure B2 in appendix B for detailed maps showing the 1993 and 2003 classification systems. “ERS/USDA Briefing Room –
classification system was used in this thesis to account for each county’s urban population size and the functional adjacency to a metro area or areas. These factors are important when considering the magnitude of farm operators’ decisions to seek alternative, off-farm employment, as well as the overall geographic influence of farm earnings. The rurality indicator appears as nine binary dummy variables in the econometric models used, with the most metropolitan code, 0, as the reference.

6.2.2.4 Economic Typology

Code-system data were taken from the USDA’s ERS county typology, created to help identify the economic and social characteristics of every county in the United States. Primarily developed for policy implications, this typology is useful to simply identify chief economic activities in each county. The only category used in this analysis is “farming-dependent”. The format of the data is a ‘yes’/’no’ binary indicator, and the typology was completed in 1979, 1989, and in 2004. The 1979 typology was used in the 1970 and 1980 time series; the 1989 version in the 1990 series; and the 2004 version in the 2000 series.

6.2.2.5 Corn to Total Farm Land Ratio (%)

See sub-subsection 6.2.1.3 above.

6.2.2.6 Educational Attainment (%)

See sub-subsection 6.2.1.5 above.

6.2.2.7 Year

See sub-subsection 6.2.1.6 above.


15 The qualifications for a county to be identified as “farming dependent” for the 2004 system are either 15% or more of average annual labor and proprietors’ earnings derived from farming during 1998-2000 or 15% or more of employed residents worked in farm occupations in 2000. Prior qualifications consisted solely of a labor share requirement (20%). “ERS/USDA Briefing Room – Measuring Rurality: 2004 County Typology Codes,” U.S. Department of Agriculture – ERS, http://www.ers.usda.gov/Briefing/Rurality/Typology/ (accessed 2010-04-13).
6.2.3 Education and Mobility

6.2.3.1 Off-farm Employment (%)

Off-farm employment data were collected for all counties in the years 1974, -82, -92, and 2002. All data came from USDA censuses. The employment data collected is in the form of the number of operators in defined ranges of days who worked off of the farm during a given calendar year.\(^{16}\) Each categorical sum was divided by the total number of farmers whom reported none or any days worked off-farm to derive percentages. The only ranges of days worked off-farm used as dependent variables in the econometric models were “200+” and “any”. These independent variables appear as percentages in the models.

6.2.3.2 Per-capita Personal Income

Personal income data were measured for all counties in the 1970, -80, -90, and 2000 time periods. All data came from the Personal Income and Employment Summary section of the BEA’s Regional Economic Accounts database.\(^{17}\) All income figures were adjusted for inflation and translated to 1990 dollars. This measure was used to calculate the differential described in the next sub-subsection, but was dropped as a separate explanatory variable from the regression models.

6.2.3.3 Farm to Personal Per-capita Income Differential

This differential was created by dividing Per-capita Farm Income (see sub-subsection 6.2.2.1) by Per-capita Personal Income for each county. The result is a valuable comparison of farm

\(^{16}\) A day worked off-farm is defined as at least four hours off the farm and does not include exchange farm work. “Census of Agriculture – 1992 – Volume 1, Chapter2: County Level Data,” U.S. Department of Agriculture – NASS, http://www.agcensus.usda.gov/Publications/1992/Volume_1_Chapter_2_County_Tables/index.asp (accessed 2010-03-30).

\(^{17}\) Calculated using the U.S. Census Bureau’s annual midyear populations estimates, personal income is “calculated as the sum of wage and salary disbursements, supplements to wages and salaries, proprietors’ income with inventory valuation and capital consumption adjustments, rental income of persons with capital consumption adjustment, personal dividend income, personal interest income, and personal current transfer receipts, less contributions for government social insurance.” “BEA: Personal Income,” U.S. Department of Commerce – BEA, http://www.bea.gov/regional/definitions/nextpage.cfm?key=Per%20capita %20personal %20income (accessed 2010-04-13).
income and general income in each county, and was used as an explanatory variable in the labor mobility econometric models.

6.2.3.4 Age

*See sub-subsection 6.2.2.2 above.*

6.2.3.5 Rurality Indicator

*See sub-subsection 6.2.2.3 above.*

6.2.3.6 Economic Typology

*See sub-subsection 6.2.2.4 above.*

6.2.3.7 Corn to Total Farm Land Ratio (%)  
*See sub-subsection 6.2.1.3 above.*

6.2.3.8 Educational Attainment (%)  
*See sub-subsection 6.2.1.5 above.*

6.2.3.9 Year  
*See sub-subsection 6.2.1.6 above*
CHAPTER 7
STATISTICAL MODELS

7.1 Interpretation of Theory

The uniting and expressive role of theory in the social sciences is one of incalculable importance. Theories have a unique compounding affect on a discipline, motivating constant consideration, argumentation, and innovation. Yet, the plausibility of such theories can be tested only through empirical analysis and correlative validity. The realization and quantification of economic theory can only be produced through empirical content. Simply put, econometric modeling can be thought of as a critical “conjunction of economic theory and actual measurements, using the theory and statistical inference as a bridge pier.”

As indicated, the presence of three distinct statistical objectives in the thesis required separate empirical models. Each objective was treated as an individual analysis, independent of one another. The data and measures described in chapter 6 were used to construct all dependent and explanatory parts of the statistical models. Educational attainment was treated as the primary explanatory variable, and its’ specific coefficients, marginal effects, and significance test statistics were studied with particular interest. That said, the full results of all regression analyses will be discussed, noting that the overall significance of a model is paramount to the results produced.

Due to the availability of sound data for the counties making up the Heartland agricultural region over a thirty-year period, and the implicit empirical advantages of the model, panel data analysis was utilized in all three objectives. As briefly described in the introduction of chapter 6, panel data offers a unique perspective by combining time series and

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1 Gujarati, 2.
cross-sectional observations. Analysis of such pooled data enhances traditional ordinary least squares (OLS) regression by measuring the changes within units of the different panels, as opposed to the differences between units.\footnote{OLS regression takes its name from the ‘best fitting’ regression line which minimizes the sum of squares of the vertical deviations of all the pairs of values (X and Y) from the regression line. Feinstein and Thomas, 98.} Specific to educational attainment, the relationships between output and income measures and the overall advancements in educational supply over time are best measured by panel data. However, OLS regressions were also used to test all three objectives and to contrast the results produced by the panel data analyses. Therefore, the OLS data was constructed by “stacking” the cross-sectional county data sets for all four time periods, and regression analysis was performed as normal.

7.2 Model Specifications

Prior to the specification of the econometric models used in the thesis, it is worthwhile to summarize the applicable hypotheses behind the three statistical objectives. Hypothesis A states that a positive correlation exists between average educational attainment percentage and output of corn, as measured on the county level in the Heartland region. This hypothesis is based on the belief that education is a production function input, similar to other forms of capital. Hypothesis B posits that a positive correlation exists between average educational attainment percentage and per-capita income earned by farm laborers, as measured on the county level in the Heartland region. Hypothesis B regards education rather as an investment that provides a return via personal earnings. Hypothesis C states that a positive correlation exists between average educational attainment percentage and the off-farm employment percentage of farmers, as measured on the county level in the Heartland region. Hypothesis D stipulates the previous hypotheses by stating that the correlative relationships between average educational attainment percentage and the dependent variables are not continuously
measured. Specifically, tertiary educational attainment may result in opposite correlations with output and earnings than secondary educational attainment.

The selection of pertinent econometric models, and their included parameters, follows the statement of hypotheses. Such models are intended to measure the inexact relationships between economic variables via the inclusion of an error term \( (u) \). All models used in this thesis are regression models, hypothesizing inexact relationships between the dependent (\( Y \)) and explanatory (\( X \)) variables. All models are intrinsically linear despite the fact that some \( Y \) and \( X \) variables are in natural log form. In other words, while some of the models are not linear in all their variables, they are linear in parameters. All regression models used are based on the OLS method for measuring the economic relationships specified in each model. As previously indicated, each objective was analyzed via two separate regression models – (1) a standard OLS regression model with pooled data and categorical time variables (dummy) to measure level differences between counties, and (2) a fixed-effects panel regression model, also with categorical time variables, to capture the impacts of changes over time in the \( X \) variables on the different \( Y \) variables, depending on the objective.

### 7.2.1 Education and Output

Several models were tested systematically through stepwise introduction of explanatory variables and the consideration of variable function form. Pursuant to such testing, specific \( X \) variables were selected. Nonetheless, the models’ rawness was unavoidable due to factor simplicity and problematic data proxies. However, the models’ crudeness was fully realized prior to the testing and is also considered when interpreting any of the results produced. The models used are described in sub-subsections 7.2.1.1 and 7.2.1.2.

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3 Gujarati, 5.
7.2.1.1 OLS Regression Model

This first objective tested the variation in output of corn (bushels) as compared to the changes in several X variables. This first model, using a standard OLS regression, follows:

\[
\ln Y_i = \beta_{1i} + \beta_2 \ln X_{2i} + \beta_3 X_{3i} + \ldots + \beta_{10} X_{10i} + u_i
\]

where,

\[
\begin{align*}
\ln Y & = \text{Output (number of bushels of corn produced)} \\
\ln X_2 & = \text{Land (number of acres of total farm land)} \\
X_3 & = \text{Total Farmland used for Corn (\%)} \\
\ln X_4 & = \text{Chemical Expense (dollars spent on fertilizers and agricultural chemicals)} \\
\ln X_5 & = \text{Petroleum Expense (dollars spent on petroleum and petroleum products)} \\
X_6 & = \text{Education (\% of population possessing at least a high school degree)} \\
X_7 & = \text{Education (\% of population possessing a university degree)} \\
X_8 & = \text{year1980 (categorical time dummy, 1970 reference)} \\
X_9 & = \text{year1990 (categorical time dummy, 1970 reference)} \\
X_{10} & = \text{year2000 (categorical time dummy, 1970 reference)}
\end{align*}
\]

Equation (7-1) also includes a stochastic disturbance (error) term, \( u_i \). The subscript \( i \) represents the \( i \)th observation, or in the case of this model, one of the 2,112 county records (528 counties x 4 time periods). The coefficients \( \beta_2, \beta_3, \ldots, \beta_{10} \) represent the partial regression coefficients; each coefficient measures the change in the mean value of \( \ln Y \), or \( E(\ln Y) \), per unit change in the corresponding \( X \) variable, holding the value of all other \( X \) variables constant. Simply put, the coefficients give “direct” effects of the explanatory variables on the independent variable.\(^4\)

7.2.1.2 Panel Regression Model

The second model used is a fixed-effects panel data regression. The same \( X \) variable combination as in (7-1) is used here:

\[
\ln Y_{it} = \beta_{1i} + \beta_2 \ln X_{2it} + \beta_3 X_{3it} + \ldots + \beta_{10} X_{10it} + u_{it}
\]

---

\(^4\) Ibid., 205.
All variables are the same as presented for (7-1); however two distinct differences between (7-1) and (7-2) exist. First, the subscript $t$ appears next to the subscript $i$ for all $X$ and $Y$ variables. The subscript $i$ still represents the $i$th observation (cross-sectional), but because panel data analysis measures the impact of changes over time the inclusion of the subscript $t$, representing the specific time period, is necessary. Second, the disturbance term $u_{it}$ no longer represents a stochastic error; rather, in a fixed-effects panel regression the error term is non-random in nature and is correlated with the $X$ variables. “In many applications, the whole reason for using panel data is to allow the unobserved effect to be correlated with the explanatory variables.”\footnote{Ibid., 650.} Therefore, $u_{it}$ is the “unobserved effect” of an entire population, in this case the counties of the Heartland region.

The use of standard OLS regression and panel regression models in this first statistical objective, as also in objectives two and three, provides comparative analytical vantage points. The standard OLS regression model explains the level differences between counties, such as the variation in educational attainment or the size of corn acreage, and how such differences relate to the dependent variable, output. However, the fixed-effects panel regression model assumes that county-specific heterogeneity is constant over the four time periods and consequently controls for any time-invariant differences amongst the counties not captured in the model itself. Therefore, the fixed-effects model essentially measures the changes within the counties between panels.

\textbf{7.2.1.3 Model Characteristics}

All results are discussed in chapter 8; however, it is important to first mention some of the models’ unsatisfactory features. One of the largest issues with the collected data was the indicator representing labor. The total number of farm employees in each county was deemed a poor proxy for a labor input specific to corn output, irrelevant to corn production’s explicit
labor requirements. A corn-specific employee estimate was constructed, but because the land variables were used the employee estimate proved to be highly correlated with the land variables.\textsuperscript{6} A second major issue with the collected data was the harvested corn land variable. This land measure was highly correlated with the dependent variable, output, and thus made interpretation of the partial regression coefficients more difficult.\textsuperscript{7} Such a relationship is not considered multicollinear; however, the root of the correlation is believed to be tautological in nature. Therefore, a land proxy representing total farmland per county was introduced to allay the correlation concerns associated with the corn-specific measures.\textsuperscript{8}

Finally, two additional education indicators were considered for the OLS and panel regression models. The indicator representing the percentage of the population without a high school degree is simply the inverse of the high school indicator used ($X_6$), making its inclusion superfluous. The indicator representing the percentage of the population with some university education was decidedly inapplicable in terms of theory and consequence, and was therefore not included in any model.

\textbf{7.2.2 Education and Earnings}

Systematic testing was completed for this second statistical objective, testing the variation in annual per-capita income earned by farm proprietors and laborers as compared to the changes in several $X$ variables. Regrettably, the models used for this objective were comparatively cruder than those used elsewhere in the thesis, mostly due to questionable independent variable representation and incomplete explanatory factors. Accordingly, the results produced by the following models should be carefully interpreted.

\textsuperscript{6} These two $X$ variables were 0.9271 correlated. This seems logical since the land variable was used to formulate the corn employee estimate.

\textsuperscript{7} These $X$ and $Y$ variables were 0.9501 correlated. This comes as no surprise, as harvested corn land is actually mentioned as an “output” by the U.S. Department of Agriculture. The only variation amongst land and output can be thought of as a productivity level directly applicable to the land itself.

\textsuperscript{8} The total farmland $X$ variable was only 0.5072 correlated with the $Y$ dependent.
7.2.2.1 OLS Regression Model

The first model used for this objective was again a standard OLS regression:

\[(7-3)\]
\[
\ln Y_i = \beta_{11} + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots + \beta_{18} X_{18i} + u_i
\]

where,

\[
\ln Y = \text{Earnings (annual per-capita income of farm proprietors and laborers)}
\]
\[
X_2 = \text{Age (average age of all farm proprietors)}
\]
\[
X_3 = \text{Rurality Indicator = 1 (ERS Rural-Urban Continuum Code)}
\]
\[
X_4 = \text{Rurality Indicator = 2 (ERS Rural-Urban Continuum Code)}
\]
\[
X_5 = \text{Rurality Indicator = 3 (ERS Rural-Urban Continuum Code)}
\]
\[
X_6 = \text{Rurality Indicator = 4 (ERS Rural-Urban Continuum Code)}
\]
\[
X_7 = \text{Rurality Indicator = 5 (ERS Rural-Urban Continuum Code)}
\]
\[
X_8 = \text{Rurality Indicator = 6 (ERS Rural-Urban Continuum Code)}
\]
\[
X_9 = \text{Rurality Indicator = 7 (ERS Rural-Urban Continuum Code)}
\]
\[
X_{10} = \text{Rurality Indicator = 8 (ERS Rural-Urban Continuum Code)}
\]
\[
X_{11} = \text{Rurality Indicator = 9 (ERS Rural-Urban Continuum Code)}
\]
\[
X_{12} = \text{Farm Dependency = 1 (ERS county typology code)}
\]
\[
X_{13} = \text{Corn Specialization (% of total farmland acres used for harvested corn)}
\]
\[
X_{14} = \text{Education A (% of population possessing at least a high school degree)}
\]
\[
X_{15} = \text{Education B (% of population possessing a university degree)}
\]
\[
X_{16} = \text{year1980 (categorical time dummy, 1970 reference)}
\]
\[
X_{17} = \text{year1990 (categorical time dummy, 1970 reference)}
\]
\[
X_{18} = \text{year2000 (categorical time dummy, 1970 reference)}
\]

The log-lin equation (7-3) mirrors (7-1) in all other aspects.

7.2.2.2 Panel Regression Model

The second model used was a fixed-effects panel data regression. The \( X \) variables used were the same as those used in (7-3):

\[(7-4)\]
\[
\ln Y_i = \beta_{11t} + \beta_2 X_{2it} + \ldots + \beta_{18} X_{18it} + u_{it}
\]

Equation (7-4) has the same disturbance term and subscripts as (7-2).

7.2.2.3 Model Characteristics

Again, data insufficiencies and elementary model specifications seemed to be the cause of unsatisfactory econometric results. Yet, the models’ inconclusiveness in this second objective
was even more of a concern. Two considerable issues were the $Y$ variable’s inconsistency and relatively high percentage of negative values. Per-capita income averages for a one-year period represent but a snapshot of the agricultural sector, and the ten-year gap between time points discredits annual fluctuations which can result in vastly disparate income measures from year-to-year. Panel models are prone to greater assumptions when too few time series are used. In the case of this second objective the variance of per-capita farm income over the three decades significantly outweighs any of the variations in education, age, or corn specialization percentage. As a result, the overall significance of the models is diminished in light of unexplained factors. The two additional education indicators mentioned in sub-subsection 7.2.1.3 were considered for inclusion in the models; however, the same conclusions were drawn and both $X$ variables were subsequently disregarded. Overall, the aggregation level of the data tested (county) may be less appropriate when considering income variation than an individual basis would be. Perhaps educational attainment could be best analyzed as a personal investment in regards to future earnings. Regrettably, the data available did not allow for many meaningful conclusions from the empirical investigation conducted in this thesis.

7.2.3 Education and Mobility

Finally, the third statistical objective tested the variation in the percentage of farm proprietors in a county working off-farm as compared to the changes in several $X$ variables. Two different $Y$ variables were regressed for each of the two statistical models in this third objective, making the magnitude of the $Y$ variable, whether “200+ days” or “any days”, relevant to the particular model’s results. Each $Y$ variable was logistically transformed so that traditional OLS regression analysis could be performed. This transformation essentially
adjusted the percentage values, bounded by “0” and “1”, so that they fit into traditional linear models.\footnote{See Note 14 in chapter 8 of this thesis.}

7.2.3.1 OLS Regression Model

The first model used for this objective was again a standard OLS regression. The two equations are shown below:

\begin{align*}
(7-5) 
Y_{1i} &= \beta_{1i} + \beta_2 \ln X_{2i} + \beta_3 X_{3i} + \ldots + \beta_{20} X_{20i} + u_i \\
(7-6) 
Y_{2i} &= \beta_{1i} + \beta_2 \ln X_{2i} + \beta_3 X_{3i} + \ldots + \beta_{20} X_{20i} + u_i
\end{align*}

where,

- $Y_1$ = Off-farm Labor (% of farm proprietors who work any days off-farm in a yr)
- $Y_2$ = Off-farm Labor (% of farm proprietors who work 200+ days off-farm in a yr)
- $\ln X_2$ = Income (annual per-capita personal income for total county population)
- $X_3$ = Income Differential (annual per-capita farm to personal income differential)
- $X_4$ = Rurality Indicator = 1 (ERS Rural-Urban Continuum Code)
- $X_5$ = Rurality Indicator = 2 (ERS Rural-Urban Continuum Code)
- $X_6$ = Rurality Indicator = 3 (ERS Rural-Urban Continuum Code)
- $X_7$ = Rurality Indicator = 4 (ERS Rural-Urban Continuum Code)
- $X_8$ = Rurality Indicator = 5 (ERS Rural-Urban Continuum Code)
- $X_9$ = Rurality Indicator = 6 (ERS Rural-Urban Continuum Code)
- $X_{10}$ = Rurality Indicator = 7 (ERS Rural-Urban Continuum Code)
- $X_{11}$ = Rurality Indicator = 8 (ERS Rural-Urban Continuum Code)
- $X_{12}$ = Rurality Indicator = 9 (ERS Rural-Urban Continuum Code)
- $X_{13}$ = Farm Dependency = 1 (ERS county typology code)
- $X_{14}$ = Corn Specialization (% of total farmland acres used for harvested corn)
- $X_{15}$ = Age (average age of all farm proprietors)
- $X_{16}$ = Education B (% of population possessing at least a high school degree)
- $X_{17}$ = Education D (% of population possessing a university degree)
- $X_{18}$ = year1980 (categorical time dummy)
- $X_{19}$ = year1990 (categorical time dummy)
- $X_{20}$ = year2000 (categorical time dummy)

Equation (7-5) and (7-6) are the same as (7-1) in all other aspects.
7.2.3.2 Panel Regression Model

The second model used was a fixed-effects panel data regression. The explanatory variables that appear in (7-5) and (7-6) are the same as those that appear in these fixed-effects models.

The two equations are shown below:

\[
Y_{1it} = \beta_{1i} + \beta_2 \ln X_{2it} + \beta_3 X_{3it} + \ldots + \beta_{20} X_{20it} + u_{it}
\]

\[
Y_{2it} = \beta_{1i} + \beta_2 \ln X_{2it} + \beta_3 X_{3it} + \ldots + \beta_{20} X_{20it} + u_{it}
\]

Equations (7-7) and (7-8) have the same disturbance term and subscripts as (7-2).

7.2.3.3 Alternative Models

Just as for the first two statistical objectives incomplete data and model specifications must be considered when interpreting results. A substantial decision was made to drop the per-capita total income variable due to its unusually large coefficients and percentage effects in all models, as well as its collinearity with the high school graduation percentage indicator (0.8374). Per-capita total income produced positive coefficients and mildly significant t-tests and p-value in all models. Additionally, per-capita total income is the denominator in the income differential variable that remained in the OLS and fixed-effects panel models, which measures per-capita farm income compared to total income.

The two additional education indicators mentioned in sub-subsection 7.2.1.3 were considered in the OLS and panel regression models, yet the same conclusions were drawn and both X variables were excluded. The OLS and fixed-effects models employed for this last statistical objective lack some consequential explanatory variables such as spousal off-farm labor percentage and hired labor expenses; however, meaningful results, discussed in the following chapter, were realized.
CHAPTER 8
EMPRICAL RESULTS

8.1 Education and Output

Table C1 displays the means, standard deviations, and coefficients of variation of the variables used in the econometric models for each of the four time periods. One can view the changes over time in the size and spread of the X and Y variables, and interpret such changes as wide-scale reflections of shifting facets of the agricultural sector. For example, high school and university graduation rates markedly improved from 1970 to 2000, with the greatest increases achieved in the first decade of the total period. Figures 4 and 5 depict the changes in aggregate educational attainment for all counties, as summarized in table C1. Interestingly, the slopes of the year lines depict opposite trends for high school and university graduate percentages. As a high school degree became more commonplace throughout the thirty-year time span, the standard deviation of university graduation percentages nearly doubled. Clearly, as more people graduated high school, a sharper disparity in tertiary education arose. These trends, while ostensibly positive, support some of the points made in subsection 4.3 in chapter 4 of this thesis. It is understood that the mean high school graduation percentage continued to increase through 2000, yet the condensation of the deviation and variation between counties is believed to be an effect of age cohort replacement.

Output has steadily increased over the four time periods, with deviation and variation levels registering about the same in 2000 as were present in 1970. This translates to overall improvement in the production function. Despite the marginal reduction in total farmland over the three decades, the percentage of farmland dedicated to corn production has increased
from 24.8% in 1970 to 31.0% in 2000, reflecting the crop’s technologically-driven spread of use, as well as the liberties granted to farmers by the 1996 FAIR Act.¹

Figure 4. High School Graduation Trends

Figure 5. University Graduation Trends

Source: ERS/USDA County-Level Education Data

Table C2 shows estimations of the pooled OLS and fixed-effects panel models by providing the coefficients, percentage effects, and $p$ values for all explanatory variables. To review what was stated in sub-subsection 7.2.1.1, each partial regression coefficient represents the change in the mean of $\ln Y$, or output, per unit change in the corresponding $X$ variable, holding the value of all other $X$ variables constant. The percentage effect offers a more comprehensible measure of the explanatory variables’ effects on $Y$; this measure indicates the percentage change in output, $Y$, of a one unit change in each corresponding explanatory variable. Also depicted are $p$-values for each explanatory variable. These probability values signify the “lowest significance level at which a null hypothesis can be rejected,” and maintain a more consequential measure of significance than conventional fixed levels, such as 5%.2

The $R^2$ in the OLS model is 0.8584, which implies that the model accounts for about 86% of the level differences between counties. The within-county $R^2$ in the fixed-effects panel model is 0.6798, which means that the model accounts for about 68% of the variation within counties over the four time periods. The overall model significance that the $R^2$ indicates would preferably have been much higher, especially in the fixed-effects panel model. This suggests that additional pertinent explanatory factors exist, such as a reputable labor indicator, as well as measures of extension and research services, and commodity price information. In fact, a study with a quite different aim could be made on how corn production has been correlated with commodity prices, global demand shifts, and governmental market interventions. Nevertheless, the models used in this thesis offer substantial support for the variations in output.

Farmland shows quite varied coefficients in the OLS and fixed-effects panel models, with the percentage effect in the OLS model registering 22% and the effect in the fixed-

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2 Gujarati, 137.
effects model a tremendous 197%. This indicates that the level differences between county outputs are much less correlated with the land input than are the within county changes. Thus, the physical size of farmland can be attributed to vast differences within county production levels over time. Schultz proclaimed that material inputs, like farmland, can be continually improved to some extent, yet the magnitude of the simple size of area’s land is unavoidable.\(^3\)

Perhaps more relevant to the fixed-effects model, though, is the fact that the quantity of farmland within counties changed very little over thirty years. So, being that the variation in output is more than double the variation in farmland may explain for such a high coefficient. The percentage of farmland dedicated to corn production’s coefficient in both models is relatively small yet extremely significant, with \(t\)-tests of 20.27 and 28.27 in the OLS and fixed-effects models, respectively. Logically, counties with higher concentrations in corn production would expect to produce relatively more corn. Although the percentage effects are only between 4.3% and 4.5%, this means that with each percentage point increase in corn-to-total farmland, an attributable increase of over 4% in output is valid. In terms of human capital, crop specialization may demand specific knowledge attained via alternative mediums from formalized secondary schooling. Such “expert” knowledge is not considered in this model; however the concept cannot be entirely ignored.

Agricultural chemical and petroleum expenditures reveal very robust coefficients and percentage effects in both models. Petroleum expenditures, however, result in opposite correlations – positive in the OLS model and negative in the fixed-effects. One possible explanation for the fixed-effects’ negative correlation is that because the petroleum expenditures are representative of all farming activities, increases in petrol use may be more associated with other crops and/or livestock operations. The agricultural expenditures variable interestingly correlates well with output (0.7680), total land (0.6602), and corn

\(^3\) Schultz, *Transforming*, 146.
concentration percentage (0.6487). The large coefficients in the OLS and fixed-effects models represent the power of fertilizers and chemicals to differentiate output between counties and also within counties over time. This runs parallel with Schultz’s theory that modern agricultural growth is largely the effect of human ability and technological change. Furthermore, modern material inputs such as chemicals and advanced machinery are irrelevant factors without proper knowledge and skills.\(^4\)

The two education variables used in the models present quite contrasting results. Two overwhelming aspects of these results are the significance of the ‘high school or greater’ percentage variable and the negative correlation of the university graduation percentage variable. Table 7 below depicts the pertinent statistics of the two educational variables’ relationship with output. The high school indicator offers solid statistical results in both models. Furthermore, it is worth mentioning that the percentage effect, although seemingly low in comparison with some of the X variables discussed above, represents the percentage change in output based on a one-unit percentage increase in county ‘high school or greater’ share. This is more meaningful than a one unit increase in yearly educational attainment, which is a common education indicator in other models. Simply put, a county’s increase in average ‘high school or greater’ percentage can equate to more than just a one year rise in attainment. The only problematic result is the university graduation percentage variable in the fixed-effects model, due to its insignificant t-test. Nevertheless, it is extremely interesting to note the negative correlation the variable has with output in both models. Such results support the thesis’ fourth hypothesis and are interpreted as evidence of tertiary education’s declination of agricultural production. The ERS Rurality Indicator, described in chapter 5, was not used in this model; however, the correlation between it and university graduation percentage is relevant. Essentially, the rurality of a county is negatively correlated with the

\(^4\) Ibid, 175.
university graduation percentage (-0.4187). Thus, university education is implied to have a negative relationship with agricultural production.

| Table 7 |
|------------------|------------------|------------------|------------------|
|                | OLS              | Fixed-effects Panel |
|                | High School University | High School University |
| Coefficient   | 0.01946   -0.01697 | 0.01829   -0.00321 |
| % Effect      | 1.97      -1.68   | 1.85      -0.32   |
| t-statistic   | 9.54      -7.28   | 6.37      -0.87   |
| p-value       | 0.000     0.000    | 0.000     0.384    |

The statistical results presented in this subsection provide a further look into the role of education in agricultural production. The coefficients and percentage effects depicted in table 7 speak to Welch’s notion of education’s “worker effect”. This effect simply refers to the increased output resulting from educational attainment. In the empirical models presented in this thesis such an effect can apply to the level differences among counties of the Heartland region and also to the changes within the counties over the last three decades of the twentieth century. Perhaps intrinsically more difficult to measure is education’s “allocative effect”, studied comprehensibly by both Welch and Huffman. This effect describes education as a decoder of sorts, which is applied to the introduction of new inputs and the altering of existing factors to advance production as a whole. The “allocative effect” remains a theoretical consideration in this thesis, yet the role of education is believed to permeate some of the models’ other explanatory variables in the form of land efficiency, chemical application, and crop specialization. The Heartland region, blessed with historically strong educational attainment rates, provided a remarkable setting for the models employed in this first objective. From the statistical results achieved secondary schooling proves quite significant in the variation of output. Contrarily, tertiary schooling reveals negative

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5 Welch, 36-7.
correlations with corn production. The additional distributive effects of human capital may indeed rest in informal educational sources, of which many may exist in contrast to tertiary schooling.

8.2 Education and Earnings

Table C3 displays the means, standard deviations, and coefficients of variation of the variables used in this objective’s econometric models for each of the four time points. As presented in the previous subsection, this table allows one to analyze the changes over time in the size and spread of the $X$ and $Y$ variables. The education variables are the same as the ones used in the empirical models appearing in the previous subsection. Figures 4 and 5, located in the previous subsection, depict the changes in aggregate educational attainment for all counties, as summarized in table C3. The independent variable, per-capita farm income, has been quite inconsistent over the four time points; its highest mean occurring in 1970 and its lowest ten years later in 1980. These findings support previous studies of the instability of agricultural income throughout the United States.\(^6\) The descriptive statistics for the $Y$ variable in 1980 are admittedly skewed due to several negative real income values that were converted to “1” so that natural logs could be computed.\(^7\) But even ignoring the 1980 results, the standard deviations and variances in 1990 and 2000 are a great deal higher than in 1970, signifying growing income disparity within the agricultural sector.

Age, aside from the 1980 measure, has steadily increased over the entire time period. This is surely due to a “persistent pattern of net outmigration from agricultural production

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\(^6\) See Mishra and Sandretto, 208-215, as an example.

\(^7\) There were 113 counties with negative real earnings in 1980, compared to only 13 for the other three time points combined. Thus, it was undesirable to simply delete these counties from the models. The natural log of 1 is equal to 0. Therefore, the mean value for 1980 is significantly lower than the other time points. Also, the standard deviation and variance statistics are unnaturally high because of the several values equal to 0.
and rural areas in general, resulting in an aging farm population.\(^8\) Also related to migratory patterns are the descriptive changes shown for the \(X\) variables, rurality and farm dependency indicators. The decline in the mean of the rurality indicator indicates a higher percentage of counties considered to be metropolitan areas. The extreme reduction in the mean of the farm dependency indicator highlights the diminished importance of agricultural production in more and more counties of the Heartland region, and the associated job growth in manufacturing, service, and other goods-producing sectors.\(^9\)

Table C4 shows estimations of the pooled OLS and fixed-effects panel models by providing the coefficient, percentage effect, and \(p\) value for each \(X\) variable. Clearly, neither model stands as a highly significant representation of the factors contributing to the variation in farm earnings. Furthermore, neither one of the two education variables included in the models produced significant explanatory results. Nonetheless, it remains fruitful to briefly review the empirical results attained from both models before discussing alternative explanations. The \(R^2\) in the OLS model is 0.2820, which implies that the model accounts for about 28\% of the level differences between counties. The within-county \(R^2\) in the fixed-effects panel model is 0.3081, which means that the model accounts for about 31\% of the variation within counties over the four time periods. These significance indicators plainly stress the voids in both models. Additional key explanatory factors exist; not least important are market supply and demand indicators, land valuation, and commodity price information. Furthermore, the ten-year intervals between time series data allow for considerable fluctuations in farm earnings. In fact, table 6 highlights such variation, including substantial differentiation within the farm crisis period that includes the 1980 time series (see page 60).


The age variable presents a negative correlation with farm earnings in the OLS model, implying that an increase in average age of one year will reduce county earnings by almost 8%, and that age is a negative contributor to the level difference in earnings between counties. Conversely, in the fixed-effects model the age variable carries a positive correlation, but an insignificant \( t \)-test and \( p \)-value. Still, it is worth noting that such a correlation presumes that with increased age comes valuable experience within counties over time. The rurality indicators’ significance measures are uniformly poor in both models. Interestingly, the percentage of land dedicated to corn is positively correlated with farm earnings and statistically significant. Although corn is not specifically analyzed in these models, higher-concentrated corn crop counties are estimated to gain higher earnings. Neither of the two education \( X \) variables produced consistently significant findings. Table 8 below depicts the pertinent statistics of the two educational variables’ relationship with farm earnings. The only statistically significant education variable is the ‘high school or greater’ percentage indicator in the fixed-effects panel, implying that a one-point increase in the high school attainment percentage contributes to a 3.5% increase in earnings. The university graduation percentage, conversely, shows a negative correlation with earnings in the fixed-effects model. Although statistically insignificant, the directional relationship mirrors that between university graduation percentage and output, as studied in the previous subsection, and as hypothesized.

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Fixed-effects Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High School</td>
<td>University</td>
</tr>
<tr>
<td>Coefficient</td>
<td>0.01050</td>
<td>0.00615</td>
</tr>
<tr>
<td>% Effect</td>
<td>1.06</td>
<td>0.62</td>
</tr>
<tr>
<td>( t )-statistic</td>
<td>1.18</td>
<td>0.61</td>
</tr>
<tr>
<td>( p )-value</td>
<td>0.240</td>
<td>0.539</td>
</tr>
</tbody>
</table>
The connection between education and earnings could be further explained via the consideration of technological advancements. Goldin and Katz theorized the relevance of skill-biased technological change on growing income disparity within sectors. Such demand-side forces are constantly altered by educational supply levels and overall demographic trends. In relation, the supply of education is determined by marginal cost analysis of schooling and/or training and the institutional resources that provide educational opportunities. In the case of this thesis’ look into Heartland region earnings, the absence of stronger statistical evidence could be contributed to the lack of farming practice differentiation that would indicate intra-sector preferences based on skill. While it has become clear that market health has had a large influence on per-capita earnings, product and process delineation may compound or temper such market forces, as well as the effect of educational attainment.

Four separate OLS regression models were tested for each time point to compare with the pooled OLS model’s results. The 1980 model was considerably worse than the other three years; however no individual model produced an $R^2$ higher than 0.3434 (1990). The statistical results presented in this subsection are proof that alternative models containing different data types are necessary to properly study the relationship between educational attainment and farm earnings. Becker’s marginal cost analysis studies remain pertinent to the valuation of education in terms of current and future earnings. Hourly or daily wages for farm laborers could be more easily related to educational attainment. Huffman compiled such data by county in a study of labor decisions on and off the farm. If annual income figures are to be regressed, then individual-level data may be more appropriate when considering the

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10 Four OLS models were tested, each containing the 528 county records for the associated year (1970, -80, -90, or 2000). The R2 values were 0.2965 (1970), 0.0524 (1980), 0.3434 (1990), and 0.2770 (2000). No consistently relevant partial regression coefficients were found amongst the four models.


12 See Huffman, “Farm and Off-Farm Work Decisions,” 14-23.
effect of education. Goldin and Katz have taken this approach in several of their studies, notably in their work with the 1915 Iowa State Census sample and various IPUMS data sets.\textsuperscript{13}

### 8.3 Education and Mobility

Table C5 displays the means, standard deviations, and coefficients of variation of the variables used in the econometric models for each of the four time periods. Like in tables C1 and C3, table C5 portrays the changes over time in the size and spread of the $X$ and $Y$ variables. Interpretations of those changes as shifting components of the agricultural sector during the last three decades of the twentieth century may be made. Steady growth in the means of the two $Y$ variables used for this third statistical objective, the percentage of farm proprietors working off-farm during the year (“any days off-farm”) and the percentage of those working specifically for 200+ days during the year (“200+ days off-farm”), is apparent from 1970 to 2000. An interesting relationship between the two $Y$ variables is the growing size of the 200+ days off-farm variable in relation to the any days off-farm variable (62% in 1970 and 70% in 2000). This implies that more farm proprietors are not only taking off-farm employment, but they are taking such employment as their primary job and presumable dominant source of income. Due to the stability in per-capita total income, the relationship between farm income and total income’s variation is entirely based on farm income’s fluctuations discussed in the previous subsection. All other variable descriptive statistics have been reviewed in the previous two subsections and will not be repeated here.

The estimations of the pooled OLS and fixed-effects panel regression models are depicted in tables C6 and C7. This third statistical objective features two OLS and two fixed-effects models since two separate $Y$ variables were used as regressands. Prior to the regression computation in the four models, logistic transformation was done on the two $Y$

variables. This transformation essentially fits the proportional values – percentages of farm proprietors working off-farm bounded by “0” and “1” – to linear terms.\textsuperscript{14} Starting with the “any days off-farm” regressions, the $R^2$ value in the OLS model is 0.6064 and the within $R^2$ value in the fixed-effects model is 0.6556. This means that about 61% of the level differences between counties and about 66% of variation within counties over time are explained by the two models. As warranted by these significance measures additional explanatory factors not included in the models undoubtedly exist. For the models with the “200+ days off-farm” regressand, the $R^2$ value is 0.6426 in the OLS model and the within $R^2$ is 0.6305 in the fixed-effects model. This implies that about 64% of the level differences between counties and 63% of the variation within counties over time are explained by the two models, respectively. The fact that the model significance factors for the “200+ days off-farm” models are extremely similar to the “any days off-farm” models justifies the inclusion of this more specific $Y$ regressand so that additional conclusions may be drawn about the mobility decisions made by Heartland farm proprietors.

The farm-to-total income differential variable presents very significant positive coefficient values in all four models, meaning that as a county’s average per-capita farm income increases in relation to the county’s total per-capita income it becomes less likely that farm proprietors will seek off-farm employment. The rurality indicator codes 4 through 9 all present statistically significant and sizeable negative coefficients in both OLS models, implying that in relation to farmers in the most urban counties, those proprietors in rural areas are much less likely to seek off-farm employment. Farmers in closer proximity to urban labor markets have long had advantageous access to a wider variety of employment opportunities.\textsuperscript{15}

\textsuperscript{14} The logistic transformation is calculated by: $\ln(Y/(1-Y))$. The original $Y$ values are converted to values that can be fit to traditional OLS regression. The transformed $Y$ variables represent the “natural log of the odds (in favor) of farmer’s off-farm labor force participation.” Furthermore, the partial regression coefficients now indicate percentage changes of the odds due to a one-unit increase in the level of the explanatory variables. Huffman, “Farm and Off-Farm Work Decision,” 18-9.

\textsuperscript{15} Hathaway and Perkins, 346.
Additionally, those farmers residing in counties with an economic dependency on farming (farm dependency indicator = 1) are substantially less likely to participate in off-farm employment, according to all four models. In fact, the farm dependency variable reveals the largest coefficients amongst all non-time dummy explanatory variables, indicating that farmers residing in the counties most indebted to agricultural earnings are more averse to and/or do not necessitate alternative labor opportunities. Neither the age nor percentage of farmland dedicated to corn production variables indicate strong or significant results in any of the models. The one notable exception is the statistically significant negative percentage effect of age in both fixed-effects models, implying that as farmers within counties get older they are less likely to engage in off-farm employment.

The two education variables used in the models offer remarkable implications into the correlation between educational attainment and labor mobility amongst farm proprietors. Table 9 portrays the pertinent statistics of the two variables in all four models. Most surprising are the variables’ negative coefficients, with the exception of university graduation percentage’s positive effect in both fixed-effects models. Many of the $t$-tests and $p$-values are insignificant; most concerning are the ‘high school or greater’ percentage variables in both OLS models.

<table>
<thead>
<tr>
<th></th>
<th>Any Days Off-Farm</th>
<th>200+ Days Off-Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS High School</td>
<td>OLS University</td>
</tr>
<tr>
<td>Coefficient</td>
<td>-0.00189</td>
<td>-0.00512</td>
</tr>
<tr>
<td>% Effect</td>
<td>-4.84</td>
<td>-11.38</td>
</tr>
<tr>
<td>$t$-test</td>
<td>-1.26</td>
<td>-3.25</td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.209</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Fixed-effects Panel High School</td>
<td>University</td>
</tr>
<tr>
<td>Coefficient</td>
<td>-0.00539</td>
<td>0.00818</td>
</tr>
<tr>
<td>% Effect</td>
<td>-13.50</td>
<td>22.09</td>
</tr>
<tr>
<td>$t$-test</td>
<td>-2.40</td>
<td>2.36</td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.160</td>
<td>0.018</td>
</tr>
<tr>
<td>Coefficient</td>
<td>-0.00208</td>
<td>-0.00793</td>
</tr>
<tr>
<td>% Effect</td>
<td>-4.72</td>
<td>-14.56</td>
</tr>
<tr>
<td>$t$-test</td>
<td>-1.13</td>
<td>-4.12</td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.258</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Fixed-effects Panel High School</td>
<td>University</td>
</tr>
<tr>
<td>Coefficient</td>
<td>-0.00203</td>
<td>0.00686</td>
</tr>
<tr>
<td>% Effect</td>
<td>-8.19</td>
<td>13.71</td>
</tr>
<tr>
<td>$t$-test</td>
<td>-0.76</td>
<td>1.65</td>
</tr>
<tr>
<td>$p$-value</td>
<td>0.450</td>
<td>0.099</td>
</tr>
</tbody>
</table>
As reviewed in subsection 3.6, the Harris-Todaro model considers rural-urban migration as often the result of urban-rural differences in expected earnings compounded by the expected higher earnings that result from additional educational attainment.\textsuperscript{16} Though, education can be viewed in a contrasting manner that may be more appropriate to the results found in this thesis. Farm proprietors with relatively high educational attainment may have trouble relying on hired labor as a substitute for their own on-farm labor, thus making their decision to mobilize off-farm subject to greater opportunity costs.\textsuperscript{17} In a sense, these proprietors’ valuation of their own time spent on the farm is too high to justify mobilization off the farm. The premise of the positive correlation between educational attainment and expected off-farm earnings is sound; however, the expectation of higher farm-specific earnings should not be ignored when considering the mobilization decisions of farm proprietors. Cochrane’s treadmill model, described in subsection 3.7, stresses the farm-specific benefits of relatively higher education, positing the opposite relationships between education and off-farm mobilization.\textsuperscript{18} Simply, those farmers lacking the competitive skills needed to adopt new technological advancements are more likely to rely more on alternative off-farm employment opportunities. Hathaway’s theory of education as a transferable tool is yet more difficult to support with the empirical data tested in this thesis. Summarily, he stated that the same characteristics which lead to success on the farm are likely to lead to similar success off the farm.\textsuperscript{19} In a way, this notion transcends the Harris-Todaro and treadmill models by praising the universality of knowledge and skill. While this thesis supports the theoretical concept of positive educational effects on and off the farm, the data analyzed fails to support such a claim.

\textsuperscript{16} Harris and Todaro, 128.
\textsuperscript{17} Sumner, 501.
\textsuperscript{18} Cochrane, 1006.
\textsuperscript{19} Hathaway and Perkins, 352.
CHAPTER 9

CONCLUSIONS

9.1 Summary of Thesis

Throughout this thesis education has been theorized and tested as a characteristic of differentiation and a generating factor in the processes of production, earnings, and mobility. The goal of this study was to emphasize the role of human capital in the agricultural production sector. More precisely, education has been considered in terms of the shifting constraints of the farming landscape and the aggregate trends in the market for skill. Furthermore, the direction and magnitude of education’s role was analyzed to posit more tailored explanations for county-level variation. The socioeconomic effects of education are admittedly complex and sometimes immeasurable. With this in mind, the intent of the thesis was to study the role of education in an explicit time and setting, namely Heartland region county-level corn production, agricultural earnings, and off-farm labor mobility for the last three decades of the twentieth century. Such an analytical limitation has allowed for customized empirical findings that are relatable to broader theories and prior studies. The Heartland region of the United States was chosen so that a disaggregated scope could be applied to a range of applicable notions of educational value.

After a comprehensive review of prior literature and relevant theories, a significant narrative was provided recounting the historical trends in formalized schooling and of the particular efforts to obtain proper education in agrarian regions. Additionally, details of the shifting aggregate sentiments of formalized schooling and the growing existence of a rural-urban divide were covered to highlight the supply and demand elements of knowledge and skill. The expansion and subsequent relative stagnation of formalized schooling in the
twentieth century was reviewed, as well. This extensive background is recognized as an essential precursor to the statistical portion of the thesis, and as an accomplished review of historical educational patterns. The thesis’ central themes certainly justified a narrative of such breadth. Nevertheless, the heart of this thesis was the original empirical study of the relationship between education and production, personal earnings, and off-farm labor mobility for 528 counties over four time points (1970, -80, -90, and 2000). Several econometric models were utilized to analyze the collected data and relate such results to appropriate theory. It was hypothesized that educational attainment, specifically a high school degree, shares a positive correlation with corn production (output), per-capita earnings and off-farm labor percentage. Furthermore, tertiary school attainment was conjectured to have opposite correlations from secondary school attainment.

The results produced by the empirical models employed were mixed in their signs and significance. Overall, it was found that the county share of persons with ‘high school or greater’ attainment indeed has a positive correlation with corn production and personal earnings, and that university graduation percentage rate has the opposite relationships. Conversely, the ‘high school or greater’ percentage rate, and to a lesser extent university graduation percentage rate, was found to have a negative correlation with off-farm labor mobilization odds.

9.2 Concluding Themes

9.2.1 Statistical Summation

Education maintains a critical importance throughout society by contributing to the defining characteristics of any class, culture, or landscape. From a production model standpoint, skill and knowledge are what separate the designation of labor from the interchangeability of physical capital. Human capital exudes a transformative feature which reaches beyond boundaries of industry or geography; the examination of the quantity and quality of such
capital is imperative to understanding industry practices or regional development. The objective of this thesis was to view the shape and disparity of the farming industry by measuring the effects of educational attainment on key indicators. The significance of farming to the United States has changed drastically in terms of farm and labor quantity, production efficiency, and innovative practices throughout the past two centuries. As a result, the value of education has likely changed as well. Due to data restrictions, however, it was only possible to analyze county-level data for a thirty-year period. Nonetheless, the fixed-effects panel regression model results provided a look into the effects of education over time.

In the output dependent model the high school graduation percentage variable’s coefficient is positive and implies that with every increased percentage point in a specific county’s high school graduation rate an increase of 1.85% in production is estimated over time. Similarly, in the earnings regressand fixed-effects model the high school graduation percentage variable’s coefficient denotes a 3.57% increase in estimated per-capita earnings from one decade to the next. Although comparatively small, the high school variable’s coefficient in the “any days off-farm” labor regressand fixed-effects model is negative and statistically significant, indicating a 0.54% decrease in the odds of farmers seeking off-farm employment for every one-point increase in county graduation percentage.

As predicted, the university graduation percentage variable resulted in opposite correlations with the three dependent variables. Regrettably, some of the university graduation coefficients lacked the statistical significances necessary for sound conclusions, though. The strongest results were in the output and labor mobility dependent models. A one-point increase in the university graduation percentage is estimated to result in a 1.68% decrease in corn production between counties, and a 0.5% decrease in the odds of off-farm labor mobilization between counties. In the “any days off-farm” regressand fixed-effects model the university variable produces a positive coefficient, symbolizing a 0.82% increase.
in the odds of off-farm labor mobilization within counties over time for every one-unit increase in graduation percentage.

Overall, the education variables present solid statistical support of certain theoretical considerations. The percentage effects mentioned above are comparatively smaller than those calculated for many other model variables like land, agricultural chemical expense, and farm-to-total income ratio; however, one must carefully consider the parameters of each model to properly interpret the results. The education indicators used represent aggregate graduation rates rather than an incremental attainment measure. Thus, a one-unit increase in the aggregate graduation rate denotes substantial improvement in the overall educational makeup of a county. Furthermore, several of the other explanatory variables are either binary or in natural log form, causing their percentage effects to reflect estimations of the independent variable based on sizeable increases (i.e. a binary $X$ variable’s movement from “0” to “1” or an $X$ variable in natural log form’s relative movement along the log scale). In summing up, the econometric results for the education indicators’ percentage effects should be viewed as legitimate findings of education’s value within the defined parameters and statistical significance of the models.

9.2.2 Theoretical Interpretations

The thesis’ three primary statistical objectives commanded the valuation of educational attainment in three separate spheres, and the empirical testing of each objective resulted in conclusions of varying manner and strength. The results of all statistical analysis were weighed against the notable theories described in chapter 3 of the thesis. The first statistical objective evaluated education’s role in the production function of corn. As stated, high school attainment reveals a positive correlation with output while university attainment has the opposite relationship. It is important to note the dual meaning of the regression model results: an increase in high school attainment is estimated to increase county production in terms of
both the level differences between counties and the change within counties over time. Thus, education can be seen as a source of differentiation amongst regions, but also as a springboard for future growth within regions. Transformation of production practices and utilization of technologies hinge on human capital investment. When studying county-level data, such an investment in education can be likened to admirable attendance patterns, competitive test scores, and overall school district success. Still most important to agricultural advancements are manmade capabilities that can overcome endowment deficiencies and agroclimatic variables. Also vital to the interpretation of this objective’s results is the recognition of university attainment as a reversal of high school’s contributive production value. Tertiary education is believed to entail general knowledge consumption leading farm youth toward more urbanized means of employment rather than specialized agrarian science concentration equipping farm youth to further improve production practices. This implies that while human capital fuels agricultural transformation, further educational attainment can stimulate alternative labor and lifestyle aspirations and lead to relative disadvantages in agricultural production.

The second statistical objective assessed education’s value on average per-capita farm earnings. In this case the county aggregated data did not provide the meaningful conclusions that individual household data presumably would. Typical earnings functions where education is treated as an opportunity cost investment offer appropriate conclusions about education’s value. Yet even county data can be consequential, although hourly or daily wage information as opposed to per-capita annual income is preferable. All this said, the thesis was unable to accurately test education’s role as a personal investment. Nonetheless, it is believed that high school education’s positive correlation with earnings in the OLS and fixed-effects models is sensible. Despite the low level of job differentiation within agricultural production
as compared to many service and other goods producing industries, it is believed that certain premiums on knowledge and skill exist.

The last statistical objective estimated educational attainment’s role in the off-farm labor mobilization decisions made by farm proprietors. As mentioned, the majority of educational attainment’s correlation effects in the OLS and fixed-effects models were surprisingly negative. The interpretation of such results is unclear, as contrasting relevant theories are seemingly applicable. Mobility hinges on the exact valuation of education – either as a source of specific agrarian knowledge or a transferable tool useful in off-farm circumstances. It could be said that those farmers possessing higher levels of education enjoy an advantage on the farm, forcing those less fortunate to off-farm alternatives, or that those with relatively more education are more capable of off-farm success, implying a positive correlation between education and off-farm labor mobility. Ultimately it is believed that education has a considerable degree of transferability, yet in the case of the Heartland region, farm proprietors in those counties with higher secondary and tertiary attainment rates are less likely to seek off-farm employment. This result is contrary to the thesis’ hypothesis. The university graduation indicator in the “any days off-farm” dependent fixed-effects model offers the lone positive coefficient, possibly justifying the notion of increased education within counties over time leading to a higher percentage of off-farm employment.

9.3 Implications of the Study

The study’s basis of educational analysis – level of formalized schooling – should be noted, for the concept of human capital undoubtedly encompasses alternative means of knowledge and skill attainment, such as on-the-job training, exposure to knowledge extension services, and industry experience. The measurement of formalized schooling remains a strong and accurate indication of human capital, yet agricultural production may be somewhat unique considering the typical generation-to-generation linkages amongst farm families that could
justify alternative means of knowledge and skill bestowal. Assumptions about the relationships between such alternative channels of human capital and agricultural production should not be made based on the results achieved in this thesis.

The setting of this study – the United States, and specifically the Heartland region – had some inherent bearing on the theories considered and results produced. The United States has widely been considered the leader in formalized education throughout much of the twentieth century, as justified by the Goldin and Katz’ title of the “American Century”. The United States has traditionally possessed both halves of the validation of educational value: (1) the institutional resources which provide educational opportunities, and (2) the transparent labor demand for skills. Hence, the application of particular studies of educational value, such as the one conducted in this thesis, can be made to other regions or countries if comparable conditions are present. Namely, any region which has graduated from traditional to modern agricultural production practices, as professed by Schultz, is prone to the influence of educational attainment via labor skill and overall factor improvement.

Finally, the theories, historical trends, and empirical models discussed in this thesis should be carefully considered in terms of real world implications. First, the theories and models used typically relate to a single aspect of agricultural production, whether it is corn output, off-farm mobility or farm earnings. While it sometimes seems logical that certain cause-and-effect relationships exist (e.g. lower farm earnings equates to higher off-farm mobility), it is crucial that each of the singular relationships with educational attainment are left to stand on their own. Second, due to the complexity of any real world production and/or labor scenario, the models and theories employed typically rely on assumptions and proxies to exemplify what is rather unexplainable. Theories and models, in addition to historical trends, can only estimate the importance of certain factors, the strength of specific correlations, and the significance of particular phenomena.
9.4 Topics for Further Analysis

While this thesis has analyzed several relationships involving educational attainment, any of the three primary statistical objectives could be extended and/or improved in a variety of ways. The production function used in the first objective could be enhanced via the inclusion of additional input indicators such as commodity price data and extension and research support measures, or the expansion of the time series data to include consecutive annual time points. The earnings function used in the second objective could be appreciably improved by the use of more representational earnings data like county-level hourly wage or household income figures, as well as considerations of market influences. Non-specific to any of the primary objectives, an analysis with particular emphasis on crop comparison could be made to consider skill-biased demand change and to estimate the educational differentials amongst various crop specializations. Finally, randomized county data could be taken from a few different agricultural regions throughout the United States so that comparisons concerning educational patterns and their effects on output and labor indicators could be made in a geographically-diverse context.
### Table A1

**Returns to Education by Type of Schooling, Iowa 1914: Males, 18- to 65-years old by Farm and Non-Farm Occupations**

<table>
<thead>
<tr>
<th></th>
<th>(1) All Occupations</th>
<th>(2) Non-farm Occupations</th>
<th>(3) Farm Occupations</th>
<th>(1) All Occupations</th>
<th>(2) Non-farm Occupations</th>
<th>(3) Farm Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common school - Years</strong></td>
<td>0.0427</td>
<td>0.0400</td>
<td>0.0375</td>
<td>0.0483</td>
<td>0.0375</td>
<td>0.0637</td>
</tr>
<tr>
<td></td>
<td>(0.00269)</td>
<td>(0.00300)</td>
<td>(0.00555)</td>
<td>(0.00395)</td>
<td>(0.00442)</td>
<td>(0.00837)</td>
</tr>
<tr>
<td><strong>Grammar School - Years</strong></td>
<td>0.0533</td>
<td>0.0647</td>
<td>0.0232</td>
<td>0.0693</td>
<td>0.0671</td>
<td>0.0568</td>
</tr>
<tr>
<td></td>
<td>(0.00292)</td>
<td>(0.00304)</td>
<td>(0.00800)</td>
<td>(0.00421)</td>
<td>(0.00443)</td>
<td>(0.0110)</td>
</tr>
<tr>
<td><strong>High School - Years</strong></td>
<td>0.103</td>
<td>0.102</td>
<td>0.114</td>
<td>0.120</td>
<td>0.114</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>(0.00448)</td>
<td>(0.00401)</td>
<td>(0.0146)</td>
<td>(0.00564)</td>
<td>(0.00516)</td>
<td>(0.0176)</td>
</tr>
<tr>
<td><strong>College - Years</strong></td>
<td>0.103</td>
<td>0.106</td>
<td>0.132</td>
<td>0.146</td>
<td>0.143</td>
<td>0.166</td>
</tr>
<tr>
<td></td>
<td>(0.00604)</td>
<td>(0.00520)</td>
<td>(0.0254)</td>
<td>(0.00915)</td>
<td>(0.00799)</td>
<td>(0.0381)</td>
</tr>
<tr>
<td><strong>Business School - Dummy</strong></td>
<td>0.379</td>
<td>0.393</td>
<td>-</td>
<td>0.284</td>
<td>0.273</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.0850)</td>
<td>(0.0705)</td>
<td>-</td>
<td>(0.0988)</td>
<td>(0.0831)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Native Born</strong></td>
<td>0.222</td>
<td>0.178</td>
<td>0.262</td>
<td>0.210</td>
<td>0.145</td>
<td>0.284</td>
</tr>
<tr>
<td></td>
<td>(0.0252)</td>
<td>(0.0253)</td>
<td>(0.0593)</td>
<td>(0.0324)</td>
<td>(0.0330)</td>
<td>(0.0766)</td>
</tr>
<tr>
<td><strong>(Years in U.S. x 10^{-3}) x foreign bom</strong></td>
<td>0.677</td>
<td>0.409</td>
<td>0.913</td>
<td>1.14</td>
<td>0.497</td>
<td>1.780</td>
</tr>
<tr>
<td></td>
<td>(0.0923)</td>
<td>(0.0943)</td>
<td>(0.218)</td>
<td>(0.223)</td>
<td>(0.238)</td>
<td>(0.489)</td>
</tr>
</tbody>
</table>

R²: 0.199 0.256 0.209 0.251 0.296 0.241

Standard Error: 0.624 0.546 0.702 0.567 0.501 0.645

Number of Observations: 14 699 10 695 3 705 7 145 5 249 1 784

---

**Notes:** The dependent variable is log (annual earnings). Sample excludes bottom 0.2 percent of earnings distribution (less than $60) and is restricted to those out of school. Regressions also contain a quartic in potential experience, a race dummy, and a dummy variable for those missing "years in U.S." Potential experience is defined as min(age - 15, age - years of schooling - 7). All regressions are weighted by urban and rural sampling weights. Figures in parentheses are standard errors.

**Source:** Transferred from Goldin and Katz, "The Returns to Skill," 19; in which data was compiled from the 1915 Iowa State Census.
### Table A2

Farm Productivity and Education: Iowa Counties, 1915 and 1925

<table>
<thead>
<tr>
<th>Dependent Variable: log (crop value per farm x $10^{-3}$), 1910 or 1920 or Difference</th>
<th>1915</th>
<th>1925</th>
<th>Difference</th>
<th>1915</th>
<th>1925</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>Dependent Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.345</td>
</tr>
<tr>
<td>Log (machinery value per farm x $10^{-3}$), 1910 or 1920 or difference</td>
<td>0.814</td>
<td>0.820</td>
<td>0.577</td>
<td>-0.834</td>
<td>0.343</td>
<td>1.177</td>
</tr>
<tr>
<td>(0.0835)</td>
<td>(0.0533)</td>
<td>(0.102)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (land in acres per farm x $10^{-3}$), 1910 or 1920 or difference</td>
<td>0.130</td>
<td>0.215</td>
<td>0.104</td>
<td>-1.85</td>
<td>-1.84</td>
<td>0.00414</td>
</tr>
<tr>
<td>(0.0928)</td>
<td>(0.0835)</td>
<td>(0.200)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fraction with any high school or college &gt; 20 years old, 1915 or 1925 or difference</td>
<td>1.30</td>
<td>0.927</td>
<td>1.17</td>
<td>0.228</td>
<td>0.328</td>
<td>0.102</td>
</tr>
<tr>
<td>(0.270)</td>
<td>(0.165)</td>
<td>(0.432)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.845</td>
<td>0.917</td>
<td>0.324</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.100</td>
<td>0.082</td>
<td>0.116</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Observations</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes**: Years in the column headings refer to the year of the educational information. Crop value, machinery value, and land in acres per farm are for 1910 in columns 1 and 4, and for 1920 in columns 2 and 5. Fraction with any high school or college is for 1915 in columns 1 and 4, and 1925 in columns 2 and 5. Regressions in columns 1 and 2 also include four soil-type dummies (Missouri loess, Iowa drift, Mississippi loess, and South Iowa loess), a dummy variable for Polk County (Des Moines), and a dummy variable indicating whether a county is on either the Mississippi or the Missouri rivers. The land types are from State of Iowa, *Thirteenth Annual Iowa Yearbook*, 670. Figures in parentheses are standard errors.

**Source**: Transferred from Goldin and Katz, "Evidence from the Prairies," 803; in which data was compiled from the 1915 and 1925 Iowa State Censuses, and U.S. Bureau of the Census, Thirteenth and Fourteenth Censuses.
### Table A3

**Changes in Relative Wages by Education and the Supply and Demand for Educated Workers: 1950 to 2005 (100 x Annual Log Changes)**

<table>
<thead>
<tr>
<th>Period</th>
<th>Relative Wage</th>
<th>Relative Supply</th>
<th>Relative Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-60</td>
<td>0.83</td>
<td>2.91</td>
<td>4.28</td>
</tr>
<tr>
<td>1960-70</td>
<td>0.69</td>
<td>2.55</td>
<td>3.69</td>
</tr>
<tr>
<td>1970-80</td>
<td>-0.74</td>
<td><strong>4.99</strong></td>
<td>3.77</td>
</tr>
<tr>
<td>1980-90</td>
<td>1.51</td>
<td>2.53</td>
<td><strong>5.01</strong></td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.58</td>
<td>2.03</td>
<td>2.98</td>
</tr>
<tr>
<td>1990-2005</td>
<td>0.50</td>
<td>1.65</td>
<td>2.46</td>
</tr>
<tr>
<td>1950-80</td>
<td>0.26</td>
<td>3.49</td>
<td>3.91</td>
</tr>
<tr>
<td>1960-80</td>
<td>-0.02</td>
<td>3.77</td>
<td>3.73</td>
</tr>
<tr>
<td>1980-2000</td>
<td>1.04</td>
<td>2.28</td>
<td>3.99</td>
</tr>
<tr>
<td>1980-2005</td>
<td>0.90</td>
<td>2.00</td>
<td>3.48</td>
</tr>
</tbody>
</table>

**Notes**: The “relative wage” is the log (college wage/high school wage). The relative supply and demand measures are for college "equivalents" (college graduates plus half of those with some college) and high school "equivalents" (those with 12 or fewer years of schooling and half of those with some college). The implied relative demand changes assume an aggregate elasticity of substitution between college equivalents and high school equivalents of 1.64. The log relative supply of college equivalents is given by the log relative wage bill share of college equivalents minus the log relative wage series. The approach adjusts the relative supply measure for changes in the age-sex composition of the pools of college and high school equivalents. To ensure data consistency across samples, changes from 1980 to 1990 use the CPS, changes from 1990 to 2000 use the census, and changes from the 2000 to 2005 use the CPS.

**Source**: Transferred from Goldin and Katz, *The Race*, 101; in which data was compiled from the 1940 to 2000 Census IPUMS and the 1980 to 2005 CPS MORG samples.
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Gender:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>-2.9</td>
<td>-4.9</td>
<td>-4.2</td>
<td>-12.0</td>
</tr>
<tr>
<td>Female</td>
<td>11.2</td>
<td>15.7</td>
<td>11.2</td>
<td><strong>38.2</strong></td>
</tr>
<tr>
<td><strong>Education:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-11 years</td>
<td>-35.2</td>
<td>-48.6</td>
<td>-41.9</td>
<td>-125.7</td>
</tr>
<tr>
<td>12 years</td>
<td>7.6</td>
<td>-4.8</td>
<td>-4.8</td>
<td>-2.0</td>
</tr>
<tr>
<td>13-15 years</td>
<td>20.3</td>
<td>23.3</td>
<td>6.7</td>
<td><strong>50.3</strong></td>
</tr>
<tr>
<td>16+ years</td>
<td>17.8</td>
<td>24.1</td>
<td>15.6</td>
<td><strong>57.5</strong></td>
</tr>
<tr>
<td><strong>Experience:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>30.3</td>
<td>16.3</td>
<td>-27.9</td>
<td><strong>18.6</strong></td>
</tr>
<tr>
<td>6-10 years</td>
<td>14.2</td>
<td>19.5</td>
<td>-10.4</td>
<td><strong>23.4</strong></td>
</tr>
<tr>
<td>11-15 years</td>
<td>-4.3</td>
<td>6.9</td>
<td>17.5</td>
<td><strong>20.1</strong></td>
</tr>
<tr>
<td>16-20 years</td>
<td>-17.8</td>
<td>-6.6</td>
<td>22.7</td>
<td>-1.7</td>
</tr>
<tr>
<td>21-25 years</td>
<td>-15.5</td>
<td>-16.9</td>
<td>0.0</td>
<td>-32.3</td>
</tr>
<tr>
<td>26-35 years</td>
<td>-5.5</td>
<td>-23.8</td>
<td>-17.4</td>
<td>-46.7</td>
</tr>
</tbody>
</table>

**Notes:** The numbers in the table represent log changes in each group's share of total labor supply measured in efficiency units (annual hours x the average relative wage of the group for the 1963-87 period).

**Source:** Transferred from Katz and Murphy, "Changes in Relative Wages," 10; in which data was compiled from the 1964-88 March Current Population Surveys.
APPENDIX B

CLASSIFICATION MAPS

Figure B1. U.S. Agricultural Resource Regions

Source: Transferred from Grundersen and others, A Safety Net for Farm Households, 7.
Figure B2. USDA Rural-Urban Continuum Codes

Rural-urban continuum codes, 1993


Rural-urban continuum codes, 2003

## Descriptive Statistics of Variables in Output Regression

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>CV</td>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>CV</td>
<td></td>
</tr>
<tr>
<td>Output (Bushels) (^a)</td>
<td>15.075</td>
<td>1.089</td>
<td>0.072</td>
<td></td>
<td>15.347</td>
<td>1.429</td>
<td>0.093</td>
<td></td>
</tr>
<tr>
<td>Total farmland acres (^\text{b})</td>
<td>12.434</td>
<td>0.467</td>
<td>0.038</td>
<td></td>
<td>12.404</td>
<td>0.477</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Farmland dedicated to corn (%)</td>
<td>24.821</td>
<td>11.356</td>
<td>0.458</td>
<td></td>
<td>30.919</td>
<td>15.088</td>
<td>0.488</td>
<td></td>
</tr>
<tr>
<td>Chemicals expense (^\text{a})</td>
<td>8.548</td>
<td>0.689</td>
<td>0.081</td>
<td></td>
<td>9.278</td>
<td>0.722</td>
<td>0.078</td>
<td></td>
</tr>
<tr>
<td>Petroleum expense (^\text{a})</td>
<td>7.797</td>
<td>0.552</td>
<td>0.071</td>
<td></td>
<td>8.565</td>
<td>0.610</td>
<td>0.071</td>
<td></td>
</tr>
<tr>
<td>High school education (% (\geq) HS)</td>
<td>49.906</td>
<td>8.791</td>
<td>0.176</td>
<td></td>
<td>63.564</td>
<td>7.912</td>
<td>0.124</td>
<td></td>
</tr>
<tr>
<td>University education (% univ.)</td>
<td>6.743</td>
<td>3.552</td>
<td>0.527</td>
<td></td>
<td>10.504</td>
<td>4.522</td>
<td>0.430</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>528</td>
<td></td>
<td></td>
<td></td>
<td>528</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: \(^a\) Variable is in natural log form.
Table C2
OLS and Fixed-Effects Panel Regression Models of Total Corn Output

<table>
<thead>
<tr>
<th></th>
<th>OLS Model (level)</th>
<th>Fixed Effects Model (change)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>% effect</td>
</tr>
<tr>
<td>Total farmland acres(ln)</td>
<td>0.20015</td>
<td>22.16</td>
</tr>
<tr>
<td>Farmland dedicated to corn (%)</td>
<td>0.04222</td>
<td>4.31</td>
</tr>
<tr>
<td>Chemicals expense (ln)</td>
<td>0.42364</td>
<td>52.75</td>
</tr>
<tr>
<td>Petroleum expense (ln)</td>
<td>0.35354</td>
<td>42.41</td>
</tr>
<tr>
<td>High school education (% ≥ HS)</td>
<td>0.01946</td>
<td>1.97</td>
</tr>
<tr>
<td>University education (% university)</td>
<td>-0.01697</td>
<td>-1.68</td>
</tr>
<tr>
<td>1980 Year (1970 reference)</td>
<td>-0.76180</td>
<td>-53.32</td>
</tr>
<tr>
<td>1990 Year</td>
<td>-0.06584</td>
<td>-6.37</td>
</tr>
<tr>
<td>2000 Year</td>
<td>0.11878</td>
<td>12.61</td>
</tr>
<tr>
<td>Constant</td>
<td>4.30376</td>
<td>0.000</td>
</tr>
</tbody>
</table>

R² within                        | 0.6798               |
R² between                       | 0.8478               |
R² overall                       | 0.8584               |

Notes: The dependent variable is the natural logarithm of total output of corn (in bushels) for all farms in each county. Heteroskedasticity robust standard errors were applied to the model.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>CV</td>
<td>Mean</td>
</tr>
<tr>
<td>Per-cap Farm Income(^a)</td>
<td>9.477</td>
<td>0.895</td>
<td>0.094</td>
<td>6.620</td>
</tr>
<tr>
<td>Age</td>
<td>50.540</td>
<td>1.536</td>
<td>0.030</td>
<td>48.905</td>
</tr>
<tr>
<td>Rurality Indicator (categorical)</td>
<td>5.860</td>
<td>2.304</td>
<td>0.393</td>
<td>5.799</td>
</tr>
<tr>
<td>Farm-dependency Indicator (binary)</td>
<td>0.367</td>
<td>0.483</td>
<td>1.313</td>
<td>0.367</td>
</tr>
<tr>
<td>Farmland dedicated to corn (%)</td>
<td>24.821</td>
<td>11.356</td>
<td>0.458</td>
<td>30.919</td>
</tr>
<tr>
<td>High school education (% ≥ HS)</td>
<td>49.906</td>
<td>8.791</td>
<td>0.176</td>
<td>63.564</td>
</tr>
<tr>
<td>University education (% univ.)</td>
<td>6.743</td>
<td>3.552</td>
<td>0.527</td>
<td>10.504</td>
</tr>
<tr>
<td>N</td>
<td>528</td>
<td></td>
<td></td>
<td>528</td>
</tr>
</tbody>
</table>

Notes: \(^a\) Variable is in natural log form.
<table>
<thead>
<tr>
<th></th>
<th>OLS Model (level)</th>
<th>Fixed Effects Model (change)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>% effect</td>
</tr>
<tr>
<td>Age</td>
<td>-0.08181</td>
<td>-7.86</td>
</tr>
<tr>
<td>Rurality Indicator = 1</td>
<td>-0.45736</td>
<td>-36.70</td>
</tr>
<tr>
<td>Rurality Indicator = 2</td>
<td>-0.64479</td>
<td>-47.52</td>
</tr>
<tr>
<td>Rurality Indicator = 3</td>
<td>-0.52284</td>
<td>-40.72</td>
</tr>
<tr>
<td>Rurality Indicator = 4</td>
<td>-0.37805</td>
<td>-31.48</td>
</tr>
<tr>
<td>Rurality Indicator = 5</td>
<td>-0.45611</td>
<td>-36.63</td>
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<td>Rurality Indicator = 6</td>
<td>-0.38267</td>
<td>-31.80</td>
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<td>Rurality Indicator = 7</td>
<td>-0.36185</td>
<td>-30.36</td>
</tr>
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<td>Rurality Indicator = 8</td>
<td>-0.54618</td>
<td>-42.08</td>
</tr>
<tr>
<td>Rurality Indicator = 9</td>
<td>-0.63557</td>
<td>-47.04</td>
</tr>
<tr>
<td>Farm-dependency Indicator = 1</td>
<td>0.24897</td>
<td>28.27</td>
</tr>
<tr>
<td>Farmland dedicated to corn (%)</td>
<td>0.02467</td>
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</tr>
<tr>
<td>High school education (% ≥ HS)</td>
<td>0.01050</td>
<td>1.06</td>
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<tr>
<td>University education (% univ. degree)</td>
<td>0.00615</td>
<td>0.62</td>
</tr>
<tr>
<td>1980 Year (1970 reference)</td>
<td>-3.30908</td>
<td>-96.35</td>
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<tr>
<td>1990 Year</td>
<td>-0.57208</td>
<td>0.002</td>
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<tr>
<td>2000 Year</td>
<td>-0.81857</td>
<td>0.002</td>
</tr>
<tr>
<td>Constant</td>
<td>12.79207</td>
<td>0.000</td>
</tr>
</tbody>
</table>

R² within 0.3081
R² between 0.1245
R² overall 0.2548
N 2112
p(F) 0.000

Notes: The dependent variable is the natural logarithm of per-capita farm income for all farm proprietors and laborers in each county. Heteroskedasticity robust standard errors were applied to the models.
### Table C5
Descriptive Statistics of Variables in Mobility Regression

<table>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>CV</td>
<td>Mean</td>
</tr>
<tr>
<td>Off-farm Labor - 200+ days (%)</td>
<td>26.361</td>
<td>12.468</td>
<td>0.473</td>
<td>32.387</td>
</tr>
<tr>
<td>Off-farm Labor - any days (%)</td>
<td>42.310</td>
<td>12.583</td>
<td>0.297</td>
<td>53.056</td>
</tr>
<tr>
<td>Farm to Total Income Ratio</td>
<td>1.313</td>
<td>0.582</td>
<td>0.443</td>
<td>0.404</td>
</tr>
<tr>
<td>Rurality Indicator (categorical)</td>
<td>5.860</td>
<td>2.304</td>
<td>0.397</td>
<td>5.799</td>
</tr>
<tr>
<td>Farm-dependency Indicator (binary)</td>
<td>0.367</td>
<td>0.483</td>
<td>1.313</td>
<td>0.367</td>
</tr>
<tr>
<td>Farmland dedicated to corn (%)</td>
<td>24.821</td>
<td>11.356</td>
<td>0.458</td>
<td>30.919</td>
</tr>
<tr>
<td>Age</td>
<td>50.540</td>
<td>1.536</td>
<td>0.030</td>
<td>48.905</td>
</tr>
<tr>
<td>High school education (% ≥ HS)</td>
<td>49.906</td>
<td>8.791</td>
<td>0.176</td>
<td>63.564</td>
</tr>
<tr>
<td>University education (% univ.)</td>
<td>6.743</td>
<td>3.552</td>
<td>0.527</td>
<td>10.504</td>
</tr>
<tr>
<td>N</td>
<td>528</td>
<td>528</td>
<td>528</td>
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</table>
## Table C6
**OLS and Fixed-Effects Panel Regression Models of % of Farm Proprietors Working Any Days Off-farm**

<table>
<thead>
<tr>
<th>OLS Model (level)</th>
<th>Fixed Effects Model (change)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
</tr>
</tbody>
</table>

**Farm to Total Income**
- Ratio: -0.23769, -21.16, 0.000, -0.09161, -8.75, 0.000
- Rurality Indicator = 1: -0.08169, -7.84, 0.037, -0.13619, -12.73, 0.008
- Rurality Indicator = 2: -0.00294, -0.29, 0.940, 0.05101, 5.23, 0.455
- Rurality Indicator = 3: -0.06688, -6.47, 0.088, -0.01219, -1.21, 0.860
- Rurality Indicator = 4: -0.12986, -12.18, 0.005, 0.00990, 0.99, 0.892
- Rurality Indicator = 5: -0.15952, -14.74, 0.000, 0.10000, 10.52, 0.236
- Rurality Indicator = 6: -0.12273, -11.55, 0.001, 0.03205, 3.26, 0.606
- Rurality Indicator = 7: -0.25015, -22.13, 0.000, 0.01821, 1.84, 0.795
- Rurality Indicator = 8: -0.17693, -16.22, 0.000, 0.06979, 7.23, 0.354
- Rurality Indicator = 9: -0.24872, -22.02, 0.000, 0.13762, 14.75, 0.084

**Farm-dependency Indicator = 1**
- -0.33714, -28.62, 0.000, -0.23325, -20.80, 0.000

**Farmland dedicated to corn (%)**
- -0.00504, -0.50, 0.000, 0.00419, 0.42, 0.000

**Age**
- 0.00119, 0.12, 0.805, -0.04218, -4.13, 0.000

**High school education (% ≥ HS)**
- -0.00189, -0.19, 0.209, -0.00539, -0.54, 0.016

**University education (% univ. degree)**
- -0.00512, -0.51, 0.001, 0.00818, 0.82, 0.018

**1980 Year (1970 reference)**
- 0.32152, 37.92, 0.000, 0.32625, 38.58, 0.000

**1990 Year**
- 0.39255, 0.000, 0.47861, 0.000

**2000 Year**
- 0.37826, 0.000, 0.65883, 0.000

**Constant**
- 0.46217, 0.098, 2.08094, 0.000

| R² within | 0.6556 |
| R² between | 0.0212 |
| R² overall | 0.2479 |

| N | 2112 |
| p(F) | 0.000 |

*Notes:* The dependent variable is the logistic transformation of the % of farm proprietors in each county having reported working off-farm any days in the calendar year. The transformation is from \( Y \) to \( \ln(Y/(1-Y)) \). Heteroskedasticity robust standard errors were applied to the model.
Table C7
OLS and Fixed-Effects Panel Regression Models of % of Farm Proprietors Working 200+ Days Off-farm

<table>
<thead>
<tr>
<th></th>
<th>OLS Model (level)</th>
<th>Fixed Effects Model (change)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>% effect</td>
</tr>
<tr>
<td>Farm to Total Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio</td>
<td>-0.28652</td>
<td>-24.91</td>
</tr>
<tr>
<td>Rurality Indicator = 1</td>
<td>-0.09080</td>
<td>-8.68</td>
</tr>
<tr>
<td>Rurality Indicator = 2</td>
<td>-0.00962</td>
<td>-0.96</td>
</tr>
<tr>
<td>Rurality Indicator = 3</td>
<td>-0.07647</td>
<td>-7.36</td>
</tr>
<tr>
<td>Rurality Indicator = 4</td>
<td>-0.17968</td>
<td>-15.79</td>
</tr>
<tr>
<td>Rurality Indicator = 5</td>
<td>-0.21978</td>
<td>-19.73</td>
</tr>
<tr>
<td>Rurality Indicator = 6</td>
<td>-0.17786</td>
<td>-16.29</td>
</tr>
<tr>
<td>Rurality Indicator = 7</td>
<td>-0.37140</td>
<td>-31.02</td>
</tr>
<tr>
<td>Rurality Indicator = 8</td>
<td>-0.23198</td>
<td>-20.70</td>
</tr>
<tr>
<td>Rurality Indicator = 9</td>
<td>-0.38087</td>
<td>-31.67</td>
</tr>
<tr>
<td>Farm-dependency</td>
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<td></td>
</tr>
<tr>
<td>Indicator = 1</td>
<td>-0.46490</td>
<td>-37.18</td>
</tr>
<tr>
<td>Farmland dedicated to corn (%)</td>
<td>-0.00747</td>
<td>-0.74</td>
</tr>
<tr>
<td>Age</td>
<td>0.01591</td>
<td>1.60</td>
</tr>
<tr>
<td>High school education (% ≥ HS)</td>
<td>-0.00208</td>
<td>-0.21</td>
</tr>
<tr>
<td>University education (% univ. degree)</td>
<td>-0.00799</td>
<td>-0.80</td>
</tr>
<tr>
<td>1990 Year (1970 reference)</td>
<td>0.22264</td>
<td>24.94</td>
</tr>
<tr>
<td>1990 Year</td>
<td>0.40072</td>
<td>0.000</td>
</tr>
<tr>
<td>2000 Year</td>
<td>0.42821</td>
<td>0.000</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.82359</td>
<td>0.013</td>
</tr>
</tbody>
</table>

R² within 0.6305
R² between 0.0256
R² overall 0.2098
N 2112
p(F) 0.000

Notes: The dependent variable is the logistic transformation of the % of farm proprietors in each county having reported working off-farm 200+ days in the calendar year. The transformation is from Y to ln(Y/(1-Y)). Heteroskedasticity robust standard errors were applied to the model.
WORKS CITED


