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The Private and Public Effects of School Reform: Educational Investment, Human Capital Spillovers and Intergenerational Mobility During the Expansion of Public Schools in the United States

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ABSTRACT

The Private and Public Effects of School Reform: Educational Investment, Human Capital Spillovers and Intergenerational Mobility During the Expansion of Public Schools in the United States

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The expansion of public education at the beginning of the twentieth century had a profound effect on the American economy. This dissertation explores the impact of changing educational institutions on both individuals and communities with a study of Iowa during its introduction of modern grammar schools and high schools during the first decades of the twentieth century. Through the construction and analysis of two new datasets containing unique school district data and intergenerational income and educational attainment data, we demonstrate that school expansion had significant effects, both positive and negative, on local economies well beyond the private returns to education.

The first chapters focus on the effects of improvements in public school access and quality on intergenerational mobility. We link multiple censuses and school district records together to create a dataset of intergenerational income and educational attainment data. These data reveal a dramatic decline in intergenerational income mobility concurrent

with the massive expansion of public grammar schools and high schools. We find that communities with better public schools had lower mobility rates than communities with poor schooling resources. Educational attainment estimates reveal that this seemingly counterintuitive result was a product of wealthy families' educational investment decisions being much more responsive to increasing school access than those of poor families.

The final chapters focus on the effects of educated individuals on their neighbors. We begin with an examination of agricultural innovation during the public school expansion and show that education was helping farmers successfully experiment with and adopt new technologies. The practices of educated farmers could be replicated by their neighbors, creating the potential for human capital spillovers. To test for these spillovers, we construct a dataset linking income and educational attainment data for farmers to spatial data for their farms. Using these data, we estimate that an additional year of education not only raised a farmer's own earnings but also significantly increased the earnings of his neighbors, revealing an important public dimension to schooling. These findings, coupled with the mobility results, capture the complicated and important role public school expansion had in the development of the American economy.

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CHAPTER 1

American Mobility and Education over the Twentieth Century

1.1. Introduction

The expansion of public education in the United States, particularly the introduction of public secondary schooling and the dramatic increases in school enrollment over the first half of the twentieth century, played a central role in the growth of the American economy and the evolution of its income distribution. While the importance of the expansion of public education in creating an educated, highly productive workforce and raising the incomes of individuals has been studied in the past, particularly in the context of an increasingly industrialized economy, several important aspects of the effects of public school expansion have escaped thorough examination. This dissertation explores the role of emerging public schools in the American Midwest, focusing on their effects on agricultural productivity and on the rigidity of the income distribution. Through a thorough investigation of the impact of schools on individual and community-wide outcomes at the beginning of the twentieth century, we reveal a complicated role for education in the Midwest that extends well beyond its function as a producer of human capital. The evolution of the public school system changed the relationships between members of a community, altering the importance of the distribution of resources and the benefits of social networks in determining the socioeconomic outcomes of individuals both in absolute terms and relative to the rest of the community. Emerging educational institutions created the potential for large economic gains in absolute terms through increasing productivity but simultaneously decreased relative mobility, producing widening income gaps and an increasingly rigid income distribution.

Our investigation begins with an examination of intergenerational income mobility at the turn of the century. In this first chapter, we provide an overview of mobility and educational institutions over the twentieth century and introduce a new intergenerational income dataset to study the correlation between the incomes of fathers and their sons in Iowa at a time when the educational system was going through dramatic change. Chapter 2 uses these data to estimate intergenerational income mobility rates at the beginning of the twentieth century. Our data reveal a tremendous amount of intergenerational income mobility on the eve of America's "high school movement," the mass expansion of public secondary schooling between 1910 and 1940. Any position in the income distribution was open to a son regardless of the income of his father. We contrast this with modern day income mobility rates and find that America was a much more mobile society at the beginning of the high school movement than by its completion.

Whether the expansion of public schools could have contributed to the decline in income mobility is an important question but has received little attention. Schools provide the primary means of achieving upward mobility and the creation of public schools gave less advantaged individuals a way to better their socioeconomic status relative to their parents. However, schools also offer a channel for parents to invest their wealth in their children. Through the acquisition of better schooling, educational institutions provide a formal way for parents to translate their economic success into a greater likelihood of economic success for their children. These two roles of education make predictions of the effect of expanding educational opportunities on mobility ambiguous. In the third chapter, we use the historical experience of Iowa to test the effect of school improvements on mobility. With the inclusion of educational data in our intergenerational income dataset, we can study the relationship between the introduction of public schools in Iowa and intergenerational mobility. Examining mobility rates across communities with different school types and qualities allows us to estimate the role of both school quality and school access on mobility and in both cases, we find that improvements in public education actually produce a decline in intergenerational mobility.

Understanding this negative relationship between public education and mobility, a seemingly counterintuitive result, requires looking at the individual educational decisions being made by families. To this end, we estimate the educational attainments of individuals as a function of parental income and school quality and access. The intuition behind the puzzling result of declining mobility with improving public schooling is revealed by the results of these estimates: improvements in the quality and availability of public education lead to increases in educational investments for families of all incomes but those increases were the largest for the wealthiest families. Public education improvements helped everyone in absolute terms but helped children from wealthy families substantially more than children from poor families.

Our investigation of the relationship between mobility and public education casts doubt on whether public school expansion had purely positive effects on social welfare in the American economy. It certainly led to increases in average income levels and contributed to economic growth, but our mobility results raise the possibility that these benefits were disproportionately bestowed on the wealthy, forcing a reconsideration of the social gains from public education. Evaluating the benefits of public school expansion requires taking a normative stance on the social benefits of absolute income gains relative to increasing income inequality and rigidity in the income distribution. We do not attempt to condone or condemn public school expansion for its effects on the distribution of income. Instead, we introduce empirical results that are needed as a foundation for any stance on the merits of school reform that takes seriously the effects of schooling beyond the simple private returns to students.

In an effort to further understand the total impact of school reform at the turn of the century, the final chapter focuses on the returns to education in the agricultural sector of Iowa at the turn of the century. We shift focus from the relationship between income and education across family generations to the relationship between income and education across space. Using a combination of individual income and educational attainment data for farmers in conjunction with spatial data, we estimate both the private returns to education of farmers and the human capital spillovers that resulted when an individual's neighbor rather than the individual farmer himself was the recipient of additional schooling. We find that education, in particular the secondary schooling becoming more widely available during the high school movement, had significant impacts on agricultural productivity, both for the farmer who received that education and for his neighbors. These results reveal a very important public component to the returns to education.

Taken together, the chapters of this dissertation reveal a complicated role for public educational institutions in the development of the American economy. The emergence of public schools gave individuals a powerful tool to increase their human capital and achieve substantial income gains. These significant returns to education were not limited to white collar professions; the agricultural sector benefited tremendously from the expansion of educational institutions. Gains came not only through the increased productivity of educated workers but also from productivity gains experienced by others through human capital spillovers. These benefits did come with a cost, though. The improving public school system, while raising wages across the income distribution in absolute terms, provided a formal channel through which relative positions in the income distribution could be reinforced, decreasing intergenerational mobility. The expansion of public schools was a major influence, in both expected and unexpected ways, on the evolution of the American income distribution.

1.2. Mobility and the Evolution of Public Schools over the Twentieth Century

Current income mobility rates in the United States are similar to or below those of other developed countries. International comparisons of intergenerational income elasticities reveal that the intergenerational income elasticity in the United States is comparable to or higher than elasticities measured for other developed nations (Solon, 2002), suggesting that if anything the United States is a somewhat less mobile society, and that those elasticities have been fairly stable in recent decades (Hertz, 2007; Solon & Lee, 2006). However, historically this has not been the case. Ferrie's (2005) study of intergenerational occupational mobility rates in the United States and Britain reveals that the U.S. had high levels of mobility in the late 1800s that converged over the twentieth century to the more modest international levels. While these occupational mobility rates do not translate perfectly into intergenerational income elasticities due to overlap in income ranges across occupation categories and their inability to capture income mobility that does not correspond to a change in occupation, they do suggest that American income mobility rates observed in modern studies are likely significantly lower than their levels at the beginning of the twentieth century.

Several changes in the American economy over the twentieth century could have contributed to this decline in mobility. Major shocks to the economy including both world wars and the Great Depression as well as more gradual transitions such as the closing of the frontier and rural to urban migration could all have altered labor markets and influenced mobility rates. While the influence of these changes on mobility are all worthy of study, the major institutional transition of interest in this study is the evolution of the public education system.

At the end of the nineteenth century, education in the United States bore little resemblance to the modern school system. The first decades of the twentieth century ushered in the compulsory attendance laws, public funding of education, grammar schools and high schools that are all now basic features of the public education system (Goldin, 1998; Lleras-Muney, 2002; Moehling, 1999). This transformation of American educational institutions led to dramatic increases in educational attainment and literacy rates (Goldin, 1998). While occurring at different times in different areas of the country, the whole of the movement took place during the first half of the twentieth century, making it concurrent with and a potential contributing factor to the decline in American mobility.

Beyond the coincidence of its timing, the growth of public education provides a promising explanation of the mobility decline because of the central role schools play in the transmission of economic success from one generation to the next. Educational attainment has a significant impact on earnings, a fact that is particularly true at the time of the public school transformation as evidenced by the large returns to education during the high school movement estimated by Goldin and Katz (2000). An individual's educational attainment depends on family resource constraints. In this respect, access to education is a clear channel through which parental income affects children's future earnings. The introduction of public education altered the financial and geographical access constraints individuals faced when choosing levels of educational investment and therefore directly impacted the determinants of mobility.

The direction of this impact is ambiguous. Intuitively, the expansion of public schools should have created a more egalitarian school system and consequently greater mobility. Models of the transmission of earnings across generations in the tradition of Becker (1983) and Becker and Tomes (1986), such as the recent work of Solon (2004), indeed predict an increase in intergenerational income mobility with a rise in government spending on education.[1] However, there is a small body of empirical evidence suggesting that in practice additional government spending on education can actually lead to declining mobility. Efforts to improve access to higher education in Britain provide a modern example of this; wealthy families were able to take fuller advantage of the expanded opportunities leading to an overall decline in intergenerational mobility (Blanden et al., 2004; Blanden & Machin, 2004). If wealthy families take advantage of expanded educational opportunities but poor families do not, either because of differences in preferences, financial constraints, or geographical access to quality schools, additional government spending on education can effectively subsidize the wealthy. Depending on how families of different means responded to the improvements in education, the expansion of public education throughout the United States could have contributed to either an increase or a decline in mobility.

1.3. Iowa's School System at the Turn of the Century

While the motivation for examining educational institutions in a study of mobility is clear, the mechanics of doing so are far from obvious. From a data perspective,

[1]It should be noted that Iyigun (1999) develops a model in which the expansion of public education can lead to decreases in mobility. However, this result depends on modeling school admissions as a competitive process. This mechanism is not relevant to the early twentieth century educational institutions examined here. The models of Becker and Solon are much more applicable to the schools of interest in this paper despite their predictions being at odds with the observed decline in mobility occurring during a rise in government spending on education.

information on income is rare historically. The sort of panel studies used to estimate modern mobility rates simply have no historical counterpart. Income data is extremely rare prior to 1940, let alone information on both a father and son's incomes. There is a similar paucity of educational attainment data. Beyond data issues, there is a more fundamental problem that even in the presence of ideal data, the expansion of public schools was far from an abrupt transition. With public education decisions made at the state and local level, the appearance of high schools and general improvements to public education occurred at different times in different areas over a period of decades, a period which, as discussed earlier, witnessed several major shocks and transformations to the American economy. A solution to these problems is to exploit the uniqueness of Iowa as a leader in education and, equally important, a leader in data collection.

Iowa was one of the first states to begin the transition to modern public graded schools and high schools. At the end of the nineteenth century, Iowa's school system consisted primarily of private religious academies and single room common schools, the little red schoolhouses found in nostalgic accounts of the prairie. A series of changes occurred in the late nineteenth century that led to dramatic changes in the school system. Between 1857 and 1870, several pieces of legislation were introduced that increased the ability of townships to vote for the creation of schools and fund those schools through local taxes, increasing overall education expenditures and reducing the tuition burden on students (see Smisher (1946) for a review of Iowa school legislation in the nineteenth century). Between 1870 and 1900, the number of high schools in Iowa increased from 40 to over 200 (Smisher, 1946). In just the five years between 1895 and 1900, the number of graded schools increased by nearly 20 percent (Iowa Dept. of Public Instruction, 1900b). In addition to this rise in the number of graded schools, there was a movement at the turn of the century toward school consolidation in the rural school districts, increasing the quality of education available to children in rural areas. The result of all of these changes was a dramatic rise in both educational access and school quality between 1890 and 1910. This movement toward higher quality education and modern graded schools in Iowa preceded much of the rest of the nation by two decades, with the bulk of the transformation of Iowa schools occurring prior to World War I. A cross section of Iowa school districts in 1900 reveals a wide range of school types and quality, from one room common schools with a handful of students to large high schools accredited by Iowa universities.

The position of Iowa as a leader in the expansion of public education is echoed by the state's efforts to maintain detailed records of educational statistics. The county superintendents of schools were required to gather data on enrollments, teachers, expenditures, revenues and other variables for all of the school districts in their county each year and submit this information to the Department of Public Instruction. These statistics were compiled into annual reports and published. The original data are stored at the state archives and are now available on microfilm as far back as 1873. These records provide an extraordinary level of detail on each school district throughout the transition to modern public schools and allow for the reconstruction of not only the differences in school types and quality across districts but also the pace at which schools changed.

These data on school districts offer an impressive level of detail on the educational resources available to children growing up in Iowa at the turn of the century. Supplementing these data with individual level data from the Iowa state census allows for identification of how families utilized these resources. With the 1915 Iowa census, the state sought to produce data on the exact extent to which Iowa was a leader in education. To this end, a series of questions on educational attainment was included in the census. Each respondent was asked for the number of years they attended common school, grammar school, high school and college. This represents a dramatic improvement over the traditional educational attainment questions common to state and federal censuses that were limited to literacy and current enrollment status. Beyond this education information, the 1915 census also asked individuals for their annual earnings, making the census the only large survey containing income data for the United States prior to the 1940 federal census. By linking adult sons to their fathers in the Iowa census, a process described in detail in the next section, an intergenerational dataset can be generated containing two generations of income and educational attainment data. The uniqueness of the Iowa income data coupled with the matching procedure present the first opportunity to study intergenerational income mobility in a historical context.

With a rapidly changing mix of schools, a wealth of school district data, and educational attainment and income data for the entire state population, Iowa is an extraordinarily attractive candidate for a study of the relationship between education and mobility. While Iowa was an outlier in terms of the timing of the evolution of its educational institutions, the changes to those institutions were of the same nature as the changes that would eventually occur throughout the rest of the nation. With appropriate caveats, identifying the effect of the introduction of modern public schooling in Iowa on intergenerational mobility will offer meaningful insight into the contribution of changing educational institutions to the overall decline in American mobility in the first half of the twentieth century and the relationship between educational institutions and mobility in general.

1.4. Constructing an Intergenerational Dataset

The data for this study are drawn from three main sources. The first two are the reports of the county superintendents of schools and the 1915 Iowa state census discussed in the previous section. The third is the 1900 federal census. Given that education and income are observed for only a single cross section of Iowa residents, it is necessary to use the federal census schedules to reconstruct the childhood households of the observed individuals and acquire the parental occupation and earnings data necessary for a study of intergenerational mobility. This section details the relevant features of each individual data source and describes the process of building the intergenerational sample.

The construction of an intergenerational dataset begins with the sample of the 1915 Iowa state census transcribed by Goldin and Katz for their study on the returns to education (Goldin & Katz, 2000). They sample ten rural counties and the three counties with large urban populations (containing the cities of Davenport, Des Moines and Dubuque).[2] The resulting sample includes roughly 60,000 individuals. All of the data available in the state census are transcribed. For the purposes of this paper, the relevant variables include age, birthplace, parents' birthplaces, year of immigration if applicable, years of schooling by school type (common, grammar, high school, college), occupation, months employed in the previous year, and annual earnings for the previous year.

[2]A map of the locations of these counties is provided in Figure C.1 of the appendix.

From this sample of individuals, we select all males between the ages of 20 and 35. These individuals will constitute the sons of the father-son pairs in the final intergenerational dataset. The age range is chosen such that the men are old enough to no longer be living in their parents' household but young enough that their fathers can still be located in the 1915 Iowa state census. A major restriction in choosing the sample is the fact that educational attainment and income are only available in the 1915 census. If both father and son's total educational attainment and income are to be observed, it is necessary for both the father and son to be living adults in 1915, hence the limited age range.

These young adult males are then located in records of the 1900 federal census. The 1900 federal census is the only census in which the vast majority of the sons, aged 5 to 20 at the time of the census, will be living with their parents. The complete population schedules of the 1900 federal census are searched by son's name, birthplace and age using an online database. Once a son in matched to the federal census, information on his parents and siblings is transcribed from an image file of the original 1900 census form. Parents' birthplaces are recorded and used to confirm the accuracy of the match. Sibling information is used to determine the birth order of the individual. The father's name, age, birthplace, occupation and parents' birthplaces are recorded.

The father can then be located in the 1915 Iowa state census through a combination of searching the Goldin-Katz sample and the original census records available on microfilm at the Newberry Library in Chicago.[3] Name, age, birthplace and parents' birthplaces provide the criteria for identifying correct matches. Once located in the 1915 Iowa census, the

[3]An electronic index of these records is now available online on a subscription basis at www.ancestry.com.

Table 1.1: Summary statistics for Iowa father-son sample, 1915.

Father's income observed for all	yes	no	no
Father's education observed for all	yes	yes	no
Father's occupation observed for all	yes	yes	yes
	(1)	(2)	(3)
Son's log annual earnings	6.26	6.32	6.44
	(.67)	(.69)	(.66)
Father's log annual earnings	6.68	6.68	6.68
	(.76)	(.76)	(.76)
Son's log monthly earnings	3.89	3.94	4.05
	(.60)	(.61)	(.60)
Father's log monthly earnings	4.28	4.28	4.28
	(.72)	(.72)	(.72)
Son's age	25.3	26.4	27.0
	(5.4)	(6.0)	(5.1)
Father's age	57.0	59.0	60.2
	(7.4)	(8.4)	(8.9)
Son's years of education	9.1	9.1	9.2
	(2.5)	(2.6)	(2.7)
Father's years of education	7.9	7.8	7.8
	(2.7)	(2.6)	(2.6)
Number of observations	1094	1480	3487

Notes: All values are for the year 1915. Standard deviations are given in parentheses. An observation is considered one father-son pair.

1915 location, occupation, educational attainment, months employed and annual earnings of the father are recorded.

The end result of this process is a sample of father-son pairs for which the locations of both fathers and sons in 1900 and 1915 are known, occupation and earnings of both are known in 1915, overall educational attainment for both is known, and father's occupation is known in 1900. These variables allow for measures of geographical, occupational and income mobility. As discussed in the previous section, the intergenerational income data is unique for a historical dataset. Furthermore, because the dataset is constructed from complete census records, the final sample is comparable in size to the modern panel studies used to estimate intergenerational income elasticities. Table 1.1 provides summary statistics for the final sample of father-son pairs. Column 1 corresponds to the father-son pairs for which incomes are observed for both the father and son. Column 2 includes those fathers found in the 1915 Iowa census but who were either unemployed or retired, allowing for educational attainment and occupation (based on the 1900 census) to be observed but not income. Column 3 adds fathers who were found in the 1900 federal census but not the 1915 census and consequently have an occupation observed but not income or educational attainment. The sample sizes are fairly large, ranging from 1,094 father-son pairs with complete income and occupation information to 3,487 pairs when including all observations for which there is at least an occupation for the father. The effects of the high school movement can be seen by noting the jump in average educational attainment of over a year from the fathers' generation to the sons'. The lower earnings of the sons are attributable to the difference in average age between the sons and fathers.

While this sample of father-son pairs does have educational attainment data, it lacks information on educational access and quality, both of which are central to decisions about educational attainment and likely to be major factors in the extent to which education influences mobility. To incorporate these data into the father-son sample, the county superintendents of schools records from 1900 are transcribed and the sons are matched to their respective school districts based on their 1900 household locations. For the majority of individuals, this means assigning them to the school district for their township. There is a complication when townships contain independent school districts within the township-wide district, occurring most frequently when a larger town exists within the township. In these situations, two separate approaches to matching individuals to school districts can be taken. The first is to assign individuals living within the independent district to that district and all other individuals to the township-wide district. The second approach, and the one used in the analysis, relaxes this strict division and allows for the possibility that any individual in a given township may have attended any school within that township. In this case, the township and independent district data are aggregated together and all individuals in the township are assigned to this constructed aggregate school district.[4] See Figure C.2 and Figure C.3 in the appendix for an illustrative example of these independent school districts as well as a depiction of a typical distribution of schools within a township.

Incorporating the county superintendent data adds information on the availability of schooling types, local education expenditures, school district taxes, tuition levels, costs of books, teacher quality and curriculum to the father-son pairs. Table 1.2 summarizes the main school district variables for the counties in the Goldin-Katz sample. Along every dimension, the school districts exhibit tremendous variation. The wide range of spending levels, attendance rates, and resources across districts demonstrates the rich variety of schools that makes turn of the century Iowa such an attractive subject for this study. This intergenerational dataset, with its detailed income, education and school district

[4]The major motivation for assuming individuals may attend any school in their township is that independent districts often contain the only high school within a school district. Under the strict division of children by whether they live within the boundaries of the independent district or not, the possibility of an individual living outside of the main town attending the town's high school is not allowed, giving an underestimate of the education an individual has access to. Enrollment levels in these independent districts often exceed the enumeration of school-aged children in the district, confirming that out-of-district students are attending the schools.

Table 1.2: School district characteristics for counties in the Goldin-Katz sample, 1900

	Townships w/ Ind. Districts	All districts
Ungraded schools	6.47	1.92
	(5.75)	(2.61)
Classrooms in graded schools	5.70	1.69
	(23.86)	(10.64)
Months in school year	7.93	7.75
	(1.52)	(1.78)
Number of children of school age	638	189
	(1817)	(920)
Percentage of children enrolled	79.4	82.9
	(20.4)	(107.2)
Monthly tuition	1.95	2.04
	(.62)	(.97)
Volumes in library	263	78
	(808)	(420)
Taxes per child	9.36	9.16
	(3.95)	(4.81)
Spending per child	11.81	11.38
	(5.30)	(6.64)
Percentage with graded schools	41.5	14.5
Number of districts	164	549

Notes: The first column merges independent districts within a township into the township district. The second column treats townships and independent districts as separate observations. Standard deviations are given in parentheses. All dollar amounts are given in 1900 dollars.

data, will serve as the foundation of our empirical investigation of schooling and mobility in the following chapters.

CHAPTER 2

Intergenerational Income Mobility, 1915 to 2001

2.1. Measuring Income Mobility

The data present several options for measuring intergenerational mobility. With the occupations of sons and fathers observed, one plausible measure of mobility would be occupational transitions. However, occupational mobility can be difficult to translate into changes in welfare due to extensive variation in incomes within occupational categories. The household locations in 1900 and 1915 allow for measures of geographical mobility. While geographical mobility may be useful in explaining how occupational and income transitions are achieved, taken by itself it too suffers from a lack of clear welfare implications. The most attractive measure of mobility utilizes the unique intergenerational income data in the sample. With these data, intergenerational income elasticities, the intergenerational mobility measure most commonly used in modern studies, can be estimated.[1] Income is an appealing variable as its scale is understood and changes in income have a clear normative interpretation.

Formally, the relationship of interest is captured by the following equation

$$\ln \overline{y}_{i,s} = \alpha_0 + \alpha_1 \ln \overline{y}_{i,f} + \varepsilon_i \tag{2.1}$$

[1] The intergenerational income elasticity is only one of many income mobility measures. The appendix contains a brief discussion and estimates of several additional measures. These additional mobility estimates all reveal similar declines in income mobility consistent with the intergenerational income elasticity estimates presented in this section.

where $\ln \overline{y}_{i,f}$ is a measure of the average log annual income of the father in father-son pair i and $\ln \overline{y}_{i,s}$ is a measure of the average log annual income of the son. The coefficient α_1 on log parental income represents the intergenerational income elasticity. A larger value for the intergenerational income elasticity indicates less income mobility.

While this is a relatively simple relationship, its proper estimation is quite problematic. The trouble stems from poor measures of average log annual income. Annual income varies from year to year because of both random, transitory shocks and systematic changes in income over the life cycle. Both of these sources of variation make any single observation of annual income a poor proxy of average annual income over the lifetime of the individual. The measurement error introduced by using annual income in a specific year as a proxy for average lifetime income will bias estimates of α_1 downward, leading to an underestimate of the intergenerational income elasticity and a corresponding overstatement of the degree of intergenerational mobility observed.

The contribution of age-specific changes in income can be controlled for through the inclusion of quadratics in sons' and fathers' ages, capturing the concave shape of the typical life cycle earnings profile. Controlling for age in this manner is particularly important given that fathers and sons are observed at very different stages in the life cycle. Due to differences in earnings over the life cycle, the observed incomes for fathers will tend to be greater than their average annual income over the life cycle while observed incomes for sons will tend to to be lower than their average over the life cycle. Allowing the coefficients on the sons' age terms to differ from those of the fathers will allow for the shape of the lifetime earnings profile of the fathers' cohort to differ from that of the sons' cohort.

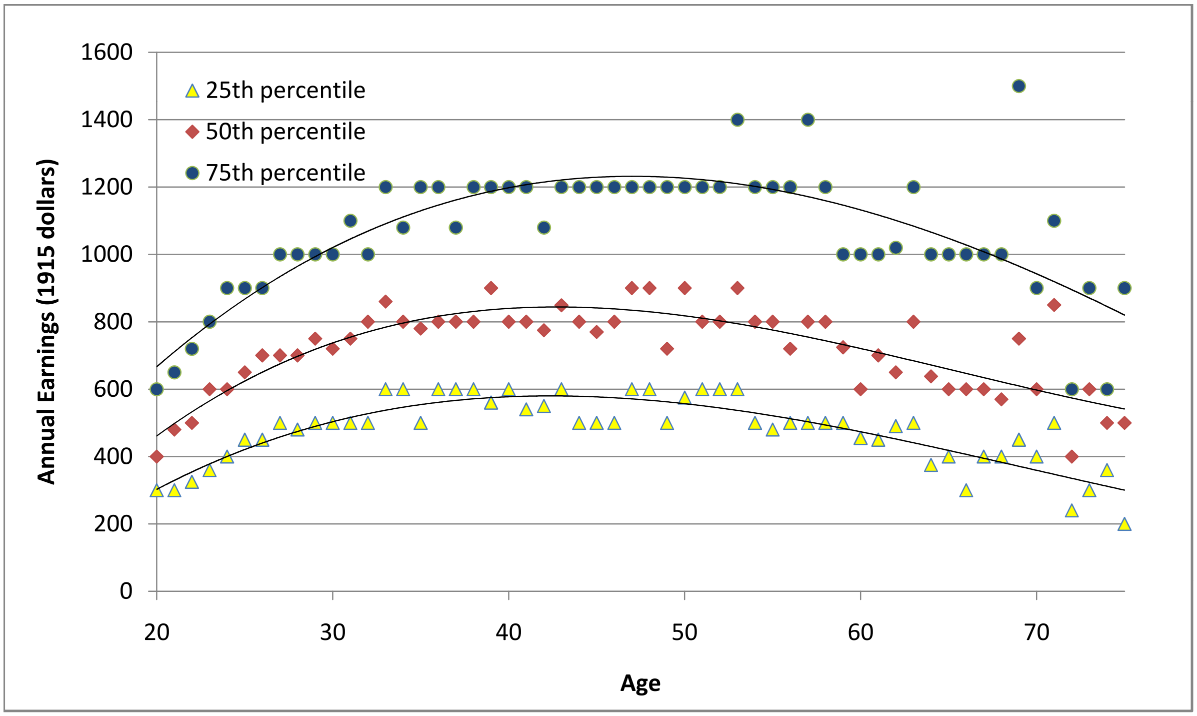


Figure 2.1: 25th, 50th and 75th percentiles of earnings distribution by age, Iowa, 1915

A second problem with systematic earnings differences over the lifecycle pertains to differences in the shape of the lifetime earnings profile for low and high income individuals. The steeper earnings trajectory early in life of high lifetime earnings individuals relative to low lifetime earnings individuals leads to different estimates of intergenerational income elasticity depending on the age at which individuals are observed (Grawe, 2006; Haider & Solon, 2006). The steeper trajectory of the earnings profile for high income individuals results in annual income being closer to the cohort's mean early in the life cycle and diverging from the mean later in the lifecycle. As a result, measures of intergenerational income elasticity using young adults tend to underestimate the true elasticity while measurements relying on older individuals will provide an overestimate. Figure 2.1, depicting the 25th, 50th and 75th percentiles of the income distribution by age for the Iowa sample, shows the noticeable divergence of the earnings of low and high income individuals and underscores the importance of controlling for age when estimating the intergenerational income elasticity. To control for the divergence of earnings over the life cycle, I follow the approach of Solon and Lee (2006) and interact son's age with father's income, allowing the intergenerational income elasticity to vary with son's age. Incorporating these age controls and interaction terms, the regression equation becomes

$$\begin{aligned} \ln y_{i,s} &= \gamma_0 + \gamma_1 \ln y_{i,f} + \gamma_2 A_{i,s} \ln y_{i,f} + \gamma_3 A_{i,s}^2 \ln y_{i,f} + \\ &\quad \gamma_4 A_{i,f} + \gamma_5 A_{i,f}^2 + \gamma_6 A_{i,s} + \gamma_7 A_{i,s}^2 + u_i. \end{aligned} \tag{2.2}$$

where $A_{i,s}$ and $A_{i,f}$ are the son's and father's ages respectively. By defining $A_{i,s}$ to be son's age at the time of the income observation minus 30, γ_1 can be interpreted as the intergenerational income elasticity for an individual at the age of 30, a measure comparable to the elasticities estimated in modern studies that have the benefit of panel data.

The transitory fluctuations in income present a less tractable problem. The standard approach to minimizing the bias introduced by these fluctuations is to average several observations of log annual income, a luxury not afforded by the Iowa data. With only the 1915 Iowa census reporting earnings, we are limited to a single observation of annual income. This inability to average over several periods makes the measurement error more severe and the downward bias on the income elasticity estimate greater than in modern studies. To address this problem and construct meaningful comparisons of the 1915 estimates to modern mobility rates, we repeat the same analysis used for the Iowa data on a modern sample using the Panel Study of Income Dynamics (PSID). By using the same methodology and comparable variables, this approach will produce elasticity estimates for both the beginning and end of the century that, while biased downward, can still be compared in relative terms.[2] A significant difference between the intergenerational income elasticity measured for the Iowa sample and for the PSID will be the basis for assessing whether income mobility has risen or fallen over the course of the twentieth century.

Given that the young adults in the PSID are more likely to still be in school and less likely to have established families relative to their 1915 counterparts, an older cohort in the PSID may be more comparable to the 1915 sons in terms of career status. To account for this possibility, the PSID results are estimated for sons between the ages of 25 and 40 in addition to the 20 to 35 year old age range used for the Iowa sons.

2.2. Intergenerational Income Elasticities, 1915 and 2001

Table 2.1 presents the intergenerational income elasticity estimates using the 1915 Iowa father-son pairs and the PSID. Columns 1 and 2 give income elasticity estimates for Iowa in 1915 using both annual earnings and monthly earnings, defined as annual earnings divided by months employed. While annual earnings provide a better measure of overall welfare, the average monthly earnings may offer a clearer picture of the differences in the wage rates of fathers and sons. Both earnings measures produce similar estimates

[2] While the bias resulting from using a single observation of income as a measure of average lifetime income is of greatest concern, there is another measurement error issue that should be mentioned. There is a possibility that, through the linking procedure, some father-son pairs are incorrectly matched in the Iowa data. Such mismatches produce a mean-reverting measurement error for both the father's income and father's age variables in the Iowa sample that is not an issue in the PSID. For a fuller discussion of this problem and a check of the robustness of the results to different rates of mismatched data, see the appendix.

of intergenerational income elasticity, suggesting that a 10 percent increase in father's earnings leads to a roughly 1 percent increase in earnings for a son of age 30.

The elasticity estimates using the PSID (columns 3 through 6) suggest that the decline in occupational mobility identified by Ferrie holds for income mobility as well. The intergenerational income elasticity in 2001 is nearly three times that of 1915. This finding is consistent across all of the age range choices. For a 30-year-old in 2001, a ten percent increase in parental income leads to a roughly three percent increase in son's income as opposed to the one percent increase expected for a 30-year-old son in 1915. Studies by Hertz (2007) and Solon & Lee (2006) using the PSID to examine trends in intergenerational income mobility over the second half of the twentieth century show that the intergenerational income elasticity has been stable in recent decades, suggesting that this decline we identify likely occurred during the first half of the twentieth century.[3] This is a striking decline in mobility over just a handful of generations.

While this decline is quite large, there is a question of whether it signifies a true decline in intergenerational mobility over the twentieth century or whether it is instead a product of differences in sample composition between the Iowa dataset and the PSID. With a large proportion of the Iowa sample made up of farmers, concerns of variability in annual income arise. As a group, farmers have a wide range of annual incomes in the 1915 Iowa census, with farmers representing many of the poorest and richest individuals in the sample. This variability likely extends beyond differences across individuals to differences over time for any given individual, with farm output and crop prices fluctuating year to

[3]Our intergenerational income elasticity estimates using the PSID are at the low end of the range of estimates found by Hertz (2007) and Solon & Lee (2006), where intergenerational income elasticities typically fall between .3 and .5. It is unsurprising that our estimates are low relative to Lee, Solon and Hertz's as ours are subject to additional measurement error.

Table 2.1: Intergenerational income elasticity estimates, son's log earnings as dependent variable

Sample:	Iowa, 1915		PSID, 2001			
Son's Earnings Measure:	Annual Earnings	Monthly Earnings	Family Income			
Son's Age Range:	20-35	20-35	All Ages	20-35	25-35	25-40
	(1)	(2)	(3)	(4)	(5)	(6)
Father's log earnings	0.109***	0.122***	0.298**	0.289**	0.267**	0.312**
	(0.030)	(0.039)	(0.026)	(0.037)	(0.044)	(0.034)
Father's age	-0.079*	-0.068	0.053*	0.069	0.122**	0.108**
	(0.045)	(0.047)	(0.024)	(0.037)	(0.044)	(0.034)
(Father's age)^2	0.001	0.001	-0.000	-0.001	-0.001*	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Son's age	-0.054*	-0.058***	-0.026	-0.104	-0.038	-0.023
	(0.029)	(0.021)	(0.045)	(0.087)	(0.096)	(0.086)
(Son's age)^2	-0.007	-0.005	-0.001	-0.014	-0.042	0.001
	(0.005)	(0.003)	(0.004)	(0.018)	(0.033)	(0.013)
Son's age x	0.015***	0.014***	0.007	0.013	0.007	0.006
father's log earnings	(0.004)	(0.003)	(0.004)	(0.008)	(0.009)	(0.008)
(Son's age)^2 x	0.001	0.000	-0.000	0.001	0.003	-0.000
father's log earnings	(0.001)	(0.000)	(0.000)	(0.002)	(0.003)	(0.001)
Constant	8.386***	5.784***	5.584**	5.315**	3.972**	3.800**
	(1.385)	(1.353)	(0.765)	(1.068)	(1.346)	(1.057)
Number of observations	1094	1017	1879	1246	988	1403
R-squared	0.22	0.20	0.20	0.19	0.15	0.16

Standard errors in parentheses. Son's age is calculated as age at time of observation minus 30. Earnings are in 1915 dollars for columns (1) and (2) and in 2001 dollars for columns (3) through (6).

year. All of this variation decreases the precision of annual earnings as a proxy for lifetime earnings, leading to lower intergenerational income elasticity estimates. Given that farmers represent such a large fraction of the Iowa sample but only a small fraction of the PSID sample, one must be concerned that the lower income elasticities for Iowa are a direct result of variability in farmers' incomes, not a true indicator of greater mobility.

A direct way to address this problem would be through weighting the observations in the PSID or choosing an appropriate subsample to replicate the occupational distribution of the Iowa sample. However, the small size of the PSID sample and extremely small number of farmers make this approach infeasible. An alternative approach is to estimate the elasticities for the Iowa sample excluding farmers. The results for these estimations, provided in appendix table A.4, reveal that while the farming fathers and sons did depress the intergenerational income elasticity estimates, the intergenerational income elasticity for non-farmers in 1915 was still well below that of the 2001 PSID individuals, strengthening the conclusion that intergenerational income mobility was indeed much greater at the turn of the century than it is for modern America.

A lingering sample composition concern regards migration out of state. The method used to construct the intergenerational sample requires that all sons reside in Iowa in 1915. Those sons that move out of the state are never included in the dataset, making the regression sample overrepresentative of stationary individuals. It is quite reasonable to assume that more geographically mobile individuals may exhibit different income mobility patterns than less geographically mobile individuals. Failing to include individuals that move out of Iowa will bias the intergenerational income elasticity estimates in an unknown direction. Appendix tables A.5 and A.6 offer some insight into the extent of this problem by examining the characteristics of movers and non-movers. The descriptive statistics in table A.6 reveal that individuals who move long distances are indeed quite different from stationary individuals, having higher incomes, lower unemployment and more years of education on average. The fathers of these individuals also had higher incomes and educational attainment than the fathers of stationary individuals. These differences in observable characteristics suggest that including sons who move out of state, if it were possible, would lead to different intergenerational elasticity estimates. While little can be done to correct for this problem or even sign the bias it introduces, the data can say something about the magnitude of the problem. Table A.5 gives the distribution of distances moved by sons in the Iowa sample. Assuming that migration out of the state is not substantially different from migration into Iowa and long moves within Iowa, table A.5 suggests that the number of long distance movers that I fail to capture in the dataset is quite small, with the vast majority of individuals either not moving at all or only moving over small distances. While the father-son dataset excludes individuals leaving Iowa, the number of those individuals is likely quite low and the resulting impact on the intergenerational income elasticity estimates small.

2.3. Alternative Mobility Measures

The intergenerational income elasticity provides a convenient measure of mobility; its estimation is straightforward and it allows for the analysis of the effects of continuous measures of school quality on mobility carried out in the following chapter. Being a commonly used measure in the intergenerational mobility literature, direct comparisons to published mobility results from other countries and time periods can be made. However, the intergenerational income elasticity is by no means a perfect mobility measure. In particular, it only captures the relationship between a father's income and the expected value of his son's income. The intergenerational income elasticity does not distinguish between an economy in which the variance in sons' incomes conditional on the income of their fathers is large and an economy in which that variance is small as long as the expected values of the son's income are the same. Most people would agree that the former economy exhibits greater mobility than the latter but this distinction will not be made by the intergenerational income elasticity. In this section, we turn to a variety of alternative mobility measures that can offer a slightly different perspective on differences in mobility between 1915 and 2001.

A large number of mobility measures exist, each capturing a slightly different dimension of mobility. The classes of mobility measures that can be applied to the Iowa data are limited by having only a single cross section of incomes that requires comparing the incomes of a young generation to those of an older generation at the same point in time and therefore different stages in the life cycle. This prevents distinguishing between age effects and cohort effects when looking at changes in the overall income distribution. This is particularly problematic for mobility statistics like the the Shorrocks measure, in which mobility is estimated based on changes in a measure of income inequality like the Gini coefficient, or the Fields-Ok measure in which differences between fathers' and sons' log incomes are summed and used as a measure of mobility. For these types of measures focused on absolute magnitudes of income, a difference in mobility between 1915 and 2001 could be the result of either differences in the correlation of labor market outcomes of fathers and sons or differences in the shape of the income distribution over the life cycle. The effects of inter- and intragenerational mobility are indistinguishable.

Far more useful in the case of the Iowa data are those mobility measures that look at movement between different quantiles of the income distribution. Such measures include the average difference between father and son's income quantiles, the mean time before exiting a particular quantile, and the relative numbers of concordant and discordant pairs in the joint distribution of father and son's incomes. All of these measures assess how closely correlated a son's position in the income distribution is to that of his father but fail to capture absolute gains or losses in income common to all sons. The issue of observing sons and fathers at different ages is still relevant when looking at these quantile-based measures. Given that average income varies over the lifecycle, both the son and father's income quantiles will be sensitive to whether they are younger or older than their peers. Two father-son pairs, despite the sons having identical lifetime profiles as well as the fathers, could have different pairs of income quintiles if the difference in ages between the son and father is greater for one pair than the other. This issue is easily addressed by using income quantiles based on age-adjusted incomes.

Several mobility measures based on transitions between income quintiles are summarized for both the Iowa sample and the PSID sample in Table 2.2, Table 2.3 and Table 2.4. Each measure is calculated using both unadjusted incomes and age-adjusted incomes. Goodman and Kruskal's gamma and Kendall's tau-b are measures of the surplus of discordant pairs over concordant pairs in the income transition matrix.[4] These measures approach zero under perfect mobility and one in the case of perfect immobility. The mean exit times measure the average number of generations that a dynasty occupies the same income quintile given that the father was in that quintile. A larger mean exit time indicates greater persistence in that particular quintile suggesting less income mobility. The average difference in quintiles measure indicates not only how likely it is for a son to move to a different quintile but also how far in the income distribution the son moves.

All of these various measures of mobility confirm the findings from the intergenerational income elasticity estimates: income mobility was substantially higher in Iowa in 1915 than it is today. Sons were more likely to occupy a different position in the income distribution than their fathers and distances moved across the distribution were greater at the turn of the century than in modern times. These results coupled with the intergenerational income elasticity estimates demonstrate that there was a substantial decline in American income mobility over the twentieth century.

[4] In the context of intergenerational mobility a pair of father-son income quantile observations (q_f^1, q_s^1) and (q_f^2, q_s^2) would be concordant if q_f^1 is greater than q_f^2 and q_s^1 is greater than q_s^2 and discordant if q_f^1 is greater than q_f^2 but q_s^1 is less than q_s^2.

Table 2.2: Goodman and Kruskal's gamma and Kendall's tau-b calculations using age-adjusted incomes, 1915 and 2001

	Unadjusted incomes		Age-adjusted incomes	
	Iowa, 1915	PSID, 2001	Iowa, 1915	PSID, 2001
Using quintiles:				
Goodman and Kruskal's gamma	.0726	.2243	.0821	.3178
	(.032)	(.023)	(.031)	(.022)
Kendall's tau-b	.0576	.1802	.0658	.2562
	(.026)	(.018)	(.025)	(.018)
Using deciles:				
Goodman and Kruskal's gamma	.0749	.1911	.0696	.2749
	(.027)	(.019)	(.026)	(.018)
Kendall's tau-b	.0663	.1722	.0627	.2479
	(.024)	(.017)	(.023)	(.016)

Standard errors given in parentheses. Both Goodman and Kruskal's gamma and Kendall's tau-b approach zero under perfect mobility and one under perfect immobility.

Table 2.3: Mean exit time by quintile, Iowa and PSID

	Unadjusted incomes		Age-adjusted incomes	
Father's quintile	Iowa, 1915	PSID, 2001	Iowa, 1915	PSID, 2001
1	.47	.57	.38	.64
	(.04)	(.06)	(.04)	(.06)
2	.25	.24	.27	.29
	(.03)	(.04)	(.03)	(.04)
3	.29	.30	.29	.28
	(.03)	(.04)	(.03)	(.04)
4	.24	.27	.25	.29
	(.03)	(.04)	(.03)	(.05)
5	.41	.49	.38	.59
	(.04)	(.07)	(.04)	(.08)

Standard errors given in parentheses. Mean exit time is defined as the expected number of generations that a dynasty will stay in a particular income quintile given that the father was in that quintile.

Table 2.4: Average difference in quintiles between son and father, Iowa and PSID

	Iowa	PSID
Age-adjusted	1.50	1.25
incomes	(1.19)	(1.08)
Unadjusted	1.55	1.35
incomes	(1.27)	(1.13)

Standard deviations given in parentheses.

CHAPTER 3

Expanding Public Education and Intergenerational Mobility

3.1. School Access, School Quality and Mobility

The Iowa data confirm that a major decline in income mobility occurred over the twentieth century. The question that remains is whether the data can provide any evidence that this decline was due in part to the rise of the modern public education system. To answer this question, we turn from intertemporal comparisons to an examination of differences in mobility rates across locations in Iowa at the turn of the century.

Heterogeneity in school types and quality across Iowa school districts at the height of the transformation to modern public schools provides an opportunity to directly study the relationship between educational institutions and mobility. In particular, the inclusion of a measure of school quality interacted with father's log income in equation 2.2 offers a means of assessing whether the evolution of the public school system was altering mobility patterns in Iowa by testing whether intergenerational income elasticities varied across school districts of differing quality.

The inclusion of school quality transforms the regression equation into

$$\begin{aligned}\ln y_{i,s} &= \gamma_0 + \gamma_1 \ln y_{i,f} + \gamma_2 A_{i,s} \ln y_{i,f} + \gamma_3 A_{i,s}^2 \ln y_{i,f} + \\ &\quad \gamma_4 A_{i,f} + \gamma_5 A_{i,f}^2 + \gamma_6 A_{i,s} + \gamma_7 A_{i,s}^2 + \gamma_8 S_i + \gamma_9 S_i \ln y_{i,f} + u_i \qquad (3.1)\end{aligned}$$

where S_i is a measure of the school quality in the school district of father-son pair i in 1900. The term containing only S_i allows the income distribution of the sons to shift with a change in school quality. The coefficient γ_9 represents the marginal change in the intergenerational income elasticity resulting from an increase in school quality. A positive value for γ_9 would indicate that an increase in school quality corresponds to an increase in the intergenerational income elasticity, implying a decline in income mobility.

This approach requires two crucial assumptions. The first regards the validity of 1900 school quality as a proxy for school quality over the entire academic career of the son. While the county superintendent of schools records are available on an annual basis, the time costs of transcription are such that only a single year of records has been transcribed. In choosing a single year, 1900 makes an attractive candidate as it is a year in which all of the sons in the sample are of school age and it matches the year in which sons' locations in the federal census are observed. However, the large degree of heterogeneity in school types and quality across districts raises the natural question of whether a single year of school data provides a reasonable measure of school quality over a several year period.

While the question cannot be fully addressed without the collection of additional data, a plausible argument can be made for why it should not negate the relevance of any significant estimates. Because the sample is centered in the middle of the transformation to modern public schools rather than a steady state, school quality and access are increasing everywhere in Iowa as townships introduce graded schools and begin to take advantage of the newly granted ability to use local taxes to fund public education. With school quality not only increasing, but increasing through the same mechanisms and toward the same end, it is reasonable to assume that a district observed to have higher school quality in 1900 will have higher average school quality over a multi-year period. School districts are all making a transition from a system of common schools to a modern graded school system. Schools beginning that transition earlier will have higher average levels of school quality over a given period than schools that begin that transition later. Differences in school quality across districts not due to this transition will be due to factors such as tax base and population composition that evolve slowly and consequently, if present when the sample sons are beginning school, are likely to be roughly the same when the sons are exiting school. Differences in school quality in 1900, while not capturing the exact differences in average school quality over the entire academic careers of the sons, should still be an accurate means of ranking districts by average school quality.

The second key assumption is that location choices, both in terms of where families locate and where schools are built, are exogenous. If families relocate based on school quality or if school location is a product of variation in communities' tastes for public education, the school quality variable will be correlated with preferences for education, home environment and other unobserved characteristics relevant to a son's earnings. Ruling out the endogeneity of location decisions is quite difficult. Looking at the distribution of earnings within districts conditioning on school access and quality (Figure 3.1 and appendix table A.7), it appears that both school location and school district quality are independent of the location of wealthy families; there is no trend in either the mean or the shape of the earnings distribution as school access and quality rise. The similarity of the earnings distributions across school districts of different qualities and access suggests that schools were not being built with a higher frequency in wealthier districts and that there was no net migration of wealthy families, those most capable of moving, toward better school districts. While these earnings distributions help alleviate concerns of correlations between school location and the financial resources of parents, they cannot dismiss concerns of families sorting themselves among school districts according to preferences for education in a manner uncorrelated with income.

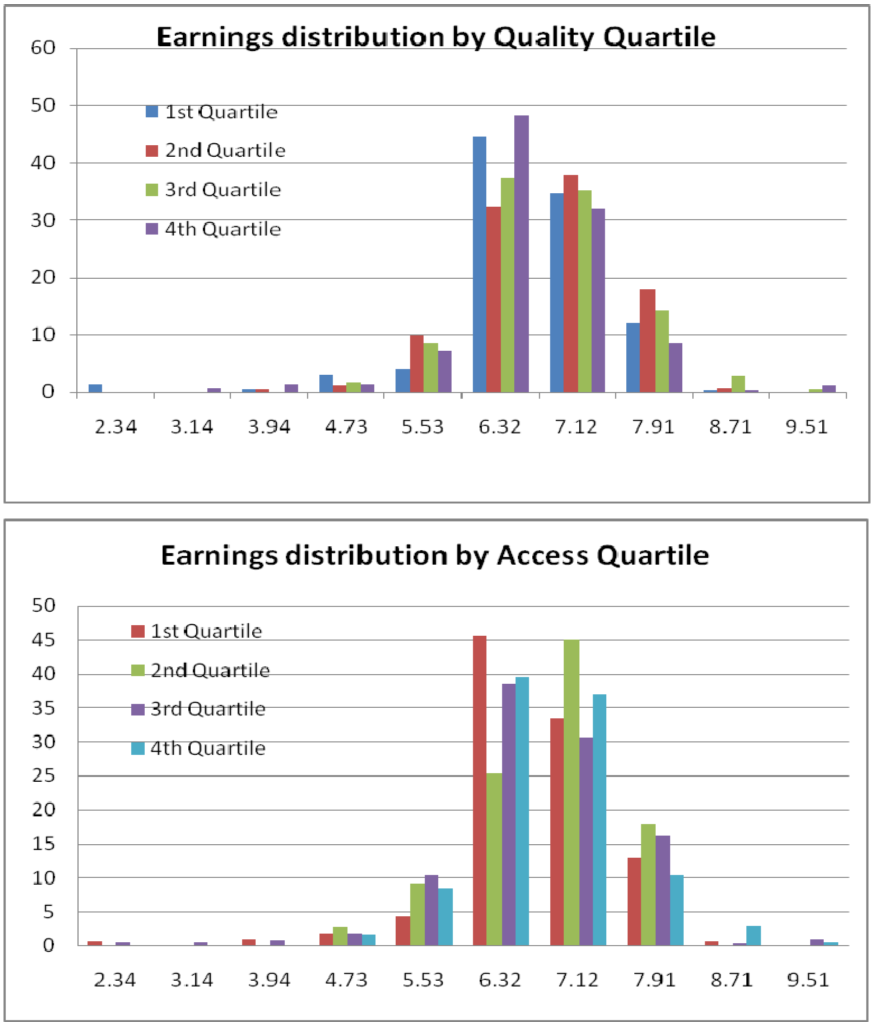


Figure 3.1: Distribution of father's log annual earnings by school quality and access quartiles. School access is defined as the number of graded classrooms per square mile. School quality is defined as the level of spending per student.

This issue of the potential endogeneity of school locations highlights one of the key advantages of using historical data. Modern school districts are the product of decades of change including gradual infrastructure development or decay, geographical mobility patterns of high and low income households, and constraints arising from a complex mix of local, state and federal funding and the various restrictions and incentives that go along with those funding sources. The Iowa school districts at the turn of the century are not firmly entrenched as institutions. By observing these schools in their infancy, we have an opportunity to observe the effects of those schools before the community and schools coevolve, creating a host of endogeneity problems related to correlations between wealthy residents, active parents and good schools. This approach of comparing mobility rates across school districts of varying quality would be impossible using modern data but is made feasible by the speed with which the public school system expanded in all areas of Iowa at the turn of the century.

The detail of the county superintendent records allows for a variety of school quality measures. Two main categories of measures will be used, measures of geographical access to schools of various types and measures of the quality of education provided at those schools. Variables constructed in the first category include an indicator variable for the presence of graded schools in a district, the number of classrooms per square mile and the number of graded classrooms per square mile. Measures of the quality of available schooling include taxes per student, total expenditures per student, students per classroom, the student teacher ratio and the amount of subsidy per student, defined as the difference between annual spending per student and annual tuition charged to an out of district student. Summary statistics of these measures are given in Table 3.1. Correlations between the measures are given in table A.8 of the appendix.

The summary statistics reveal stark although not entirely unexpected differences between rural and urban school districts. As one would predict, urban areas have on average far more classrooms per square mile. Spending and taxes are only slightly higher

Table 3.1: Summary statistics for schooling measures by population density, 1900

	Rural Individuals	Urban Individuals
Percentage of districts	.60	1.00
with graded schools	--	--
Classrooms per student	.026	.014
	(.008)	(.003)
Taxes per student	9.25	12.79
	(3.98)	(1.55)
Spending per student	11.15	14.44
	(5.45)	(1.20)
Classrooms per square mile	.27	4.95
	(.14)	(3.36)
Graded classrooms per square mile	.091	4.72
	(.146)	(3.40)
Student-teacher ratio	25.67	168.10
	(13.84)	(192.46)
Subsidy per student	-2.11	9.05
	(6.34)	(3.97)

Notes: All monetary values are in 1900 dollars. Subsidy per student is defined as annual spending per student minus annual tuition per student. Standard deviations are given in parentheses.

for urban school districts but the subsidy per student is much larger, indicating a greater reliance on taxes rather than tuition as a source of school funding in the more urban areas. While the student-teacher ratio is much higher for urban districts, the low student-teacher ratio in rural districts is a result of common schools with small numbers of students and not the indicator of higher quality instruction that low ratios are assumed to be in modern times. These descriptive statistics suggest that urban districts not only had higher quality education on average, in the sense that spending was higher, but that the provision of education may have been more egalitarian.

For the purposes of estimating equation 3.1, the sample is divided into one subsample of urban individuals and one subsample of rural individuals with separate estimations run for each sample. The motivation for estimating the intergenerational income elasticity separately for urban and rural individuals is not the differences in the means of the schooling variables discussed above; the variances of the measures are sufficiently large that the effect of school quality could be identified separately from differences in mobility purely due to a district being urban or rural. The need for separate estimations is driven instead by the differences in interpretation of the schooling variables between urban and rural areas. In particular, the density of graded classrooms as a measure of geographical access to schools changes its meaning once the number of schools becomes sufficiently large. Observed differences in the number of graded schools across rural districts correspond to large differences in physical access to education. Differences across urban districts are indicating not whether a child has access to a school but instead how many schools students are divided between in a district. Separate regressions for rural and urban individuals will allow for clearer interpretation of the schooling measures.

Table C.6 and Table C.7 of the appendix provide the intergenerational income elasticity regression results for the various school measures for urban and rural school districts respectively. The estimated coefficients for the school quality and access interaction terms for both urban and rural school districts are summarized in Table 3.2. Of the access measures that are statistically significant for rural school districts, all have signs consistent with improvements in school access reducing mobility. The positive coefficients on both the density of all classrooms and density of graded classrooms in a district suggest that improving geographical access to schools increased the intergenerational income elasticity, reducing mobility. The magnitude of this effect is substantial: introducing an additional graded school and high school to a typical rural school district (an addition of twelve

Table 3.2: Marginal effect of school quality/access on the intergenerational income elasticity by schooling measure

	Earnings x Schooling Measure	
Schooling Measure	Urban Distícts	Rural Districts
Graded schools	--	-.044
	--	(.059)
Classrooms per student	-53.71**	1.79
	(13.37)	(7.47)
Taxes per student	0.067*	.014
	(.030)	(.009)
Spending per student	.024	.012
	(.068)	(.008)
Classrooms per sq. mile	-.033**	.230*
	(.009)	(.128)
Graded classrooms per sq. mile	-.027**	.275**
	(.008)	(.111)
Student-teacher ratio	-.000*	-.004***
	(.000)	(.001)
Subsidy per student	.000	.017**
	(.011)	(.004)

Standard errors in parentheses, complete regression results are provided in the appendix. * significant at 10%; ** significant at 5%; *** significant at 1%

graded classrooms to an area of thirty-six square miles) is associated with an increase in the intergenerational income elasticity of nine percentage points.

While physical access proves to be quite important in rural districts, the results suggest that the quality within schools did not appreciably affect mobility. Neither spending per student nor taxes per student is statistically significant. The effect of the student-teacher ratio is significant but, as discussed earlier, difficult to interpret for rural school districts. Many of the lowest student-teacher ratios are for districts with small common schools and consequently correspond to lower school quality than the higher ratios of districts with large high schools. The subsidy per student, a measure of just how public or egalitarian a district is, is significant and has a positive sign consistent with the expansion of public education reducing mobility.

The urban results do little to alter this picture of mobility declining as public education expanded and improved. Spending per student and taxes per student both have large, positive coefficients suggesting that increases in urban school district quality reduced mobility although the coefficient for spending per student, arguably the best available proxy for school quality, is statistically insignificant. The student-teacher ratio, a clearer indicator of school quality in the urban case, is statistically significant but minuscule in magnitude. The classroom density coefficients have the opposite sign from rural districts but all of the urban districts had a sufficiently large number of graded classrooms that these variables can no longer be considered indicators of meaningful differences in geographical access to schools.

The results for both rural and urban school districts reveal declines in mobility as both school access and quality improved. While the effects of school quality on mobility are small and lacking in statistical significance for both urban and rural districts, the estimated effect of geographical access on intergenerational income elasticities is substantial. The introduction of additional grammar schools and high schools in Iowa districts, one of the key features of the public school expansion and high school movement, dramatically decreased intergenerational income mobility.

Table 3.3: Income quantile transitions for Iowa father-son pairs, percentages

Father's Income Quintile	Son's Income Quintile 1	2	3	4	5
1	7.59	3.11	4.02	5.30	3.66
2	3.56	3.93	4.94	4.75	2.29
3	6.86	3.66	5.76	5.21	5.39
4	4.11	1.83	2.65	3.47	3.75
5	3.84	2.29	1.92	2.01	4.11

3.2. Movement and Persistence Throughout the Income Distribution

Intergenerational income elasticities provide a convenient way to summarize and compare the overall level of mobility across school districts of varying quality. However, they do not provide a detailed picture of which individuals are moving up or down in the income distribution. This section introduces income transition tables and estimates of persistence in or movement to various income quantiles in an effort to provide a richer account of the variation in income mobility rates across school districts and offer insight into how mobility was achieved.

Income quantile transition tables offer a convenient and intuitive depiction of the relationship between father and son's incomes. Observing movement from one income quantile to another allows for assessment of whether individuals in one part of the income distribution experience greater mobility than those in another. Identifying persistence in particular regions of the income distribution and the relative likelihood of small and large movements across the distribution aids in creating a fuller picture of mobility and offers a better foundation for addressing normative questions surrounding issues of mobility.

Table 3.4: Income quantile transitions for low graded school access districts, percentages

Father's Income Quintile	Son's Income Quintile 1	2	3	4	5
1	5.37	1.79	4.18	5.97	3.88
2	5.07	2.99	7.46	4.18	3.28
3	6.87	2.39	5.97	3.58	3.28
4	5.07	1.79	1.79	4.78	3.88
5	6.27	3.28	2.99	1.19	2.69

Notes: Low graded school access is defined as being in the bottom half of the distribution of school districts by the number of graded classrooms per square mile.

Table 3.5: Income quantile transitions for high graded school access districts, percentages

Father's Income Quintile	Son's Income Quintile 1	2	3	4	5
1	8.16	2.42	4.23	3.93	3.32
2	3.32	5.74	4.83	2.72	2.11
3	3.63	3.93	4.53	5.74	3.93
4	3.32	5.74	3.32	3.63	3.93
5	3.63	2.42	1.51	3.32	6.65

Notes: High graded school access is defined as being in the top half of the distribution of school districts by the number of graded classrooms per square mile.

The income quintile transition table for the Iowa father-son pairs is shown in Table 3.3. Transition tables conditional on school access are given in Table 3.4 and Table 3.5. A cursory glance at the tables reconfirms the observation of high mobility in early twentieth century Iowa. Large movements both up and down the income distribution were not uncommon, regardless of the father's income quantile. Table 3.3 suggests that the

American dream was indeed quite realistic at the turn of the century with any position in the income distribution open to a son no matter the wealth of his father.

This picture of extensive mobility begins to change once school district characteristics are considered. When looking separately at those father-son pairs from districts in the top half of the school access distribution and those from districts in the bottom half of the school access distribution, evidence of declining mobility with rising school access once again appears. Most notably, sons from districts with good school access display a great deal more persistence in both the lower and upper tails of the income distribution, with the sons in high access districts of fathers in the bottom or top income quintile much more likely to stay in those respective quintiles than their low school access counterparts. Movement in and out of the middle quintiles of the income distribution was much more similar between the low and high access school districts. These observations are consistent with a model in which public school expansion reduces but does not eliminate constraints on educational investment. Wealthy families seeing an upper bound on educational attainment relaxed and poor families finding the increased presence of schools irrelevant given credit constraints and a heavy reliance on the labor income of their children would yield the increasing persistence in the tails of income distribution and mixed response in the middle of the distribution displayed by the data. This possible explanation of declining mobility will be considered more fully in the section on changes in educational attainment.

The noticeable differences in persistence in the upper and lower tails of the income distribution warrant further exploration. Using the occupational, geographical and educational data contained in the father-son dataset, the individual characteristics that affect the likelihood of movement or persistence in the income distribution can be identified. Following the approach of Steckel and Krishnan (2006), I estimate logit regressions for individuals persisting in or moving into both the bottom and top quintiles of the income distribution. The dependent variable for the persistence regressions is an indicator variable taking on a value of one for all observations where both the son and father were in the bottom (or top) income quintile and zero for observations where the father was in the bottom (or top) quintile and the son was in a different quintile. The dependent variable for the movement into the bottom or top quintile regressions takes on the value of one when a father was not in the bottom (or top) quintile but the son was and takes on a value of zero when both the father and son were not in the bottom (or top) quintile. The independent variables include son's education, son's age, dummy variables for whether the son moved across counties or to a city, and a set of dummies specifying the occupational categories (white collar, service/sales, agricultural, blue collar) for both father and son. The estimated coefficients for these variables quantify the relative importance of education, geographical mobility and occupational mobility in achieving income mobility.

The most prominent result from the logit regressions, summarized in appendix tables A.10 and A.11, is the importance of educational attainment in moving up in the income distribution. An additional year of education both substantially reduced the likelihood of remaining in the bottom quintile and increased the likelihood of moving into and staying in the top quintile. Occupational transitions were also highly correlated with persistence and movement in the income distribution. Entering farming or a blue collar profession increased the likelihood of entering or persisting in the bottom income quintile. Entering any occupational category other than blue collar was associated with a higher likelihood of entering or remaining in the top income quintile. Somewhat surprisingly, geographical mobility is not significantly correlated with income mobility. Moving to a city reduced the likelihood of moving into the bottom income quintile but otherwise moving across counties or into a city did not substantially increase or decrease persistence in or movement into either tail of the income distribution.[1]

These regression results identify educational attainment and occupational mobility as key factors in determining income mobility. These findings viewed in tandem with the differences in the distributions of educational attainment and occupations between high access and low access school districts begin to explain how income mobility could be decreasing as the public school system expanded. The means for the logit regression variables conditional on school district access and quality, summarized in Table 3.6, offer several insights into the sources of lower mobility rates in better schools districts. First, the persistence in the tails of the income distribution is noticeably higher in better school districts, both in terms of school access and school quality. This is particularly true of persistence in the top quintile of the income distribution, where sons in good school districts with fathers in the top income quintile were three times more likely to remain in the top quintile than sons in bad school districts. These significantly higher persistence rates are due in part to the greater educational attainment levels of sons from good school districts. Occupational transitions are also quite different for sons depending on their school district. Sons from better school districts were far less likely to remain farmers and were much more likely to enter white collar occupations when having a father in either a

[1]This finding that geographical mobility had little relation to income mobility comes with a sense of relief as it helps minimize the concerns raised earlier that failure to observe people who migrate out of state may bias mobility estimates.

Table 3.6: Means for logit variables by school district access and quality

Variable	Top half of school access	Bottom half of school access	Top - Bottom	Top half of school quality	Bottom half of school quality	Top - Bottom
Moved into bottom	0.19	0.30	-0.10	0.16	0.31	-0.15
Persisted in bottom	0.34	0.27	0.07	0.35	0.27	0.07
Moved into top	0.19	0.16	0.03	0.18	0.17	0.02
Persisted in top	0.46	0.15	0.31	0.50	0.18	0.32
Son's age	26.27	26.03	0.24	26.16	26.11	0.05
Son's years of schooling	9.59	8.90	0.69	9.64	8.76	0.88
Occupational transitions (father-son):						
white collar - white collar	0.09	0.05	0.03	0.10	0.04	0.05
white collar - service	0.01	0.00	0.01	0.01	0.01	0.00
white collar - farm	0.00	0.01	-0.01	0.01	0.01	0.00
white collar - blue collar	0.06	0.05	0.00	0.06	0.04	0.02
service - white collar	0.07	0.01	0.06	0.08	0.02	0.06
service - service	0.06	0.01	0.05	0.06	0.02	0.03
service - farm	0.01	0.01	0.00	0.00	0.01	-0.01
service - blue collar	0.05	0.02	0.03	0.06	0.03	0.03
farm - white collar	0.01	0.02	-0.01	0.01	0.02	-0.01
farm - service	0.02	0.04	-0.02	0.02	0.03	-0.02
farm - farm	0.18	0.42	-0.24	0.14	0.41	-0.26
farm - blue collar	0.06	0.06	0.00	0.05	0.06	-0.02
blue collar - white collar	0.11	0.05	0.06	0.12	0.06	0.06
blue collar - service	0.02	0.03	-0.01	0.02	0.03	-0.02
blue collar - farm	0.03	0.01	0.02	0.02	0.03	0.00
Moved across counties	0.03	0.04	-0.01	0.03	0.04	-0.01
Moved to a city	0.01	0.02	-0.01	0.01	0.02	-0.01

All variables except age and years of schooling are dummy variables taking on a value of either one or zero. School access is defined as the number of graded classrooms per square mile. School quality is defined as spending per student. Top half/bottom half refer to being in either the top half or bottom half of the school access or quality distribution.

service, sales or blue collar job and much more likely to remain in a white collar occupation if their father had a white collar job. However, sons of farmers were less upwardly mobile in the better school districts, with transitions to the lucrative white collar, sales and service sectors less likely and transitions to blue collar occupations, associated with movement into and persistence in the bottom income quintile, far more likely. Levels of geographical mobility were fairly similar across school districts, suggesting that differences in income mobility across districts were more a product of differences in educational attainment leading to differences in occupational mobility and earnings, not of movement to different labor markets.

3.3. School Access, School Quality and Educational Attainment Decisions

The income elasticity regressions reveal that access to schools had a significant impact on mobility rates, suggesting that the evolution of public schools affected wealthy families to a different extent than it affected poor families. The analysis of persistence and mobility within the income distribution and differences in sons' characteristics across districts reveals that these differences in mobility stem from differences in the distribution of educational attainment and the way in which that education translated into occupations and earnings between districts with good school access and districts with poor school access. These findings suggest that the differential impact of public school expansion on wealthy and poor families was a result of some combination of differences in the returns to education and in levels of educational attainment for wealthy and poor families. Wage regressions conditioning on parental income, the results of which are provided in appendix tables A.12 and A.13, reveal that the high returns to education found by Goldin and Katz (2000) are insensitive to parental income. An additional year of schooling offered the same increase in earnings regardless of family background. This leaves differences in educational attainment decisions as the primary explanation of the observed decline in mobility.

To identify differences in the responses of educational investments of wealthy and poor families to increasing school access and quality, I estimate an ordered probit model with years of schooling as the dependent variable. Years of schooling are assumed to be a function of parental income, local school quality measured as spending per student, local school access measured as the number of graded classrooms per square mile, school tuition costs and whether the family lives in an urban or rural area. Including interactions between parental income and the school access and quality variables allows the response to a change in local schools to vary across the income distribution. Positive coefficients on these interaction terms would indicate that wealthy families' schooling investments were more elastic with respect to school access and quality than poor families', offering an explanation for the lower mobility levels in communities with better schools.[2]

A concern with this approach is how much freedom families had to choose schooling levels. If compulsory schooling and child labor laws were binding constraints, educational attainment could be entirely unresponsive to changes in school quality and access. Iowa introduced compulsory schooling with the Compulsory School Act of 1902 and passed its first child labor legislation in 1906. These laws were passed in the middle of the educational careers of the sons in the sample and consequently present a major concern. The laws mandated that children must enter school by the age of 7, could not leave school

[2]A simple model of educational investment is presented in the following section providing intuition for differing elasticities of educational investment with respect to school access for poor and wealthy families. An example of quasilinear preferences of parents over consumption and schooling produces the two main results of this section: an elasticity of schooling with respect to school access that is increasing in parental income and an elasticity of schooling with respect to school quality that is constant across parental incomes.

until the age of 16, could not work before the age of 14 and could not work until completing 6 years of school. The combined effect of these laws was that a child was required to have at least 8 years of schooling.[3] The distribution of years of educational attainment, shown in figure A.5 of the appendix, suggests that these laws were enforced, with 34 percent of the sons in the sample obtaining exactly the minimum 8 years of schooling. Given these compulsory schooling laws, two different measures of educational attainment are used as dependent variables. The first is years of schooling of any type beyond the minimum 8 years and the second is years of high school. Years of high school are chosen both because they were fairly unconstrained by compulsory schooling laws and because the earnings returns to an additional year of high school were significantly higher than the returns to an additional year of common or grammar school, making changes in high school more significant in terms of economic welfare than changes in total schooling.

Coefficients for the probit estimates are given in appendix table A.14. Both years of total schooling and years of high school are insensitive to school quality but are significantly affected by school access. While the coefficients on school access are negative, they should not be interpreted as educational attainment declining as school access increases. The contribution from the earnings-school access interaction term offsets this negative coefficient and results in a net increase in educational attainment with an increase in school access at nearly all observed income levels. It is the coefficient on this

[3]The timing of the laws is such that the older sons in the sample should have been unaffected by the laws. However, the distribution of educational attainment for the complete sample and for just those sons who were born in 1895 (and therefore fully constrained by the laws) are nearly identical, with a similar percentage of sons receiving the minimum eight years of education (see figure A.5 in the appendix). Given this observation, I treat all sons as if the schooling laws were binding.

Table 3.7: Years of schooling difference in differences varying school access

Father's Earnings	High		High	Low		Low
School Access	High		Low	High		Low
School Quality	Mean		Mean	Mean		Mean
Years of Schooling	9.7825		9.5661	9.3301		9.3154
Edu(high)-Edu(low)		0.2164			0.0147	
Δ(high inc)-Δ(low inc)			**0.2017**			
Years of High School	1.0645		0.8085	0.6184		0.5658
Edu(high)-Edu(low)		0.256			0.0526	
Δ(high inc)-Δ(low inc)			**0.2034**			

Expected years of schooling are calculated using the ordered probit coefficients given in Table A.14. High and low values for a variable are defined as the 80th and 20th percentile of that variable's distribution respectively. All variables other than father's earnings and school access and quality are held at their means.

Table 3.8: Years of schooling difference in differences varying school quality

Father's Earnings	High		High	Low		Low
School Access	Mean		Mean	Mean		Mean
School Quality	High		Low	High		Low
Years of Schooling	9.8059		9.5042	9.3497		9.2742
Edu(high)-Edu(low)		0.3017			0.0755	
Δ(high inc)-Δ(low inc)			**0.2262**			
Years of High School	1.0827		0.7528	0.7202		0.4177
Edu(high)-Edu(low)		0.3299			0.3025	
Δ(high inc)-Δ(low inc)			**0.0274**			

Expected years of schooling are calculated using the ordered probit coefficients given in Table A.14. High and low values for a variable are defined as the 80th and 20th percentile of that variable's distribution respectively. All variables other than father's earnings and school access and quality are held at their means.

earnings-school access interaction term that is of greatest interest. The positive coefficient indicates that for a given increase in school access, the educational attainment of children from wealthy families increases more than that of children from poor families. This effect can be seen in Table 3.7 in which school quality is fixed at its mean while school access is varied between its values at the 20th and 80th percentiles of the school access distribution. The predicted level of educational attainment is calculated at these two school access values for families from the 80th and 20th percentiles of the income distribution, allowing for a differences in differences calculation to compare the responses of wealthy and poor families to increasing school access. The expected number of years of high school increase substantially for children from high income households relative to children from low income households, with an increase in expected years of high school of .26 for wealthy children compared to an increase of .05 years for poor children. Using the returns to education estimates included in the appendix, these figures translate into a 2.8 percent increase in annual earnings for sons from wealthy families relative to only a .6 percent increase in annual earnings for sons from poor families.

These figures may actually understate the differential impact of increasing school access. The predicted probability of attaining a full four years of high school rose nearly 5 percent for wealthy sons compared to less than 1 percent for poor sons. To the extent that part of the returns to attending high school came through credentialing, the importance of which is established by Labaree's (1988) work on Philadelphia high schools from the same period, the increasing probability of high school completion could provide even greater future returns for wealthy children than predicted from the returns to a year of high school estimated in the appendix.

Table 3.8 contains a second set of difference in differences calculations holding school access fixed and varying school quality between its values at the 20th and 80th percentiles of the school quality distribution. Although total schooling does rise more for wealthy families, this increase is largely due to changes in grammar and common school. The difference in the increase in high school attainment between wealthy and poor families is quite small, indicating that the large disparity in earnings gains resulting from increasing school access does not result from a similar increase in school quality.

These educational attainment estimates provide evidence that years of schooling and in particular years of high school, while fairly unresponsive to changes in school quality, were quite responsive to school access. The greater elasticity of the educational attainment for high income households suggests that increasing educational access was raising the future earnings of wealthy children at a faster rate than it was for poor children. While individuals across the income distribution were gaining better access to education and higher earnings potential as a result, the gains were greater for individuals at the upper end of the distribution, providing an explanation for why mobility rates declined and persistence in the tails of the income distribution increased as public education expanded.

3.4. A Simple Model of Educational Investment

The intuition behind the greater elasticity of educational investment with respect to school access for wealthy families relative to poor families can be seen quite clearly through a simple model of educational investment in which parents allocate resources between current consumption and investment in their children. In this section we present a basic model that produces our main empirical findings of increasing educational investments for all families with improvements in school quality and access and a greater elasticity of educational investment with respect to school access for wealthy families than for poor families. Our model is a modified version of the one proposed by Solon (2004) to explain variation in intergenerational mobility over time and place.

Consider a household i consisting of one parent and one child. The parent derives utility from consumption in the current period t and the child's income as an adult in period $t+1$. The utility function of the parent is

$$U(c_{i,t}, y_{i,t+1}) = \alpha \ln c_{i,t} + (1-\alpha) \ln y_{i,t+1} \tag{3.2}$$

where $c_{i,t}$ is household consumption in period t and $y_{i,t+1}$ is the the child's income in period $t+1$.

The parent can increase the future income of the child by investing in education. Let the level of schooling received by the child in the first period be $S_{i,t}$. The future earnings of the child are given by

$$\ln y_{i,t+1} = \mu + \theta q_i S_{i,t} + \nu_{i,t+1} \tag{3.3}$$

where q_i is a measure of school quality in household i's school district and $\nu_{i,t+1}$ is a stochastic shock to the child's income independent of educational investment or parental income. This form of the child's earnings function coupled with the above utility function generates quasilinear preferences for the parent over consumption in period t and schooling.

The problem of the parent is to choose the optimal level of schooling given the household budget constraint in period t:

$$c_{i,t} + \pi S_{i,t} = y_{i,t} + \tilde{y}_{i,t}(\overline{S} - S_{i,t}) \tag{3.4}$$

in which consumption and spending on schooling in period t is equal to the earnings of the parent in period t, $y_{i,t}$, plus the earnings of child during the time that he is not in school, $\tilde{y}_{i,t}(\overline{S} - S_{i,t})$. The marginal cost of an additional year of school includes both the direct cost π of an additional unit of schooling as well as the foregone earnings of the child, $\tilde{y}_{i,t}$, during the additional time spent in school. The effects of public school expansion enter the model through the direct price of schooling π and the school quality parameter q_i. The reductions in tuition costs would lead to lower values of π. Increasing geographical access to schools also lowers π through decreasing travel costs.[4]

Given the above utility function and budget constraint, the optimal level of schooling for the child in period t is

$$S^*_{i,t} = \frac{1}{\tilde{y}_{i,t} + \pi} y_{i,t} + \frac{\tilde{y}_{i,t}\overline{S}}{\tilde{y}_{i,t} + \pi} - \frac{\alpha}{(1-\alpha)\theta q_i}. \tag{3.5}$$

Optimal schooling is increasing in parental income and decreasing in the cost of schooling π as one would expect. Of interest to the paper is how the responsiveness of schooling investment to changes in the price and quality of schools varies with parental income. From equation (7) it is apparent that as school quality rises, increasing the marginal benefit of schooling, the optimal level of schooling rises but the magnitude of the increase is the same across all income levels. This is consistent with the empirical results in section 8 that show a uniform increase in schooling at all income levels with an increase in school quality.

[4]Decreasing travel costs could also be thought of as reducing the opportunity cost of attending school by decreasing the time given up in order to attend an additional year of school. Because $\tilde{y}_{i,t}$ is assumed to be constant, incorporating the reduced travel costs in either π or $\tilde{y}_{i,t}$ will have the same effect on the marginal costs of schooling and lead to the same interpretation of the effects of public school expansion.

The effect of changes in the price of schooling do vary with parental income. Note that

$$\frac{d^2 S^*_{i,t}}{dy_{i,t}d\pi} = -\frac{1}{(\tilde{y}_{i,t} + \pi)^2}. \tag{3.6}$$

The slope of schooling as a function of parental income is increasing as the price of schooling falls. This implies that as the price of schooling falls as a result of the expansion of public education, the increase in schooling for a child from a wealthy family will be larger than the increase in schooling for a child from a poor family. This pattern is shown in panel (a) of Figure 3.2.

Incorporating the effects of compulsory schooling laws and an upper bound on educational attainment imposed by the absence of local high schools prior to public school expansion magnifies these differences between wealthy and poor families. Given a lower bound on educational attainment imposed by compulsory schooling laws, the poorest families will be completely unresponsive to changes in the price of schooling as long as the price is still sufficiently high to make the compulsory level of schooling binding.

Adding an upper bound on the level of educational attainment due to a lack of local high schools that is lifted as a result of public school expansion will lead to an even larger response by wealthy families. All of the wealthy families for which that upper bound was binding will substantially increase schooling investments once high schools are constructed. The effects of these constraints on the poorest and wealthiest families as the price of schooling falls and high school access improves are shown in panel (b) of Figure 3.2.

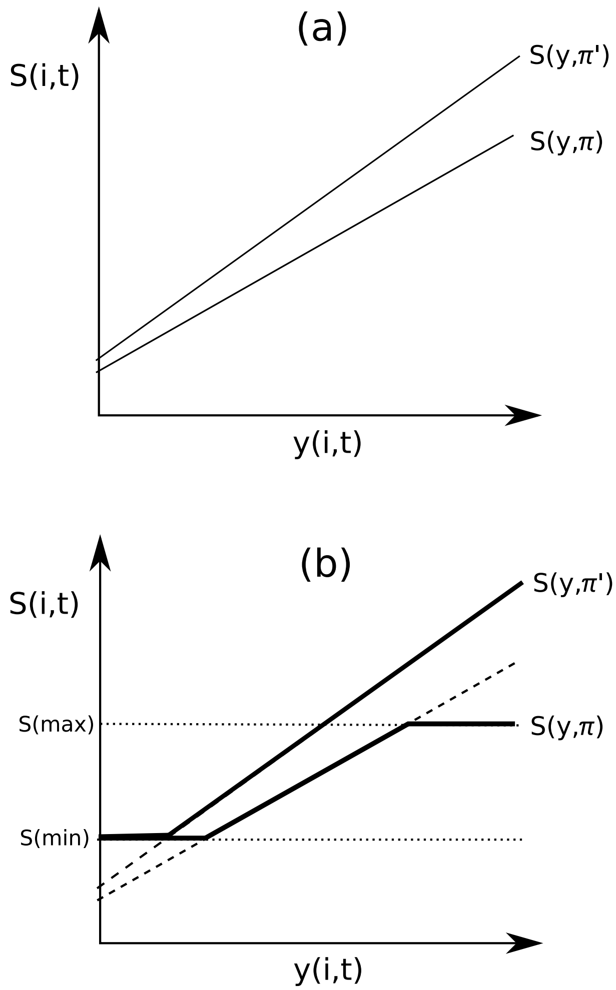


Figure 3.2: Optimal level of schooling as a function of parental income before and after the price of schooling falls from π to π'. Panel (a) shows the change in the absence of binding constraints on schooling. In panel (b), compulsory schooling laws impose a lower bound of $S(min)$ both before and after school expansion and an initial lack of high schools imposes an upper bound of $S(max)$ that is relaxed as new schools are introduced.

While this is a very basic model of educational investment, it does match the responses of families to the main features of the public school expansion: improving school quality, declining costs of attending school both in terms of tuition and foregone earnings and the relaxing of geographical access constraints. Even though the true educational investment decisions of parents are likely a much more complex process, this simple exercise demonstrates that the educational attainment responses and mobility patterns observed in the data can be explained as a rational response of parents who value both consumption and the welfare of their children to changes in the price, quality and availability of public schools.

3.5. Conclusion

The Iowa data demonstrate that there was a substantial decline in American income mobility over the twentieth century concurrent with the rise of modern public education. While the expansion of public education benefited people across the income distribution, increasing average educational attainment and wages, the magnitudes of those benefits varied. A greater propensity to take advantage of high school education, whether a product of fewer financial constraints, stronger preferences for education or other factors, led to wealthy families benefiting disproportionately from improvements to public education. At the individual level, these effects were evidenced by large increases in high school attainment for wealthy individuals relative to poor individuals. At the community level, these differences in educational investments translated into decreased mobility and in particular increased persistence in the tails of the income distribution in those townships with more developed public schools.

While this relationship between public school expansion and declining intergenerational mobility can appear disheartening, it must not be viewed as a broad indictment of the public education system. Public education did lead to absolute gains in educational attainment and earnings throughout the income distribution, even if the magnitudes of those gains were skewed in favor of wealthy families. Further, the potential benefits of education were equal across the income distribution ex ante; the potential returns to educational investment were equally high for individuals from poor backgrounds and individuals from wealthy backgrounds. The benefits of the newly created public schools only proved to be unequal as a result of differences in educational investment decisions on the part of the family. The prospects of a son from a poor family were limited not necessarily by the structure of the educational system but by the preferences and financial constraints of his family.

These observations suggest that the emerging public education system, while associated with declining mobility, may still have been the best option available for expanding schools at a time when education was becoming increasingly important in labor markets. If one takes the increasing demand for education by workers and employers as an inevitable product of the growing economy, the proper focus is not whether the introduction of public grammar and high schools decreased mobility, but whether it did so to a greater or lesser extent than the school system that would have arisen in its place. Private schools, particularly religious academies, were spread throughout Iowa at the end of the nineteenth century and could have expanded to serve the increasing demand for education. The public school system observed in Iowa at the turn of the century, with its public subsidization of education, concern for both urban and rural areas, and responsiveness to community preferences and needs through local political institutions, had fewer geographical access and financial constraints than any private system would have. The features of the school system that led to reduced mobility would be a part of any school system that developed and were minimized by a public system.

The extent to which the observed mobility patterns translated into permanent changes in class rigidities is a matter requiring further study. If they were the result of wealthy families adjusting more quickly to changes in educational institutions, it is possible that the effects have dissipated over time. However, if they were instead the result of more fundamental differences in the educational investment decisions of and constraints faced by wealthy and poor families, the effects on mobility may persist over time and would likely have a modern day analogue in college attendance decisions. They would also be amplified by the increasing correlation between school quality and the geographical distribution of wealth. As section 3.1 showed, the location of schools and the quality of those schools in our sample were not strongly correlated with average community income. The quality of modern school districts is much more correlated with community wealth and could lead to an even greater share of the benefits of schools going to children from wealthy families. Further work to incorporate travel costs for attending school, market and non-market labor income of children, the pace at which schools were being introduced, the changing relationship between community wealth and school quality and the role of private education markets would help identify the contribution of evolving educational institutions to the overall decline in American mobility over the twentieth century. While questions remain about the lasting effects of public school expansion on American intergenerational mobility and class rigidities, our results do show that at the time of public school expansion, improvements in school access and quality, while promoting absolute gains in educational attainment and income across the income distribution, were contributing to declines in relative mobility.

CHAPTER 4

Returns to Education and Human Capital Spillovers in Agriculture

4.1. Introduction

The previous chapters have focused on the links between education and income across generations. The emergence of public schools provided a formal channel through which the income of parents could be transformed into the future economic success of their children. In this respect, the benefits of the newly introduced public schools went disproportionately to children from wealthy families, casting doubt on the social welfare gains from public school expansion. In this chapter we turn from links between education and income across generations to links between education and income across space, focusing on the role of education as a public good. We consider the importance of education in building productive human capital in agriculture at the turn of the century and examine the role of human capital spillovers in farming. In doing so, a much more positive view of public school expansion arises, one in which the private returns to education may have gone disproportionately to those who could best afford school but the public returns, resulting from spillovers across farms, were experienced by farmers of all incomes and education levels.

Central to identifying the effects of the emergence of public education on American agriculture is understanding the role of human capital in agriculture. Productivity in agriculture is highly dependent on allocating resources efficiently, adapting to changes in relative prices, assessing and selectively adopting new technologies and successfully incorporating agricultural advances into farming practices. In all of these aspects of farming, the human capital of the farmer will influence his degree of success. Acquiring human capital, then, is an important step in increasing a farmer's productivity.

While the extensive agricultural economics literature acknowledges the importance of human capital in farming, there is little agreement as to how that human capital is acquired in practice, let alone what the most effective method of accumulating human capital is. Various studies identify a variety of channels through which a farmer might accumulate human capital. Among the most commonly discussed are agricultural extension services, private experimentation, social networks and formal schooling. These various channels need not be independent of each other. Additional formal schooling, for example, may make a farmer more likely to incorporate information from extension agents into his own farming practices.

Regardless of how it is acquired, an individual farmer's human capital is not a purely private input in farm production. If human capital is productive because it allows a farmer to choose better farming technologies, better performing seed varieties or more efficient allocations of his land, it also has value to other farmers who can observe both these decisions and their results. In this sense, by acquiring additional human capital, the farmer improves his own output as well as that of his neighbors or members of his social network. Agricultural production, particularly in the context of smaller single-family farms, is conducive to human capital spillovers.

This chapter introduces a new dataset to explore the effects of schooling and human capital spillovers in early twentieth century American agriculture. The early 1900s were a period in which public education was expanding at a rapid pace and a period which, while predating the dramatic biological advances in agriculture of the 1930s and 1940s, witnessed a wide range of important agricultural innovations. Public schools offered a channel to disseminate information on innovations from the growing agriculture programs at land-grant colleges, giving farmers a new way to accumulate productive human capital. We construct a dataset containing income, education and a variety of unique spatial data for a sample of Iowa farmers and use it to estimate significant income gains both from an increase in a farmer's own education and from increases in the educational attainment of his farmer neighbors.

These estimates of the private returns to education and human capital spillovers for farmers reveal that even prior to the major agricultural innovations of the mid-twentieth century, formal schooling played an important role in increasing farm productivity. The significant private and public returns to education suggest that there were tremendous social welfare gains created by the Midwest's aggressive introduction of public graded schools and high schools in the early twentieth century. These findings shed new light on the forces underlying early public school expansion in the United States and on the potential importance of public schooling in modern developing countries with large agricultural sectors.

4.2. Human Capital, Schooling and Agriculture

The role of human capital in agriculture has received considerable attention but there is little consensus about the magnitude of its importance. Any uncertainty regarding the importance of human capital accumulation to farmer productivity is amplified when looking specifically at the effects of human capital acquired through formal schooling. This can be seen in Figure 4.1 which shows the distribution of the estimated returns to schooling for farmers from 22 different studies conducted around the world.[1] These

[1] For surveys of these and other studies estimating the return to schooling for farmers, see Jamison and Lau (1982), Huffman (2001) and Huffman and Orazem (2007).

studies find a wide range of returns to education, both in magnitude and sign, making it clear that schooling cannot be assumed to be strictly productive in agriculture. Assessing how schooling affects farmer productivity both in modern times and historically requires understanding the complicated role of human capital in agriculture. This section outlines what is known about the returns to formal education and other forms of learning in agriculture and what questions about the relationship between human capital and agricultural productivity remain unresolved.[2]

It is not difficult to envision a role for human capital in farming. Farming is a complex task requiring decisions to be made over a variety of inputs and outputs and a wide and ever-changing set of technologies. Optimal decisions depend on knowledge of prices, local land characteristics, weather and current agricultural science. Successful farming requires not simply physical effort but also a remarkable amount of decision-making akin to that of any firm, only without the support of executives, analysts and consultants. Viewed in this light, it is clear that human capital is a crucial input in successful farming. What is far less obvious is what form that human capital takes and how it is best acquired.

Before considering the acquisition of human capital, it is instructive to be more specific about the types of human capital potentially relevant to farmer productivity. For our purposes, human capital's effects can be divided into two broadly defined aspects of productivity. The first is technical efficiency, the ability of the farm to maximize output

[2]In this study we are concerned with human capital as it relates to the knowledge and skills of a farmer that make him more productive. An additional aspect of human capital central to agricultural productivity is health, with a healthier farmer capable of providing more units of effective labor. This role of physiological capital is particularly important given the physical nature of farming. While the health of farmers is not the focus of this paper, it does have an interesting relationship with the sort of public school expansion discussed in the following sections. One feature of the curriculum in these schools was promoting modern views on health and hygiene. This is one more channel through which the introduction of public schools may have increased farm productivity in our period of interest and is worthy of future study.

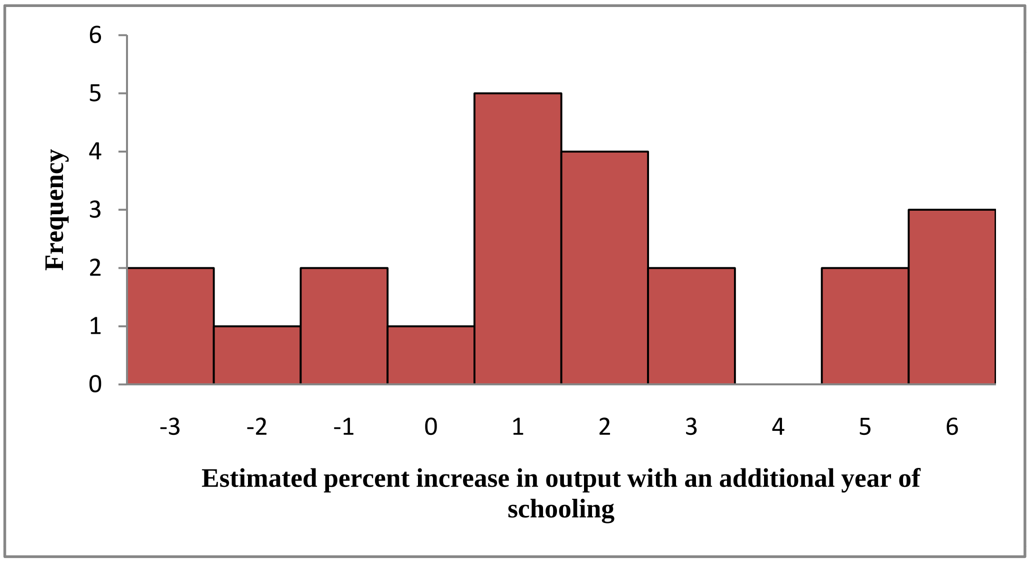


Figure 4.1: Estimated returns to education for farmers from 22 studies. Estimated returns are the percentage increase in output from one additional year of schooling, rounded to the nearest percent. Estimated returns are taken from Table 2-2 of Jamison and Lau's *Farmer Education and Farm Efficiency.*

given a particular set of inputs. The second is allocative efficiency, the ability of the farmer to properly distribute resources to maximize overall farm profits. These are two very different aspects of efficiency in agriculture and, as the existing literature shows, have very different relationships to the various ways of acquiring human capital.

Technical efficiency can be obtained in a variety of ways. The basic competencies developed through early schooling including literacy, numeracy and general cognitive skills all contribute to technical proficiency. The proper use of fertilizer, use and maintenance of machinery, and a variety of other aspects of agriculture all depend on these basic skills for success. However, while elementary levels of schooling create the invaluable literacy and numeracy needed by farmers, advanced schooling may not necessarily contribute to technical efficiency, particularly when considered relative to the foregone experience associated with additional years of schooling. The ability to use inputs efficiently is likely to be more strongly related to experience in working with those inputs rather than knowledge obtained from the classroom. It comes as no surprise then that studies of the returns to education in agriculture reveal that farmer's schooling has little effect on technical efficiency (Huffman, 1999). This should not be taken as an indication that human capital is not of central importance to technical efficiency but rather that the sort of human capital that contributes to technical efficiency is best acquired through channels other than formal schooling.

The role of schooling in allocative efficiency is much more complex and important. Allocative efficiency is relevant in any context in which there are changes in some dimension of agricultural production, including the relative prices of inputs or outputs, growing conditions, or the set of available technologies. A farmer's overall productivity and profitability will be dependent on his ability to adapt to new conditions through reallocating resources and adopting new practices. This adaptive ability is a function of a farmer's human capital stock. One component of this human capital is a stock of knowledge, information on prices, new technologies and so on. A second component is the ability to adapt, to properly apply new information and successfully experiment with new approaches to farming to improve productivity.[3]

The first component is relatively straightforward. A farmer's stock of relevant information will grow through exposure to that information, exposure that can occur through

[3]The role of human capital in helping a farmer adapt to a changing environment is raised in Schultz's work on human capital and the ability to deal with disequilibria (1975). The changing agricultural technologies of the late nineteenth and early twentieth century are consistent with Schultz's notion of disequilibrium and the distinctions he draws between traditional agriculture and agriculture in a modernizing economy.

a variety of obvious channels including extension agents, trade publications, social networks and formal schooling in which agricultural topics are taught. The role of schooling manifests itself in both direct and indirect ways. Schooling directly impacts the stock of knowledge through a farmer or future farmer learning about new topics in the classroom. Schools provide a setting in which the latest advances in agricultural science can be taught to students. If this were the only way in which formal education added to a farmer's human capital stock, we would expect the returns to education to diminish over his career as the information he was taught becomes outdated. However, schooling has an indirect and lasting impact through making a farmer more likely to seek out information. Several studies have found farmers with higher levels of education are both more receptive to new information and more likely to seek it out. Wozniak (1993) examined innovations in livestock feeding in Iowa and found that more educated farmers were more likely to contact extension agents for information about new technologies. Bindlish & Evensen (1997) find a similar result when looking at extension programs in Kenya and Burkina Faso. In both countries, more educated farmers were more likely to participate in extension services and seek out information from other farmers, leading to educated farmers learning about and adopting new technologies earlier than less educated farmers. Bindlish and Evenson find that the educated farmers had a greater appreciation for the value of information from extension services and higher expectations regarding the returns to that information. Additional formal education makes farmers more likely to continue building their stock of useful knowledge throughout their careers, learning about the latest agricultural advances even if they occur after schooling has been completed.

Production of the second component of human capital relevant to allocative efficiency, the ability to successfully experiment and adopt new information and technology, is far less straightforward. Certainly a portion of this adaptive ability is innate. However, there is evidence that adaptive ability can not only be learned, but learned through formal schooling. Abdulai and Huffman (2005) find that a farmer's likelihood of adopting hybrid cow technology in Tanzania depended positively on his level of schooling. Lin (1991) finds similar results for the case of hybrid rice in China. Wozniak (1993) shows that higher education for a farmer significantly increased the probability of adopting new technologies.[4] The greater likelihood of adopting new technologies coupled with the greater likelihood of properly utilizing new information are important ways in which additional education translates into higher productivity of farmers.

The magnitude of productivity gains arising from this role of education and from the simpler role of information acquisition discussed earlier will be highly dependent on the level of change and innovation in the agricultural industry. In a period of rapid scientific advance or major fluctuations in prices of outputs, prices of inputs or growing conditions, adaptive ability becomes crucial to productivity and the returns to education for farmers will be at their highest. An example of this phenomenon can be found in the work of Foster & Rosenzweig (1996) in which returns to schooling rose with increases in the rate of technological advances during the Green Revolution in India. In cases where there is a great deal of uncertainty in either the benefits of the new technologies or in the optimal way to use them, the ability to experiment and adapt to technologies

[4]The existing literature does not unanimously support this link between schooling and technology adoption. Pitt and Sumodiigrat (1991) study the choice of seed varieties in Indonesia and find that while education affects seed variety specific profit and input demand (aspects of technical efficiency), it does not significantly affect the choice of seed variety.

takes on added importance. Munshi (2004) studies technology adoption during India's Green Revolution and finds that experimentation by farmers on their own land was quite important for rice growers, where significant heterogeneity in growing conditions existed and unobserved characteristics were important, but less relevant for wheat production where useful information could be obtained through social networks, something that will be discussed in the next section. Formal education, to the extent that it improves the ability to acquire information and experiment, takes on additional importance not simply when technologies are changing but also when the benefits of those technologies depend on very local growing conditions or on farmer characteristics.

An additional component of adaptive ability beyond experimenting with and successfully adopting new technologies when they become available is adapting the set of technologies and inputs used when relative prices of inputs and outputs change, influencing profitability but not necessarily productivity as measured by yields. Even if a farmer is aware of current technologies and methods and understands how to properly use them, his success still depends choosing the most profitable approach to his farm. The empirical literature reveals that this is yet another area influenced by a farmer's level of education. Huffman (1977) examines the responses of farmers in the U.S. Corn Belt to changes in the price of nitrogen fertilizer and finds that more educated farmers adjust fertilizer usage toward the optimal level more rapidly than less educated farmers when prices change. Petzel (1978) finds a similar result when the relative prices of outputs rather than inputs change. Farmers with more education adjusted their mix of crops more quickly to changes in the price of soybeans relative to corn and cotton than less educated farmers did. In these studies it is the rate of adjustment that is influenced by education, reinforcing the argument that the gains from formal education will be greatest for farmers in settings with a great deal of change, whether that change is in the form of new technologies being developed or simply change in market prices for inputs and outputs.

This discussion of human capital and farmer productivity leads to a mixed outlook on the value of schooling to farmers, consistent with the mixed estimates of the returns to education in agriculture captured in Figure 4.1. Elementary schooling is beneficial, creating the basic literacy, numeracy and cognitive skills required of any occupation. More advanced schooling, while having little impact on technical efficiency, has potentially large effects on a farmer's stock of useful information and on his adaptive ability. The magnitude of these effects will be largest in the presence of rapid innovation in agricultural science. While schooling beyond a basic minimum cannot be considered unconditionally productive in agriculture, it can be exceedingly productive in the proper environment.

4.3. The Transmission of Agricultural Knowledge

As the previous section outlined, a main source of the returns to human capital in agriculture is the acquisition and incorporation of current information into farming practices and the adoption of new technologies and techniques. The public nature of information and farming practices, due both to the public roots of agricultural research and the observability and easy replication of farming practices, creates important roles for human capital spillovers in agricultural production. The presence and magnitude of these spillovers will influence the social value of schooling in agricultural communities.

Human capital spillovers in agriculture have two important sources: the public nature of innovation and the transmission of information through social networks. The first source of spillovers, innovation, relates to the role of human capital in making individuals more likely to successfully experiment with new technologies. A farmer who experiments with new technologies or techniques and finds success contributes an important piece of information to collective local farming knowledge, potentially raising the productivity of other farmers in the community. To the extent that farming practices and results are highly observable to everyone in the local community, innovation on one farm produces non-excludable, non-rival knowledge for the community as a whole. The returns to schooling take on a public component when that schooling leads to greater levels of successful experimentation with new technologies on farms.[5] With higher educational attainment of any one individual farmer or higher numbers of educated farmers in a community, the stock of useful public agricultural knowledge will grow.

The second source of human capital spillovers relates to the diffusion of information as opposed to the creation of information discussed above. Social networks allow information to flow easily from one farmer to another. In this way, information received by an individual farmer either through own experimentation or from learning through education, publications or extension becomes public as that farmer passes information along to acquaintances through his social network or to neighbors through his publicly observable actions. The productivity gains resulting from a farmer accumulating human capital

[5]The concept of successful experimentation is used quite broadly in this context. For an individual farmer experimenting with his own land, success may be easily defined as something that improves his productivity or profitability. This definition can be expanded when considering the social returns to individual experimentation. An experiment that is a failure for the experimenter still has positive value to the rest of the community by allowing other farmers to eliminate one unsuccessful experimentation path from their choice set without incurring any costs, increasing their probability of success should they decide to engage in their own experimentation.

become shared through social networks, making the social returns to that human capital significantly higher than the farmer's private returns.

Several modern studies have found significant spillovers in agriculture. Foster and Rosenzweig (1995) find that in the case of new seed varieties in India, there were important learning spillovers, with farmers learning effectively from their neighbors who were experimenting with new seed varieties. Bandiera and Rasul (2006) find that the decision of farmers in Mozambique to adopt a new crop depend on the decisions of family and friends in their social network to adopt the new crops. The pineapple industry in Ghana provides another example of this, with farmers learning about successful fertilizer usage from the results of experimentation with fertilizer by other members of their social network (Conley & Udry, 2001). An older study, and one closer to the farmers that are the subject of this study, is a classic sociological study of innovation diffusion by Ryan & Gross (1943). Ryan and Gross surveyed Iowa farmers in 1941 to understand the diffusion of hybrid seed corn. While the most common way for farmers to initially learn of hybrid seed corn was through salesman, farmers cited the most influential source of information as being neighbors (14.6 percent of farmers first heard of hybrid seed from neighbors yet 45.5 percent claimed that neighbors were the most influential information source when choosing to adopt hybrid seed). As Ryan and Gross note, early adopters of hybrid seed corn "provided a community laboratory from which neighbors could gain some vicarious experience with the new seed."

Collectively, these studies demonstrate that learning from others is important in agriculture in the presence of technological innovation. That learning can occur through social networks of friends and families or simply from informal observation of neighbors.

However the information is transmitted, the implication is that human capital spillovers exist and that there are positive externalities resulting from a farmer's human capital accumulation.

The importance of these spillovers will depend on the rate of technological change in agriculture, the nature of that technological change and the presence of others channels of disseminating information. In the studies of Foster and Rosenzweig, Conley and Udry and Bandiera and Rasul, new technologies were introduced that required experimentation to adopt profitably. In these cases, own experience accumulated over years of farming did not help with adapting to the new technology but the results of neighbors' experiments were tremendously useful. Spillovers become important because new knowledge is available and requires a certain degree of learning to implement properly. In a state of little innovation, these spillovers decline in importance. They will also decline if there is a channel other than social networks for new knowledge to efficiently spread, for instance a well developed and trusted agricultural extension service. In the case of little to no innovation, the importance of human capital both to the individual and to the community is relatively low. In the case where innovation occurs but can be efficiently transmitted through institutions like extension services, the spillovers from human capital accumulation are reduced but the private returns can still be quite high if additional human capital helps the farmer acquire and implement the new knowledge.

4.4. Agricultural Innovation at the Turn of the Century

While there is a growing consensus that human capital is critical to productive farming and a small body of evidence suggesting that schooling can be an effective way to accumulate that human capital in modern agriculture with its steady rate of innovation, the role of human capital and schooling historically in agriculture has received little attention.[6] Part of this lack of study has been the absence of reliable data in which farmers' education and productivity are jointly observed. A much more severe barrier has been the widely held and seldom debated belief that education had little bearing on a farmer's productivity prior to the modernization of farming ushered in with the biological innovations of the mid-twentieth century. The consensus view has been that education gained importance with the rise of industry and that while schooling is important to modern farms employing modern technology and engaging in a global economy, farming at the beginning of twentieth century was not an endeavor aided by formal education.

In this section we seek to dispel this view by examining the details of agricultural innovation in the late nineteenth and early twentieth centuries in the American Midwest. A thorough examination of agricultural technology and the details of the emerging public school system reveal that there was much to be gained by individual farmers and the community as whole through formal schooling and that in their formative years, public schools were quite important in the agricultural sector not simply for the invention of new technology as the growth literature emphasizes, but also for the productivity of individual farms. Understanding that the role of education in farming was important prior to the revolutionary agricultural advances of the mid-twentieth century recasts the expansion of public education as a major contributor to economic growth through its effects on farmers at the individual level. A rough appreciation of the sizable correlation between

[6]We refer here specifically to the human capital related to skills and the ability to successfully adapt to advances in agricultural science. For a studies of the health component of human capital and its relationship to agricultural productivity, see Schultz (2001), Deolaliker (1988), Strauss (1986) and Haddad & Bouis (1991).

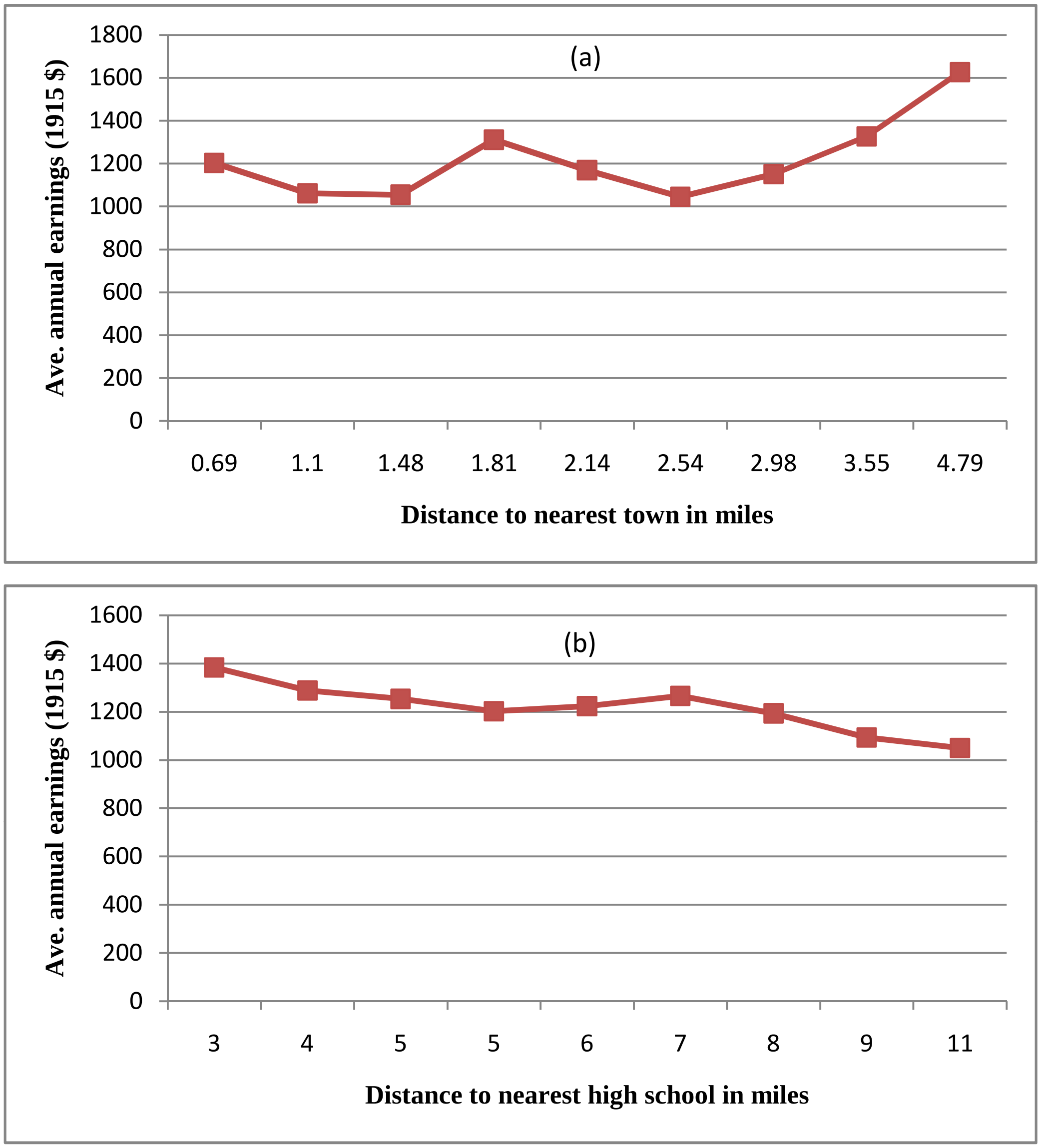


Figure 4.2: Average annual earnings for farmers by distance to nearest town (panel a) and distance to nearest high school (panel b). Data are for Iowa farmers living in Chickasaw, Poweshiek and Ringgold counties in 1915. Each point represents the mean earnings of single distance decile.

public schools and local productivity can be gained from Figure 4.2, showing average earnings for Iowa farmers at the turn of the century as a function of distance to the nearest town and distance to the nearest high school. Figure 4.2 reveals no discernible relationship between a farmer's earnings and how far he lives from a town but a large, negative relationship between earnings and the distance to the nearest high school, with average earnings dropping off by 25 percent as the distance to the nearest high school increased from three to eleven miles. The combination of higher individual educational attainment and higher human capital spillovers resulting from farming near a public high school, factors that will be discussed at length in the remainder of this paper, led to tremendous gains in agricultural productivity at the turn of the century.[7]

The stylized facts about schooling and farmer productivity reviewed in the previous section provide a foundation for understanding which features of the agricultural sector at the turn of the century may have influenced the returns to education. The modern studies we surveyed reveal that the returns to formal schooling are at their highest when there is significant innovation and that agricultural advances often require some experimentation to implement effectively. Furthermore, spillovers from formal schooling can exist under these conditions, particularly when alternative channels for disseminating new knowledge are not present. A close examination of agricultural technology in the late nineteenth and early twentieth centuries reveals that these conditions were clearly present and that the

[7]Figure 4.2 in no way demonstrates a causal relationship between the presence of local schools and farmer earnings. While we are interested in whether public schools helped farmers increase earnings, it is certainly possible that wealthy farmers tended to locate near schools or push for their creation. Our estimates of the returns to education in the following sections will control for local community fixed effects. The positive effect of education on earnings persists even once local community characteristics are controlled for.

potential for formal schooling to offer significant private returns to farmers as well as to create substantial spillovers existed.

Discussion of agricultural innovation prior to the 1930's is often focused on the introduction of new forms of mechanical technology. Mechanization of tedious and strenuous farming tasks led to greater worker productivity but did so in a way that required little additional human capital. The operation of these mechanical devices was not terribly complicated and there were few decisions to be made about how to profitably deploy new mechanical technology. Consequently, while these innovations were important to farm productivity, the productivity gains were not highly dependent on a farmer's human capital stock or level of formal schooling. The traditional view is that these mechanical innovations were responsible for nearly all of the productivity gains in farming prior to 1940. In his study of the development of American agriculture, Cochrane (1993) claims that mechanization was "almost the exclusive...form of farm technological advance".[8] He goes farther, claiming that much of the innovation, such as the introduction of the mechanical reaper and thresher, occurred early in the nineteenth century. The latter half of the nineteenth century was a time of refinement and improvement of existing machines but "not a period of innovation".[9] This traditional view, epitomized by Cochrane's observations, has fostered a belief that human capital was not important in agricultural until the biological advances of the 1930s and 1940s.

Only in recent years has this view begun to be challenged. Olmstead & Rhode (1993) demonstrated that settlement patterns and biological advances were important contributors to changes in agricultural productivity well before the 1930s. In their work on

[8]Cochrane, p. 200
[9]Cochrane, p. 196

American wheat production, they have shown that there was a steady stream of biological advances in the early twentieth century that improved crop yields (Olmstead & Rhode, 2002). They calculate that roughly one half of the labor productivity growth between 1839 and 1909 previously attributed to mechanization was actually due to biological innovations. The specific advances Olmstead and Rhode point to include the introduction of new wheat varieties and an emphasis on farm-level experimentation with various crops and techniques to improve yields and more effectively combat pathogens and insects. Their work raises the possibility that biological advances requiring the sort of experimentation and learning aided by education were as important as mechanization in improving agricultural productivity at the turn of the century. In what follows, we use the specific experience of Iowa to examine how the forces discussed by Olmstead and Rhode as a well as a variety of other innovations were changing the nature of production on farms and the role of schooling for farmers.

The challenges facing Iowa farmers at the end of the nineteenth century were similar to those that other farmers in the emerging agricultural regions of the Midwest and later the West would experience.[10] Farms in Iowa had been settled for a relatively short period of time, with much learning about how to effectively farm the land still taking place. Farmers were faced with the task of experimenting with new technologies and techniques including methods of planting, drainage systems and new seed varieties to turn Iowa into the highly productive agricultural state it is known as today. These technologies

[10]For a much more thorough account of the early history of Iowa farming, see the history published by the staff of the Iowa State College, *A Century of Farming in Iowa, 1846-1948*, from which much of the information in this section is drawn.

and techniques were neither foolproof nor equally suited to all locations. Human capital played a pivotal role in translating innovation into improved productivity.

One of the first tasks facing farmers of newly settled land in Iowa was exposing the rich soil. Early farming took place on soil that was already well drained by topography allowing the farmer to simply break the sod and begin growing crops. The heavier, more fertile soil required drainage systems to be constructed. Installation of drainage systems began in the late 1800s and continued through the early 1900s. Properly constructing drainage systems was not a trivial task to be carried out by unskilled labor. It took time to determine the best designs for Iowa, with farmers experimenting with European methods and then flat tile systems before ultimately settling on round tile drains. Even once the best type of drainage system was revealed, room for error persisted. Drainage patterns could be poorly designed and a properly designed drainage system could fail given improper maintenance. Learning to properly implement tile drainage systems transformed thousands of acres of wet lands in Iowa into highly productive land.

Properly drained soil does not guarantee that the soil remains fertile. As farmers began to heavily cultivate the Iowa soil, the soil began to lose its fertility. The turn of the century saw several advances in ways to efficiently return essential elements to the soil. One example is lime, needed to reduce the acidity of soil allowing legumes to efficiently fix the nitrogen necessary for fertile soil. At the turn of the century, scientists began testing soils for acidity as a way of identifying lime deficiency. Publications were produced to inform farmers about the need for liming, a subject that was also stressed by agricultural teachers in high schools. Lime is just one example of the improvements in soil science at the turn of the century that had the potential to dramatically improve yields if incorporated properly into farming. Knowledge of how to properly maintain nitrogen, calcium, potassium and phosphorous levels in their soil was crucial to farmers' productivity. The task of passing advances in soil science on to farmers fell primarily to government agencies producing informational publications and to instructors in the growing public school system.

Fertile soil still required proper crop selection to maximize farm productivity. Consistent with Olmstead and Rhode's accounts of the importance of experimentation with wheat varieties to increase yields and combat destructive pests, selection of crops was a central element of agricultural productivity gains in Iowa at the turn of the century. Around 1900 Iowa farmers transitioned from spring wheat to winter wheat as the hardier varieties of winter wheat discussed by Olmstead and Rhode were introduced. Growers of corn engaged in extensive experimentation with varieties. Between 1890 and 1920, experiment stations throughout the farming regions of the United States engaged in extensive corn breeding. Varietal hybridization was first introduced in Michigan in 1880. Ear-to-row breeding was introduced in Illinois in 1896, providing individual farmers and experiment stations with a systematic method to experiment with different corn varieties.[11] P. G. Holden, the first professor of agronomy in the United States, began gathering data on the performance of different corn seed and disseminated his results through teaching courses and his "Seed Corn Gospel Train." Experiments in crossbreeding corn began in the early 1900s. All of these various practices led to major advances in knowledge of corn varieties

[11]Ear-to-row breeding was a technique of choosing a selection of ears and planting them one ear to a row. Detailed records of performance were kept and used to choose the best corn to grow on the basis of both appearance and progeny performance. It essentially provided farmers with a systematic approach to crop experimentation.

and improvements in corn yields well before the broad introduction of hybrid corn in the 1930s.

Beyond better selection of crops through experimentation, yields were also improved at the turn of the century through new knowledge of how to fight pests, weeds and disease. At the end of the nineteenth century, Iowa farmers realized that spring wheat planted next to barberry bushes was more susceptible to black stem rust and that oats planted near buckthorn would get crown rust, leading to campaigns to eradicate these bushes. The late 1800's saw the development of chemicals to treat wheat seed to prevent bunt, a fungal disease. A seed law was passed in 1907 requiring that seed offered for sale be labeled with a listing of weeds. Other information on weeds was disseminated through the publication of weed guides for use by agricultural teachers and farmers. Overall, the stock of knowledge of the hindrances to healthy crops and ways to combat them was growing steadily at the turn of the century.

It is clear that much innovation was taking place in Iowa agriculture at the turn of the century beyond simply the mechanization of farming. Advances in drainage techniques, crop selection, soil science and knowledge of pests and disease all had the potential to dramatically increase farm yields but, unlike mechanization, were heavily dependent on the human capital of farmers to implement effectively. For all of these advances, the ability for new information to find its way to farmers and be successfully integrated into farming practices was crucial. The emerging public school system and extension services were particularly well suited to these tasks. The early history of Iowa agriculture saw the development of agricultural science at Iowa State College and the introduction of high schools and extension services capable of disseminating this knowledge. An examination of the history of these institutions reveals a close relationship between the sources of agricultural innovation and the formal education of farmers.

Systematic agricultural research in Iowa traces back to the foundation of the Iowa Agricultural College and Model Farm in 1858, which would become a land-grant institution in 1864 through the Morrill Act. As a land-grant institution, the college pursued the goals of accessible higher education in practical subjects and applied research. Both of these functions of the college were critical to the creation and implementation of agricultural innovations.

As a center for applied research, the college was engaging in cutting edge experimentation in all aspects of agriculture. Much of the advances in soil science and the development of better varieties of crops would come from the research done at the college and through the Agricultural and Home Economics Experiment Station established in 1888 with the passage of the Hatch Act. The scientific advances occurring at the college were passed on to farmers in two ways. The first was through directly educating the farmers, either through attendance at the college itself or its short courses and demonstrations. The second was through students and graduates of the college teaching other farmers. In biographies of alumni who graduated from the college between 1872 and 1899, nearly ten percent listed occupations of either teacher or educator (Tiernan, 1939, 1952). It was not uncommon to have "teacher and farmer" given as a graduate's occupation. The teachers educating young farmers across the state were themselves educated at the agricultural college, exposed to the latest in agricultural innovation and capable of passing it on to their students. Beyond graduates choosing teaching as a career, enrolled students at the agricultural college often taught at public schools in their time between terms as a source of income while in college (Ross, 1942). The agricultural college had clear ties to the public school system. Knowledge of the agricultural innovations being researched was passed on to farmers through schooling both at the college itself and at public schools throughout the state with college educated teachers.

This role of schooling as a channel through which agricultural innovations could be disseminated was particularly important at the turn of the century given the timing of school expansion in the state. Extensive agricultural research was being undertaken by the last decades of the nineteenth century with the creation of land-grant colleges with the Morrill Act and Hatch Act. However, it would not be until 1914 that the Smith-Lever Act would establish the Cooperative Extension Network and agricultural extension programs would fully mature. Iowa's public school system was already going through rapid expansion two decades prior to this. As common schools improved through consolidation and grammar schools and high schools were introduced, the public education system became a critical and effective means of passing knowledge and skills on to farmers. This role of the schools as a means of diffusing agricultural information was not simply a result of the educators themselves often being trained at the agricultural college but also the curriculum at every level being explicitly tailored to developing better farmers.

There is a wealth of historical sources demonstrating the desire of administrators and legislators to teach skills for agriculture in the public schools. How to better design the curriculum of rural schools to promote farming as a career and improve the productivity of farmers was a matter a much debate at the turn of the century. Rural schools were being designed with a focus on developing critical skills through more practical demonstrations and experiments rather than memorization and recitation of facts. There are a wide variety of ways in which schools tried to develop interest in farming and experimentation. In 1913, Iowa passed legislation providing state funding for consolidated schools to improve the quality of rural schools. This funding was conditional on consolidated schools maintaining an agricultural experiment plot. As L.H. Bailey (1904), a leader in the development of agricultural education, noted, the purpose of these sorts of programs at common schools was not simply to "teach technical agriculture, but to inculcate the habit of observing." Rural schools often promoted the the efforts of local boys' clubs to have school-aged boys experiment with different seeds and approaches to growing crops, share their results and compete in yield contests (Davis, 1912). Survey responses regarding successful curricula in rural schools included references to "experimental plots for plant breeding, soil inoculation, and other soil experiments; ear-to-row method of improving corn, and use of acre plots; [and] seed germinating including tests of viability."[12] There was a strong sense that a key component of rural education was to develop critical skills of observation and experimentation, skills that would help future farmers adapt to changing technologies and new agricultural information.

This emphasis on experimentation in no way implied that the more formal teaching of agriculture in the classroom was ignored. Particularly at the high school level, agricultural science and business topics relevant to managing a farm were common components of the curriculum. The curriculum for an agricultural secondary school in Minnesota included courses in agricultural botany, field agriculture, farm accounts, study of breeds, agricultural physics, dairy chemistry and dairy husbrandry in the first three terms of study alone (The University of Minnesota, 1902). Nearly forty different agriculture textbooks were

[12]Davis p. 118

produced for use in elementary and secondary schools in just the first decade of the twentieth century (Davis, 1912). In addition to these texts, pamphlets and extension bulletins containing the most recent advances in agricultural science and the teaching of agriculture were often distributed by agricultural universities and extension programs to teachers to help them incorporate recent developments into their teaching.

Schools in the Midwest were providing students with current agricultural knowledge while also instilling in them the value of critical reasoning and experimentation. From the teaching of the value of observation and experimentation in the early years of common school to the teaching of current agricultural science and management in the high schools, schools were helping individuals build human capital that would be productive in agriculture. While the value of the specific agricultural science students were learning may have diminished over time as science progressed, schools were still offering a strong base of agricultural knowledge and skills that would help the farmer adapt to innovations occurring even after his school years were well behind him.

Overall, the agricultural sector experienced substantial innovation at the turn of the century. Advances were made in seed selection, drainage techniques, disease and pest prevention and soil science all prior to the major biological advances in the mid-twentieth century. The long list of innovations created a major role for human capital, with productivity gains possible through the accumulation of new information and experimentation with new techniques. The public school system in Iowa was well positioned and in fact deliberately designed to provide that human capital. It functioned as a link between farmers throughout the state and the agricultural research taking place at land-grant colleges and experiment farms, offering a channel for the latest scientific advances to find their way to the farm. The school system also sought to improve the ability of farmers to critically think about agricultural problems and to experiment. In this respect, schools gave farmers not only the latest agricultural information but also the tools to continually take advantage of agricultural innovations.

These potential productivity gains were not necessarily limited to those farmers who attended school. The knowledge and techniques schools taught farmers were, once implemented, easily observed and replicated by neighbors. Seed choice, fertilizer usage and a variety of other decisions made by an educated farmer could be copied by his neighbors. Beyond the spillovers resulting from mimicry, the educated farmers' actions themselves could benefit his neighbors. If an educated farmer learns how to prevent the spread of pests or disease among his crops, his neighbors' crops also become less vulnerable, even with no action on the neighbors' part.[13] Whether by mimicry or more passive means, neighbors could benefit greatly from an educated farmer.

Given the variety of agricultural innovations occurring and curricula designed to promote better farming practices, the emerging public school system in Iowa was well situated to generate both substantial private returns and also significant spillovers in agricultural communities. In the following sections, we will test for both the private returns to and spillovers resulting from the formal education of farmers.

[13]This also raises the issue of negative spillovers resulting from less educated neighbors. Even if an educated farmer takes measures to eradicate a certain pest, if his less educated neighbor does not take a similar course of action, the educated farmer's crops may still be at risk. Consider the example mentioned earlier of crown rust. Oats planted near buckthorn bushes were more likely to get crown rust, leading to campaigns to remove buckthorn bushes. While an educated farmer may be responsive to these campaigns and remove any buckthorn on his land, if his neighbor does not follow suit everyone's oats remain at risk of getting crown rust.

4.5. Constructing a Spatial Dataset

Estimating the private and public returns to education at the turn of the century is difficult due to the scarcity of historical data on the incomes and educations of farmers. Income was not asked in the federal population census, the most easily accessible source of individual level data at the turn of the century. Proxies for income or farm productivity could be obtained from the federal agricultural census schedules which contained detailed information on farm size, land value, expenditures and output. Unfortunately, the records from the turn of the century have been destroyed, the 1890 schedules destroyed by fire and the 1900 and 1910 schedules by Congressional order. What remains of the agricultural censuses is data aggregated at the county level which does not allow for separately identifying the private returns to education and spillovers. Educational attainment data is even harder to come by, with the federal census not asking about educational attainment until 1940. As a result, the only proxies for educational attainment traditionally available have been literacy, numeracy and other similarly coarse measures of education. We require a more detailed measure of education.

A solution is to turn once again to the unprecedented data collected by the state of Iowa. With its 1915 state census, Iowa gathered data on both the annual earnings and the educational attainment of all residents. This census is a unique occurrence of jointly reported income and education data in the United States prior to 1940.[14] Additional details on the 1915 Iowa state census can be found in chapter 1 and in Goldin & Katz

[14]While the 1915 census is the only chance to observe both income and educational attainment, it is not the only chance to observe educational attainment by itself. Educational attainment questions in the 1915 Iowa census were included in the 1925 census as well, although the annual earnings question was dropped. South Dakota, perhaps influenced by their neighbor to the southeast, also included educational attainment questions in the state census.

(2000). For our purposes here, the important features of the census are that it contained annual earnings, farm value, educational attainment by type of school (common, grammar, high school, college) and occupation. These data, coupled with the demographic variables reported (age, birthplace, years in Iowa, years in the United States, religion, parents' birthplaces), provide the information necessary to estimate the returns to education for farmers.

Because we are in part interested in spillovers resulting from farmer education, additional spatial data is required beyond what is available in the 1915 census. Location is provided in the 1915 census through the reporting of the town of residence.[15] By itself, this information will not allow us to disentangle human capital spillovers from other location specific factors such as local land fertility or weather patterns. To properly examine spillovers, finer detail on farm location is needed. For this we turn to historical plat maps showing land ownership. From these maps, we can identify the boundaries of farms and determine the neighbors of any given farmer. As we will discuss in more detail later, these plat maps can provide much more information than simply which farmers are neighbors. Through the use of Geographical Information System (GIS) software, they allow for calculation of farm acreage, distances to town centers and schools, and identification of farmers managing multiple plots of land. The drawback of using plat maps to incorporate spatial

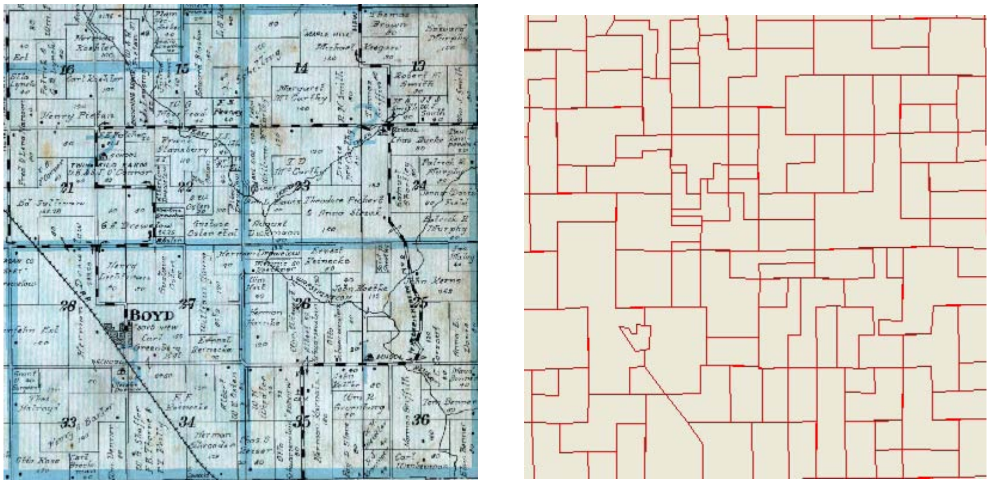
[15]In many censuses, additional locational information can be inferred from the ordering of census records, as the census enumerator would systematically work his way through the community. Neighbors would therefore appear next to each other in the census schedules. Rather than lists of people, with multiple individuals on each page, the 1915 Iowa census manuscripts are in the form of individual index cards, one per person, stored alphabetically by county. While the cards are numbered, a mapping of these numbers reveals that they were not numbered by location or path of the enumerator. Consequently, nothing can be inferred about the location of individuals beyond which town they live in.

data is that it restricts us to land owning farmers, eliminating farm laborers, tenants, and managers from our analysis unless they are listed as the owners of the farm.

The process of creating our dataset begins with county plat maps. To create a reasonably large sample of farmers, we focus on complete samples of farmers from three different counties. The counties of Chickasaw, Poweshiek and Ringgold were chosen on the basis of being located in three distinct agricultural regions of Iowa and having well preserved, complete plat maps published within one year of the 1915 Iowa census.[16] In the first stage of dataset construction, digital images of the township plat maps are georeferenced to a digital map file of township boundaries for the county.[17] Through this process, we stitch the individual township plat maps together and create a spatial reference for the data. This allows for automating computations of distances and spatial relationships. By combining the township maps and focusing on the county level, the resulting map file can consider relationships across township borders (this is particularly useful for examining neighbors across township lines and identifying cases where the closest town or other feature of interest is not in a person's own township, something not possible with census data alone).

Once the township plat maps are stitched together and georeferenced, farm boundaries are digitized by tracing them on a computer screen and storing the resulting polygons as a GIS shapefile. Figure 4.3 provides a detail of the plat map for New Hampton township and the farm boundary polygons created from the plat map. This detail represents

[16]A map of Iowa showing these counties and the agricultural regions is provided in Figure C.1. Agricultural statistics for the counties are given in Table C.15 and demonstrate that the chosen counties are fairly representative of the state's agricultural sector.
[17]To georeference the plat maps, we match the one mile by one mile grid shown on the plat maps to the same grid on Public Land Survey System township shapefiles.



(a) (b)

Figure 4.3: Detail of New Hampton Township, Chickasaw County plat map (a) and the farm polygons created from the plat map (b) to be used for spatial analysis. Neighbors are defined as polygons that share at least one common side or vertex.

approximately .5 percent of the total land area digitized for this project. Finally, the farmer names on the plat maps are transcribed and associated with their respective polygons. The results of this process are three separate GIS datasets, one for each county, containing digitized maps of farm boundaries with a known spatial coordinate system and corresponding tables giving a unique identifier for each farm and the farm owner's name. Added to this data on farm locations are the locations of towns (also identified from the plat maps and represented as polygons). The data stored for the town polygons includes whether the town had graded schools, whether the town had high schools, and the number of graded classrooms in the town's schools. These data are taken from the reports of the county superintendents of schools.[18]

[18]Details on these county superintendents of schools records can be found in chapter 1. We include information transcribed from the 1900 school records for use in the mobility studies and well as information

Linking these geographical data to the 1915 census data begins by matching the farmer names from the plat maps to lists of adults in the 1915 state census. Given that the only information available from the plat maps is name and the township the farm is in, matching is done on only these two criteria. While we only have these two variables to match on, concerns of mismatches are minimal; knowing township location substantially narrows the set of people to consider making it straightforward to assess the quality of a match. This is distinct from the matching process used to construct intergenerational samples from censuses which requires matching across time and therefore has to allow for changes in location across the entire country, substantially increasing the difficulty of accurate matching.[19] The lists of township residents from the state census come from electronic records of the census in which name, location and age are all transcribed. Once a match is found, an image of the original census record is downloaded to transcribe information on occupation, earnings, education, religion, years in Iowa, years in the United States, incumberance on farm, and farm value.

Once all of the matching is completed and the information from the 1915 census fully transcribed, the census data is merged into the GIS databases, adding individual farmer characteristics to the farm boundary maps. The final stage in preparing the dataset for analysis involves using GIS software to perform a series of spatial calculations and append

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transcribed from the 1915 school records specifically for this chapter. Using both sets of records allows for observation of not only where schools were in 1915 but also if those schools were relatively new.

[19]While the accuracy of matches is easier to assess in this case and the set of people to search is much smaller, the actual rate of successful matching is still under 50 percent. The reason stems from the inability to use additional information to determine when people with differently spelled but similar names are actually the same person or which person is the correct match when multiple people have the same name. This is particularly problematic in the matching between plat maps and census records because the plat maps often contain only an initial for the first name, making it hard to narrow the set of potential matches.

the results to the farmer data. These calculations include calculating farm acreage (which allows for converting variables such as farm value into per acre terms), identifying and calculating the distance to the nearest town, graded school and high school and identifying neighbors and neighbor characteristics. To calculate neighbor characteristics, we use an algorithm that identifies all polygons that share a vertex or line segment with the polygon representing the farm of interest. The resulting set of polygons is defined as the set of neighbors of the farm and statistics on the characteristics of these neighbors are computed and written to the record for the farm. These statistics include the number, mean age, mean and maximum education by type, mean and maximum farm value (and value per acre) and the mean and maximum income (and income per acre) of neighboring farmers.

The final product is a sample of roughly 2,600 land owners with a wide range of farm sizes, incomes and educational attainments. Summary statistics for the main variables of interest are included in Table 4.1. As a result of being limited to property owners, the average age of the sample is relatively high at 47 years old. Mean annual earnings are also high but the variation is large. The mean farm size is close to the traditional 160 acre family farm although the largest land owners in the sample have farms that are several hundred acres in size. Even controlling for size, the reported value of farms varies extensively throughout the sample as shown by the large variation in farm value per acre. The distances to towns and schools are of interest given the role of social networks in disseminating productivity enhancing information discussed in the previous sections. Farmers live on average over two miles from the nearest town, a small distance by modern standards but sufficiently far that daily interaction in the town would likely not be occurring. Schools are even farther away, with the average distance to the nearest

Table 4.1: Summary statistics for the sample of farm owners, 1915

Variable	Mean	Standard Deviation
Age	46.70	11.68
Annual earnings	1199.62	1175.47
Farm value	17439.32	13079.76
Incumbrance on farm	3357.70	5399.68
Farm acreage	153.03	106.92
Earnings per acre	9.80	10.77
Farm value per acre	126.08	90.98
Incumbrance to farm value ratio	0.20	0.25
Distance to nearest town (miles)	2.25	1.52
Distance to nearest graded school (miles)	3.16	2.06
Distance to nearest high school (miles)	6.51	3.28
Foreign born (yes=1)	0.14	0.35
Mean total schooling for neighbors	8.51	1.92
Max total schooling for neighbors	10.23	2.76
Mean graded schooling for neighbors	0.58	1.33
Max graded schooling for neighbors	1.63	3.09
Mean high school/college for neighbors	0.30	0.68
Max high school/college for neighbors	0.87	1.71
Number of neighbors	7.84	3.26

Notes: All dollar values are in 1915 dollars. Total schooling is defined as the sum of years of common school, grammar school, high school and college.

high school of over six miles implying that for most farmers, the nearest high school was at least one township away. These distances suggest that information may have more easily and frequently been shared between adjacent neighbors than through population and schooling centers.

Many of these variables are spatially correlated. Table 4.2 gives the correlations for various characteristics between farmers and their adjacent neighbors. Along every dimension except age, neighbors exhibit similar characteristics. Highly educated farmers tend to

Table 4.2: Correlations between land owner and neighbor characteristics

Owner characteristic, neighbor characteristic	Correlation
Total schooling, mean total schooling	0.1656
Total schooling, max total schooling	0.1777
Graded schooling, mean graded schooling	0.1494
Graded schooling, max graded schooling	0.156
Annual earnings, mean annual earnings	0.2274
Annual earnings, max annual earnings	0.1898
Farm value, mean farm value	0.2309
Farm value, max farm value	0.2489
Age, mean age	0.0409

live next to other well educated farmers. Similarly, high earning, wealthy farmers tend to have well off neighbors. Assessing how local these spatial correlations are requires looking beyond adjacent neighbors. One way to do this is through constructing a semivariogram, a plot of all pairs of farmers in the data. The horizontal axis corresponds to the distance between the two farmers in a pair. The vertical axis measures the square of the difference between the farmers for a variable of interest. This offers a simple graphical depiction of how the correlation between farmers drops off as the distance between them increases.

Semivariograms from farm value and for years of total schooling are shown in Figure 4.4 and Figure 4.5 respectively. Both figures show the correlation in farmer characteristics falling off as the distance between them increases. Once farmers are a little over five miles apart, close to the width of a standard township, distance between them no longer has any perceptible influence on the correlation of their characteristics. At distances shorter than five miles, farmer characteristics are clearly not independent.[20] These spatial

[20]Regressions of the semivariance on distance for all pairs of farmers less than five miles apart give positive coefficients with t-statistics of 5.83 and 8.24 for farm value and years of total schooling respectively.

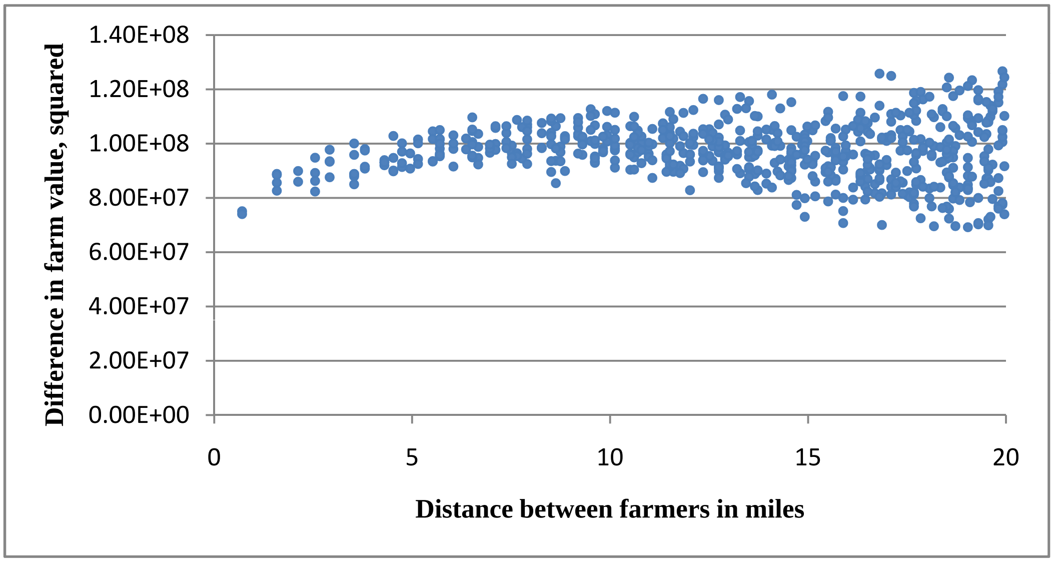

Figure 4.4: Farm value semivariogram. Each point represents a pair of farmers. The horizontal axis measures the distance between the farmers. The vertical axis measures the square of the difference in farm values between the farmers.

correlations highlight the importance of considering local community characteristics as well as individual neighbor characteristics when we estimate the returns to education.

Of particular interest to our study is the heterogeneity in educational attainment in the sample. This heterogeneity includes differences in years of schooling, type of schooling and where schooling was received. This last source of variation in education is particularly interesting in terms of the returns to education. If Iowa schools were teaching skills specific to Iowa agriculture, the returns to schooling received in Iowa would potentially be higher than the returns to schooling received outside of Iowa. However, if schooling provided more general human capital, skills like literacy, numeracy and general principles of scientific experimentation, a farmer's education could be equally productive regardless of where it was received. Table 4.3 summarizes the various measures of educational

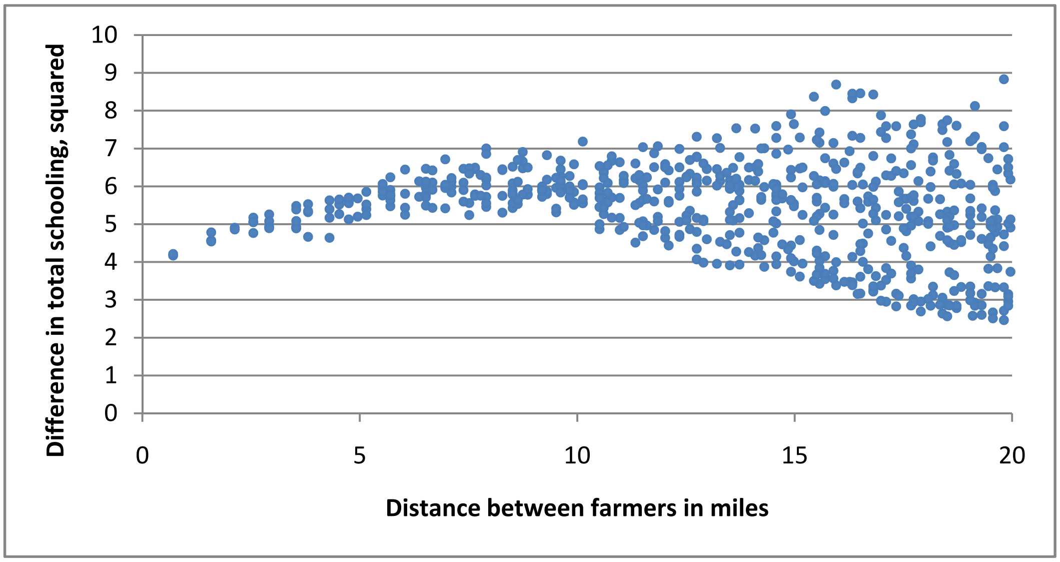

Figure 4.5: Total schooling semivariogram. Each point represents a pair of farmers. The horizontal axis measures the distance between the farmers. The vertical axis measures the square of the difference in total schooling between the farmers.

attainment, including attainment by school type and by whether schooling took place in Iowa, outside of Iowa but in the United States, or outside of the United States.[21] While the average years of schooling of the farm owners is over eight years, graded schooling is relatively rare. The majority of schooling was completed in Iowa and for those farmers who did receive graded education, nearly all of it was completed within the state. This comes as no surprise given that in 1915 Iowa's high school system was well ahead of most of the rest of the country; a common school education was easy to obtain anywhere in the United States but a high school education was much harder to come by.

[21]We determine where education was received from the reported years of education, years in Iowa and years in the United States data. We assume that individuals start school at age five and that schooling was completed with no gaps and that all years of common school were completed before the years of grammar school and then high school and then college. The assumption that schooling begins at age five is made on the basis of the county superintendents of schools records from this period listing the number of school aged children as those children between the ages and five and twenty-one.

Table 4.3: Years of schooling by schooling type and location

Variable	Mean	Standard Deviation
Total schooling	8.43	2.65
Common school	7.91	2.65
Grammar school	0.23	1.26
High school	0.19	0.72
College	0.10	0.54
Total schooling in Iowa	5.77	4.46
Total schooling in US	6.30	4.31
Total schooling outside US	2.13	3.51
Total schooling outside Iowa	2.66	3.80
Total schooling outside Iowa in US	0.54	2.02
Graded schooling	0.52	1.80
Graded schooling in Iowa	0.41	1.53
Graded schooling in US	0.44	1.63
Graded schooling outside US	0.08	0.72
Graded schooling outside Iowa	0.11	0.91
Graded schooling outside Iowa in US	0.03	0.54

Notes: Total schooling includes years of common school, grammar school, high school and college. Graded schooling includes years of grammar school, high school and college only.

4.6. Private Returns to Education for Farmers

The sample of farm owners offers data on earnings, land value, and educational attainment with which we can estimate the returns to schooling. Information on religion, immigration and farm location offer a variety of controls for important unobservables that could influence earnings. With these data, we can estimate a standard Mincer equation of the form

$$\ln Y_i = \beta_0 + \beta_1 p(A_i) + \beta_2 E_i + \alpha X_i + \epsilon_i \quad (4.1)$$

where Y_i is the annual income of farmer i, $p(A_i)$ is a polynomial in his age, E_i is a measure of his education and X_i is a vector of other observable characteristics. Throughout this section, we include controls for religion, the township in which the farm is located, whether an individual is foreign born, years in the United States if foreign born and the quality of local farm land, proxied by land value per acre. These controls are included to ensure that E_i is not picking up the effect of farming in a more productive area or living in a more wealthy area in general.

As any cursory look at the labor literature would point out, the estimation of this relationship and interpretation of the returns to education β_2 are plagued with problems, most significantly the endogeneity of the education variable. Estimating the returns to education with our sample requires consideration of these standard estimation issues as well as some unique problems presented by our data and the details of farming and education at the turn of the century.

A fundamental concern, regardless of the equation to be estimated, is sample selection bias. Our set of farmers is far from a random sample of the Iowa population or even a random sample of Iowa farmers. The largest concern is that they are all farm owners. This distinguishes them from the rest of the population and most importantly from the rest of the population employed in the agricultural sector in a significant way. The fact that these are property owners implies that our farmers have a source of wealth not held by other farmers in the state. Education could play an important role in the probability of land ownership and it is quite possible that the type of person who becomes a land owner differs in important unobservable dimensions that are correlated with educational attainment or that education serves a different role for land owners than for other agricultural workers.

This latter point is particularly relevant when considering that some portion of the returns to education comes from making a farmer more likely to adopt innovations. As several studies in the agricultural economics literature point out, the incentives to invest in new technologies depend heavily on whether a farmer owner farms his land himself or rents the land.[22] Any estimates of the returns to education, even if properly estimated for farm owners, may not be generalizable to other types of farmers.[23]

The manner in which farm owners are identified and added to our dataset also clouds the interpretation of the returns to education. To be in our dataset, a farmer's name must be associated with a plot of land on a plat map. We assume that because his name is given on the map and because his occupation is listed as farming in the census, he is farming the land we see on the map.[24] Things are certainly more complicated than this. We cannot tell if the farmer farms his land himself or if he rents out his land. We do not know if decisions are made by him or by managers that he hires. We cannot say with certainty that he is the sole owner of a farm rather than simply a majority owner. His farm may be run by his sons or his father or any of many possible combinations of unobserved partners. Without knowing what role the farm owner has in the farm operations, it is unclear how his education is being applied or even whether it is his education that

[22] See Feder et al. (1985) for a survey of papers on tenurial arrangements and technology adoption.

[23] Estimates from the intergenerational Iowa sample do reveal significant private returns to education for farm managers and farm laborers similar to the private returns we estimate for farm owners in this chapter. However, we have no way of estimating the spillovers experienced by these agricultural workers because we have no way of identifying either their precise location or the members of their social network.

[24] There are cases in the sample where an individual owns a large plot of land according to the plat maps but has listed as an occupation something other than farmer. It is uncertain whether, in addition to his listed occupation, the land owner is deriving income from the land and should be considered a farmer. We run all regressions both for the sample of land owners listed as farmers and for the complete sample of land owners. In the latter case, it is important to recognize that the estimated returns to education are due in part to the gains in non-farming income.

matters. Estimated returns to education will capture both the returns resulting from improving farming practices and the returns resulting from better management in general (for example, hiring better managers). The problem with conflating these two sources of returns is that it becomes difficult to translate any estimated returns to education into optimal school policy regarding what should be taught.

Uncertainty about involvement in non-farming occupations for the land owners is as problematic as the uncertainty over their involvement in the farming operations. In all of the census observations, only a single occupation is reported. For those who list their occupation as farmer, we cannot be certain that they do not have an additional job that accounts for a portion of their reported earnings. Any estimated returns to education may be picking up the returns to education for this additional job rather than for farming. Without knowing anything about the likelihood of farmers having additional jobs or about what individual characteristics are correlated with having an additional job, we can say very little about what portion of the returns to education we estimate is actually specific to farming rather than some other occupation.[25] When we turn to estimating spillovers, this is less of a concern as we would not expect the increased earnings from non-farming jobs to influence the earnings of neighbors.

Having a sample of farmers also presents difficulties when controlling for experience. In equation 4.1, we include a series of age controls but omit standard controls for experience. Typically, a wage regression of this sort would control for potential experience, defined as

[25]One possible assumption is that the likelihood of having additional jobs increases as the distance to the nearest town, and all of the jobs and markets associated with town centers, decreases. In the appendix, we estimate the returns to education for farmers restricting the regression sample by distance to the nearest town. Results are provided in Table C.18 and show that the high returns to high school we find actually get larger when we exclude farmers living close to towns who are more likely to have other non-farming jobs.

years that the individual has been working and calculated by determining the number of years since that individual left school. We have the age and schooling data needed for this calculation but it may be inappropriate in the context of agriculture. A year of additional schooling does not imply one less year of farming experience. Work can take place on the farm over the course of the year even if the farmer is attending school, certainly enough for the farmer to accumulate knowledge relevant to future years of farming. This is particularly true for the majority of the farmers in our sample involved in wheat and corn production which varies over the year in terms of the amount of labor required. Age, rather than an imputation of potential experience, may be a more relevant variable to capture the earnings profile over a farmer's career. While choice of age or potential experience has important implications for the interpretation of earnings over the life cycle, the results we will present for the returns to education are ultimately not sensitive to the choice of experience controls.

One last issue raised by focusing on a sample of all farmers concerns the endogeneity of educational attainment. This is a standard issue in any wage regression containing education. Education will be correlated with unobservable characteristics, most notably innate ability or intelligence. One of the few approaches to correcting for this problem is finding a valid instrument for educational attainment. With our limited set of farmer characteristics, this is not an option.[26] We can, however, say something about unique features of this endogeneity problem given our data. First, the traditional issues of education

[26]In an ongoing project, we use data on the structure of a farmer's household when he was a child to instrument for educational attainment. The instruments we use require intergenerational data. The match rates to construct the intergenerational data coupled with the match rates between the Iowa census and the plat maps prevent us from using similar techniques to instrument for education here where we are concerned with observing neighbors. Preliminary results from these regressions produce large but statistically insignificant estimates for the private returns to education.

as a screening mechanism are not relevant here as every person in our sample is a self employed farmer with no reason to pursue additional schooling purely to signal ability. Schooling will only be undertaken if farmers either have a strong preference for education as a consumption good or if education is actually productive in agriculture. This former possibility seems highly unlikely given the large opportunity cost to a farming family of having children in school. The latter, however, is a rather appealing reason for farmers going to school and suggests that observed returns to education are actually capturing something about the productive nature of schooling rather than simply abilities or preferences that are correlated with educational attainment. This in no way implies that the returns to education will not pick up aspects of ability; it can certainly be the case that schooling increases productivity only for those with high ability. However, for our purposes this matter can be left unresolved. We want to know whether schooling increased productivity in turn of the century agriculture. We are not concerned with whether the returns to education were uniform across all farmers or not, but simply with whether they existed.

The estimated returns to education coefficients from various specifications of equation 4.1 are summarized in Table 4.4 (complete regression results are provided in Table C.16). The first column gives the estimated returns to education for all land owners using three different measures of educational attainment: total years of schooling, years of graded schooling (all schooling except common school), and years of schooling broken down into common school, grammar school, high school and college. The second column shows the results when the sample is restricted to those individuals with farmer given as their occupation in the census. For all coefficients, the measure of education is in years and

Table 4.4: Returns to education by type of schooling, log annual earnings as dependent variable

Measure of schooling used:	All land owners	Farmers
Total schooling	0.017***	0.013**
	(0.005)	(0.006)
Graded schooling	0.022***	0.010
	(0.008)	(0.010)
Common school	0.010*	0.011*
	(0.006)	(0.006)
Grammar school	0.005	-0.004
	(0.014)	(0.015)
High school	0.046**	0.052**
	(0.020)	(0.022)
College	0.064**	0.009
	(0.025)	(0.029)
Numbers of observations	2410	2219

Standard errors in parentheses. All regressions control for age, religion, land value per acre and township.* significant at 10%; ** significant at 5%; *** significant at 1%

the dependent variable is log annual earnings, so the coefficients can be interpreted as the percent change in annual earnings associated with an increase in educational attainment of one year. The coefficients in Table 4.4 make it clear that there were significant returns to education for land owners and specifically farmers at the turn of the century. For all land owners and farmers, an additional year of common school raised earnings by roughly one percent, a modest but statistically significant increase in earnings. Grammar school had no significant impact on earnings. High school is where large returns to education can be observed. For all land owners as well as for the subset of land owners that were farmers, an additional year of high school led to an increase in earnings of five percent.

An additional year of college was associated with a six percent increase in earnings when looking at all land owners but did not have a significant effect on the earnings of farmers.

These returns to education estimates are consistent with the predictions of the previous section, that in a time with technological innovation education would be useful to farmers both in developing basic competencies, evidenced through the returns to common school, and through more advanced studies at the high school level where more specific information can be taught and the ability to experiment and adapt can be developed. These skills can have a large impact on productivity in a period of innovation and it is therefore quite reasonable that we observe such large returns to high school education for farmers. It is unsurprising that there are no significant returns to grammar school while both common school and high school show evidence of significant returns. Most farmers had access to rural common schools early in their educational careers and could then opt to go to a high school later on. Grammar schools were located in towns and cities and were less agriculturally focused than the common schools and high schools attended by the farmers in our sample. The agricultural focus of these common schools and high schools is a compelling explanation for the significant returns to common school and high school but not grammar school for the farmers.

One question that the high returns to high school education raise is whether the human capital acquired through high school is general or whether it may be location specific. If high schools in Iowa are targeting their curricula to Iowa farmers, it is possible that the returns to education completed in Iowa may be different from the returns to education completed outside of Iowa. To explore this possibility, the earnings regressions are also run with multiple education variables capturing not only how many years of education

Table 4.5: Returns to education by location where schooling was received, log annual earnings as dependent variable

	All land owners	Farmers
Total schooling in Iowa	0.019***	0.015***
	(0.006)	(0.006)
Total schooling outside Iowa	0.013**	0.008
	(0.006)	(0.006)
Total schooling in US	0.019***	0.015***
	(0.005)	(0.006)
Total schooling outside US	0.012*	0.006
	(0.007)	(0.007)
Common school in Iowa	0.012**	0.013**
	(0.006)	(0.006)
Common school outside Iowa	0.006	0.006
	(0.007)	(0.007)
Grammar school in Iowa	-0.002	-0.007
	(0.016)	(0.019)
Grammar school outside Iowa	0.018	0.016
	(0.026)	(0.030)
High school in Iowa	0.059***	0.057**
	(0.022)	(0.023)
High school outside Iowa	-0.002	0.014
	(0.046)	(0.063)
College in Iowa	0.045	-0.013
	(0.029)	(0.032)
College outside Iowa	0.107**	0.089
	(0.052)	(0.064)
Numbers of observations	2410	2219

Standard errors in parentheses. All regressions control for age, religion, land value per acre and township.* significant at 10%; ** significant at 5%; *** significant at 1%

an individual received but also where that education was received. Table 4.5 presents the returns to education coefficients from these regressions for both the full sample of all land owners and for the farmers only (full regression results are provided in Table C.17).

The results from Table 4.5 suggest that where a person was educated did affect the returns to that education. For the farmers, it is only for education received in Iowa that the returns to education are statistically significant. Both common school and high school received in Iowa are significant and reasonably large, with returns to a year of common school in Iowa of 1.3 percent and returns to a year of high school in Iowa of 5.7 percent. The lack of precision for the estimates of the returns to schooling received outside of Iowa prevents us from concluding that common school or high school received outside of Iowa was not productive for Iowa farmers. The results change when including all land owners. We would expect that the human capital required for non-farming occupations would be less location specific. The results for total years of schooling are consistent with this reasoning, with the returns to schooling received outside of Iowa being statistically significant and similar in magnitude to the returns to schooling received in Iowa. As with the farmer only sample, the large standard errors prevent making meaningful comparisons of the returns to specific types of schooling received in and outside of Iowa. The one striking coefficient when looking at specific schooling types is that of college. The returns to college received outside of Iowa are quite large, implying a 10.7 percent increase in earnings from one additional year of college. An interpretation of this coefficient is that those individuals who are not farmers but still large land owners often have white collar occupations such as lawyer or doctor. These white collar workers tend to have high educational attainments and very high incomes relative to individuals in the farmer only sample.

4.7. Human Capital Spillovers Across Farms

The returns to education results in the previous section reveal that additional schooling did lead to higher productivity for farmers at the turn of the century. If the ways in which an educated farmer achieved higher productivity were observable we would expect that the neighboring farmers could mimic those practices and achieve higher productivity for their own farms. In this section, we test for the presence of these spillovers from education by including a measure of neighbors' education in the earnings regressions used in the previous section. With the detail of our data, we can estimate spillovers from neighbors' education while controlling for a farmer's own education and the local value of land, allowing us to distinguish human capital spillovers from the effects of own characteristics and local characteristics that are correlated with neighbors' education levels.

Deciding how to measure neighbors' education depends both on how we believe spillovers should occur and on limitations of the data. If education improves productivity purely through giving a farmer the ability to correctly utilize inputs, it may be only the most educated neighbor that matters. An example of this situation would be a farmer learning about a disease resistant seed variety through a short course sponsored by the agricultural college. If there is no uncertainty about how to grow the new variety or about its profitability relative to other varieties, the educated farmer will simply put the information into practice and obtain higher yields. It does not matter whether this information was received by one educated neighbor or several; once the first educated neighbor puts the information into practice everyone else can follow. In this situation, the number of educated neighbors does not matter, simply the level of education of the most educated neighbor.

Adapting to new innovations is rarely as simple as this example. It is more realistic to imagine several new seed varieties to choose from whose performances will depend on local soil conditions, planting techniques and a variety of other factors. An educated farmer may need to experiment to profitably adapt to new innovations. In this situation, multiple educated farmers may be better than one highly educated farmer. There is more communal information created both through knowledge disseminated through schools and knowledge created by experimentation. Several neighbors experimenting with new information are more likely to generate productivity gains than simply the actions of the single most educated neighbor. In this case, the relevant measure of education will be an aggregate statistic capturing the education of all neighbors.

We will use both the mean education of all adjacent neighbors and the maximum level of education among all adjacent neighbors as measures of neighbors' education. For both measures, we use a variety of different measures for education including years of total schooling, years of graded schooling, years of high school and years of high school and college combined. One problem with these measures is that, due to the difficulties of linking the plat maps to the census records, we do not necessarily observe all of an individual's neighbors. For the mean level of neighbor education, this is not a problem if we assume that the neighbors are missing at random.[27] However, even if neighbors are missing at random, they are problematic for measuring the maximum educational attainment across

[27]Unlike many other situations in which linked data is used, this assumption that individuals are missing at random is not unrealistic. Because we are using plat maps and census records from the same year, individuals will not be missing because they have moved. Instead, they will only be missing if their name either did not match between the maps and census records or led to multiple matches. Failure to match an individual is mainly a result of bad handwriting on the part of the census enumerator or the individual having a common last name and only initials given for the first name. It is reasonable to think that the likelihood of bad enumerator handwriting or a common last name is uncorrelated with educational attainment.

neighbors. Missing neighbors means that the maximum educational attainment across neighbors may be censored. A censored independent variable is a problem in any scenario but is particularly bad here as there is no constant cutoff across observations at which the variable is censored. We cannot say whether a particular observed maximum education is censored regardless of its value as long as some neighbors remain unobserved. The likelihood of the maximum education variable being censored depends on the number of missing neighbors, the magnitude of the observed maximum education and the correlation of education between neighbors. This censoring will tend to bias our results.[28]

Estimates of both the private returns to education and spillovers from neighbors' education are given in Table 4.6 (full regression results are provided in Table C.19). The private returns to education change very little when including neighbors' education in the regressions. We still find the returns to a year of common school to be roughly one percent, the returns to grammar school to be insignificant and the returns to a year of high school an impressive 5.5 percent. Our estimates of spillovers from neighbors' education reveal that additional schooling for neighbors has a significant impact on a farmer's earnings. An increase in mean total schooling of one year by a farmers' neighbors leads to a 2.3 percent increase in the farmer's own income. When breaking down neighbors' education by schooling type, we find that this result is being driven by increases in high school education by neighbors, with an additional year of mean high school attainment across neighbors associated with an increase of over two percent in a farmer's income. While a

[28]In the appendix, we simulate the effects of missing neighbors on the estimated coefficients for the private returns to education and spillovers. These simulations demonstrate that as the number of missing neighbors rises, the spillovers coefficient is biased toward zero while the private returns coefficient is biased upwards. The simulation results suggest that missing neighbors are leading us to underestimate both the absolute magnitude of spillovers and the size of spillovers relative to the private returns to education.

Table 4.6: Private returns to education and education spillovers for farmers by schooling type

Neighbors' education measure:	Total schooling		All graded schooling		High school		High school and college	
	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Neighbors' education	0.023***	0.026***	0.010	0.011**	0.038	0.028***	0.027	0.023***
	(0.008)	(0.006)	(0.011)	(0.005)	(0.029)	(0.011)	(0.020)	(0.008)
Own education:								
Common school	0.009	0.008	0.009	0.009	0.009	0.008	0.009	0.008
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Grammar school	-0.007	-0.008	-0.008	-0.008	-0.007	-0.008	-0.007	-0.007
	(0.016)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
High school	0.055**	0.052**	0.057***	0.057***	0.057***	0.056**	0.056**	0.055**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
College	0.021	0.021	0.023	0.023	0.022	0.023	0.021	0.021
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Number of obs.	2158	2158	2158	2158	2158	2158	2158	2158

Standard errors in parentheses. All regressions control for age, religion, land value per acre and township.* significant at 10%; ** significant at 5%; *** significant at 1%

farmer's own educational attainment has a larger impact on earnings as one would expect, this contribution of neighbors' education is quite large. These results reveal that spillovers from education were sizable in the agricultural sector at the turn of the century.

4.8. Spillovers and Public School Provision

These results on the returns to education and spillovers have important implications for understanding the forces behind public education expansion in the United States and the contributions public schools made to economic growth. The high returns to secondary schooling in the agricultural sector challenge notions that public school expansion was driven by an increasing role of human capital in industry. Recognizing that education was productive in agriculture and that spillovers existed helps further our understanding of why the Midwest led the high school movement in the United States and what gains can be expected from education in modern developing countries with large traditional agricultural sectors.[29]

The substantial returns to secondary schooling for farmers suggest that schools were serving an important role in rural communities at the turn of the century. Public subsidization of these schools was potentially important not only as a way of helping farmers overcome credit constraints to obtain education but also because of the large spillovers

[29]While they did not have the data and means to precisely estimate the returns to education, public officials in the Midwest were certainly aware of the importance of education in agriculture and this factored into the debate over school expansion. An example of this can be found in legislation passed in Iowa in 1913 regarding the creation of consolidated schools. Among other conditions, a consolidated school was required to maintain an agriculture experiment plot and proper equipment to teach agriculture in order to be eligible to receive state funds. There was even a belief that the cost of improving rural schools would be made up for by the increase in productivity. Rapeer (1920), in a call for hiring the best teachers possible for rural consolidated schools, notes that their high salaries would be covered by the "increased prosperity and wealth that would come to any community with [a consolidated rural school]." Increased agricultural productivity was not simply a fortunate by-product of public school expansion but rather one of its underlying motivations.

from secondary education. Given the magnitude of the observed spillovers, individuals would choose socially suboptimal levels of schooling in the absence of public subsidization of schooling even if they were not credit constrained.

Public subsidization of rural education has its share of problems. Typically of greatest concern are the problems arising from brain drain, the migration of the educated individuals from rural to urban areas. Because public education is largely financed at the local level, the spillovers from educated individuals are experienced by a community that does not share the burden of the costs of that education if educated individuals migrate upon completion of their educational careers. In situations of this sort, locally decided levels of public education will be too low. The high returns to education within agriculture and the potential for much of the education to be geographically specific (choice of seed varieties, maintenance of soil acidity and fertility, etc.) reduce the expected level of brain drain compared to the traditionally held view where schooling had little value in agriculture relative to other sectors. Proponents of school expansion even suggested that better rural schools were a way of retaining educated individuals. A recurring theme of the report of the Country Life Commission, appointed by President Roosevelt in 1908, was a belief that the quality of rural schools had to be improved and the curriculum more agriculturally focused in order to keep rural individuals from seeking education and employment in the towns and cities. An annual report on agricultural secondary education in Minnesota notes that "the school, then, does not educate students 'away from the farm'...on the contrary it educates them toward the farm...proved by the fact that eighty two per cent of the students return to agricultural occupation."[30] Our evidence of high private and

[30] The University of Minnesota Bulletin, p. 186

public returns to schooling in agriculture reveals that this view was not unrealistic; rural communities had strong incentives to invest in public schools.

The substantial private returns to high school made schooling attractive to farmers. The large spillovers from secondary education made education a very public good; an agriculturally based community could experience significant gains in productivity though the subsidization of public education. This adds a new dimension to the discussion of the historical evolution of public schools. The importance of education in the agricultural sector well before the Green Revolution suggests that the agricultural sector cannot be ignored when modeling public school expansion. Models like those of Galor & Moav (2006) and Galor et al. (2006) which assume that capital-skill complementarities in industrial sectors drove the desire for public education will not adequately address the American experience. In these models, schooling is assumed to be unproductive in the agricultural sector. Consequently, large land owners resist the public funding of schools and a shift in political power to capitalists, who benefit from an educated workforce, is required to make public schools politically feasible. The American experience is dramatically different from this. The Midwest and areas with low levels of manufacturing led the expansion of high schools in the United States (Goldin & Katz, 1997; Goldin, 1998). These patterns can be understood by recognizing the important role education had in the agricultural sector. The significant private returns to education and the public nature of education created by human capital spillovers produced strong incentives to build public schools in rural areas. The decentralized political mechanisms of school creation in the United States, discussed in Go & Lindert (2007) and characterized by school creation being voted on locally by majority vote and funded through property taxes, made rural communities even more likely to adopt public schools. Small farm owners, benefiting from public schools directly through subsidized schooling and indirectly through spillovers yet sharing a small portion of the costs of those schools, would vote for and take advantage of public schools.

The contributions we have identified of formal schooling to American agricultural productivity are key to understanding the patterns of high school introduction in the United States. The wide range of innovations in the agricultural sector in the late nineteenth and early twentieth centuries and the political structure of the United States made the Midwest particularly well suited to introduce and benefit from public schools. Any account of the forces behind public school expansion needs to recognize the important relationship between education and the agricultural sector.

4.9. Conclusion

The history of agriculture in the American Midwest reveals that there was substantial innovation occurring in the decades before the technological advances of the mid-twentieth century. Human capital played an important role in helping farmers profitably adopt new technologies and the public schools were well suited to producing that human capital. We have used individual level data on Iowa farmers to reveal that schools did indeed have a large impact on farmer productivity. Secondary schooling in particular led to significant increases in earnings. By linking the earnings and educational attainments of farmers to geographic data, we have shown that the benefits from formal schooling extended beyond the private returns to education for a farmer. Significant human capital spillovers existed; an additional year of schooling for a farmer substantially increased the earnings of individuals on neighboring farms.

These significant private returns to education and spillovers demonstrate that public education played a large role in agricultural productivity growth at the turn of the century. Rather than simply allowing educated individuals to escape the farm for white collar occupations in the city, public schools allowed those farmers who stayed in agriculture to increase their productivity and the productivity of other farmers in the community. Our results suggest that a full accounting of the expansion of public schools and of economic growth at the turn of the century must consider the links between education and agriculture.

Identifying human capital spillovers in agriculture at the turn of the century opens up a large set of interesting areas for future study. Knowing the size of the private and public returns to education in agriculture offers a foundation for modeling the expansion of public education throughout the United States and assessing whether there were major efficiency gains from having local control over school expansion rather than the federal control governing the expansion of educational institutions in Europe. Exploration of the role of public schools and human capital spillovers in modern developing nations is also of major importance. The lessons of the United States during a period of steady innovation can be extended to inform education policy in agricultural regions of developing nations adapting to modern agricultural innovations.

CHAPTER 5

Concluding Remarks

The expansion of public schooling in the United States had a profound effect on the American economy. The introduction of modern public schools, particularly secondary schools, fundamentally changed the way parents invested in children, the productivity of workers across all sectors and the distribution of income. Our exploration of the impact of public schools on individuals, neighbors and communities as a whole in the early years of public school expansion reveals a nuanced account of the economic impact of educational institutions, one in which schools serve their familiar function of building human capital but do so in a way the includes a variety of unexpected benefits and costs.

Modern public schools were introduced to a highly mobile American society at the start of the twentieth century. Our intergenerational data reveal that at the time modern grammar schools and high schools were first being introduced, movement throughout the income distribution was common and large rises and falls in prosperity from one generation to the next were quite possible. This intergenerational income mobility was quite high when compared with modern income mobility estimates and reveals that over the period that modern public schools were introduced and access to schools improved for all, intergenerational mobility actually declined.

Our analysis of mobility rates conditional on school quality and access suggest that the introduction of modern public schools, rather than being a purely egalitarian force, could have actually contributed to this decline in mobility. We find that as schools improved in quality and distances to schools declined, intergenerational income mobility fell. Public schools, rather than creating equality of opportunity and offering a means for children from poor families to improve their socioeconomic status, actually promoted greater income inequality; schools provided an institutional channel through which wealthy families could use their income to assure the success of their children.

Our estimates of the returns to education and of educational attainments as a function of parental income demonstrate that this perverse effect of a seemingly increasingly egalitarian educational system did not arise from some institutional barrier or direct discrimination against children from poor families. Instead, it was a product of differences in the elasticity of educational investment with respect to school quality and access between wealthy families and poor families. Wealthy families increased educational investments substantially in response to improvements in school quality and school access. Poor families also increased educational investments but those increases were much smaller in magnitude. As a result, children from poor families saw incomes rise in absolute terms but fall relative to their peers from wealthier families.

These findings complicate the evaluation of the social gains from public school expansion. Introducing public schools offered individuals a way to increase earnings through building human capital. This new opportunity was ostensibly open to all; public schools did not explicitly discriminate on the basis of class in terms of who could attend and the returns to education were equally high for everyone regardless of the income of their parents. However, differences in the constraints faced by poor and wealthy families were not simply institutional or legal in nature. In the absence of strict child labor laws and compulsory attendance, the opportunity cost of sending a child to school could easily become prohibitively high for poor families. The experience of Iowa during the high school movement offers valuable lessons about school reform. Legal and financial constraints on education need to be considered carefully when evaluating the potential effects of school reform. By itself, an expansion of public education can, and in the case of Iowa did, promote widening income gaps and declines in income mobility. Preventing these unintended effects of school expansion would have required stricter compulsory schooling laws, greater regulation of child labor or education subsidies targeted specifically at poor families. In the absence of these additional measures, the benefits of new public schools went disproportionately to the children of wealthy families.

This is not to say that net effect of public school expansion on social welfare has been negative. As our returns to education results suggest, the private benefits to attending school were high across all backgrounds. The relative losses experienced by children from poor families resulted not from a decline in their own standard of living but rather from the large gains of individuals at the upper end of the income distribution. For those children from poor families who did decide to attend the new public schools, the schooling was subsidized by wealthier individuals. In this respect, the expansion of the public school system did provide greater opportunities than a comparable expansion of private education would have. With the increasing importance of education in both agricultural and non-agricultural sectors, the demand for education was rising and required the an expansion of educational institutions. Having public schools meet this rising demand rather than private schools minimized the decline in mobility while still promoting individuals' investment in education.

Our estimates of human capital spillovers across Iowa farms during the time of school expansion provide an even more persuasive argument for the benefits of the emerging public school system. It was not simply that public schools subsidized those individuals that chose to attend; they also had a positive impact on those who did not or could not attend but lived next to educated neighbors. A constant stream of agricultural innovations at the turn of the century made human capital valuable to farmers. With much of the secondary school expansion in Iowa preceding the development of agricultural extension services, the new educational institutions provided a unique channel for the dissemination of agricultural research to farmers and for instilling in farmers the ability to experiment and adapt in the face of changing technology. The human capital stock of educated farmers enabled them to efficiently adopt new technologies and increase production. These productivity gains, the result of highly observable choices over inputs and techniques, were not limited to educated farmers. Neighbors could mimic the behaviors of educated farmers and in doing so, share in the returns to education. Education at the beginning of the high school movement in rural areas was therefore a very public good. By taking an aggressive approach to expanding public schools, the state and local governments promoted more socially efficient levels of educational investment than would otherwise have been made.

These spillovers reinforce the necessity of looking beyond the private returns to education and considering the effects of educational institutions on the community as whole. Our analysis of the effects of public school expansion confirm that the private benefits to public school were substantial for those who attended but that they capture only a fraction of the total impact school expansion had on the economy. Differential responses across the income distribution to school expansion led to declines in relative mobility, as the absolute gains realized by children from wealthy families exceeded those of children from poor families. The externalities from public schools were not, however, completely negative. Human capital spillovers in agriculture led to farmers benefiting from more educated neighbors even if they themselves did not choose to attend school.

The expansion of public educational institutions had profound effects on the shape and rigidity of the income distribution and overall productivity in the economy. These effects were not strictly positive nor restricted simply to the private returns to education; they were instead a complicated result of individual preferences, institutional, geographical and financial constraints on educational attainment and the changing role of human capital in the economy. The experience of Iowa at the turn of the century underscores the complex and critical role that expansion of public schools played in shaping the American economy.

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APPENDIX A

Mismatched Father-Son Pairs in the Iowa Sample

The process of linking the 1915 Iowa census and 1900 federal census presents the possibility that some father-son pairs are incorrectly matched. Relying on name, age and birthplace rather than a truly unique identifier makes the possibility of mismatches unavoidable. While every effort has been made to maintain strict criteria for matches, including discarding observations for which multiple individuals met the match criteria, the possibility of mismatches still looms. This section of the appendix offers a brief discussion of the estimation issues these mismatches create and an assessment of how common mismatches would have to be to account for the estimated difference in mobility rates between the 1915 Iowa and 2001 PSID samples.

In its simplest incarnation, this mismatch error could be characterized as a son being paired with his correct father with probability π and incorrectly with a father drawn at random from the population with probability $1-\pi$. The value of the father's income used in the intergenerational income elasticity regressions is then given by

$$y^*_{i,f} = \begin{cases} y_{i,f} + u_i, & \text{with probability } \pi \\ \tilde{y}, & \text{with probability } 1-\pi \end{cases}$$

where $y_{i,f}$ is the father's true income, u_i is a classical measurement error term, and $\tilde{y}$ is a randomly drawn income corresponding to some other father in the population. The distribution from which $\tilde{y}$ is drawn can be assumed to be the income distribution of the entire population. Alternatively, and perhaps more realistically, the income could come from a distribution of father's income conditional on the son's age. If the son and father are correctly matched, the income observation of the father will be his true income with some classical measurement error u_i having mean zero and uncorrelated with the true income. The measurement error for the mismatched fathers will be equal to the difference between the randomly drawn income and his true income: $\tilde{y} - y_{i,f}$. Letting ϵ_i represent the measurement error for any given individual i in the sample and assuming that $E(\tilde{y})$ is equal to $E(y_{i,f})$, the measurement error for a sample containing some mismatched individuals can be characterized as follows,

$$\epsilon_i = \begin{cases} u_i, & \text{with probability } \pi \\ \tilde{y} - y_{i,f}, & \text{with probability } 1 - \pi, \end{cases}$$

$$E(\epsilon_i) = 0,$$

$$Cov(\epsilon_i, y_{i,f}) = -(1 - \pi)Var(y_{i,f}).$$

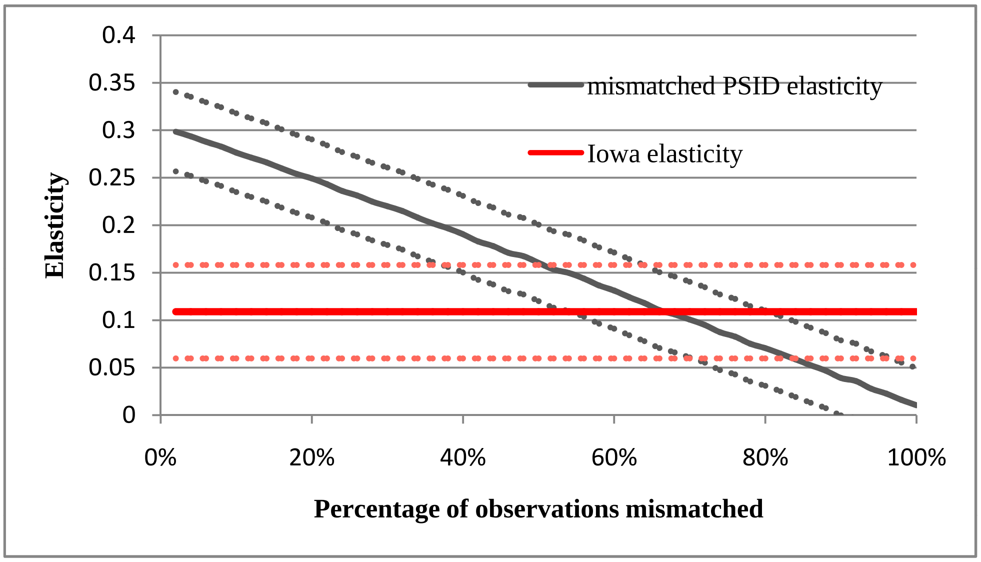
This negative correlation between the measurement error and the true value of the father's income implies that the measurement error introduced by mismatching is mean-reverting.

The problem of mean-reverting measurement error is not uncommon in the labor literature, especially in studies using various measures of income. Kim and Solon (2005) outline the dramatic effects that mean-reverting measurement error can have on the economic interpretation of wage data. Kapteyn and Ypman (2007) specifically consider the case of mismatched administrative income data and show that in the simple case where the mismeasured income variable is the single independent variable in a linear regression and mismatches are drawn from the same population as the correctly matched individuals, the estimated coefficient on income is biased downwards by an amount proportional to the rate of mismatches.

The bias introduced in the intergenerational income elasticity estimates by mismatched data is not easily characterized. The estimation equation includes both the mismatched variable and interactions of the mismatched variable with the correctly measured age of the son as regressors. Furthermore, the distribution from which a mismatch is drawn is dependent on the true value of the son's age. A final complication is that the likelihood of a son and father being mismatched may be correlated with characteristics of the son and father including age, income, location, literacy and so on that enter the income elasticity regressions either directly or through the error term. All of these factors make it difficult to assess how large a problem mismatch is for the Iowa data. Unlike the classical measurement error for the income variables discussed in Chapter 2 common to both the Iowa and PSID data, this source of error is specific to the Iowa sample and consequently could lead to a bias that generates the observed difference in intergenerational income elasticities between the Iowa and PSID samples even if the true elasticities are the same.

While there is no way to confidently state the number of mismatches in the linked Iowa sample, it is possible to introduce mismatches in the PSID data and determine the level of mismatches required to obtain similar elasticity estimates for both the Iowa and PSID data. To generate random mismatches in the PSID data, an appropriate number of father-son observations are chosen at random to be mismatched. The father's income and age information is discarded. A new age for the father is randomly drawn from the distribution of father ages conditional on the son's age. The father's income is then randomly drawn from the distribution of income conditional on the father's newly chosen age. The new sample of individuals is then used to estimate the intergenerational income elasticity. The original dataset is restored and then the entire process is repeated with new random number seeds.

Figure A.1 depicts the results from simulating mismatches in the PSID sample. Mismatch rates of 2 percent to 100 percent are simulated, with 1,000 iterations of the mismatch and estimation procedure completed for each rate. The figure demonstrates that a mismatch rate approaching 50 percent would be required to account for the observed difference in 1915 and 2001 elasticities if the true elasticities are actually the same.



Notes: Dashed lines correspond to a 90 percent confidence interval. For each mismatch, a random age for the father was drawn from the distribution of father ages conditional on the son's age and then a random income was drawn from the distribution of father incomes conditional on the father's newly assigned age.

Figure A.1: Intergenerational income elasticity estimates using PSID data with random mismatches

APPENDIX B

Missing Neighbors and the Estimation of Spillovers

The fact that not all of a farmer's neighbors are observed presents difficulties for our estimation of human capital spillovers, particularly in the context of estimating the effects of the maximum level of education across all neighbors. This section presents a brief discussion of why missing neighbors are problematic and how the level of missing neighbors affects the bias of our estimated coefficients.

Our spillover estimates focus on two main types of measures for neighbors' education, the mean education of all neighbors and the maximum individual education across all neighbors. If we assume that the probability of a neighbor being missing is independent of their education level, the expected value of the mean education level of the observed neighbors is equivalent to the expected value of the mean education level of all neighbors, observed and unobserved.[1] A greater number of missing neighbors simply increases the level of classical measurement error in our mean neighbor education variable, a common measurement problem that will introduce a downward bias in the estimated spillover coefficient.

When using the maximum level of education across all neighbors, the effects of missing neighbors are more complicated. This is no longer a case of classical measurement error. With any number of missing neighbors, the observed maximum education level provides a lower bound on the true maximum across all neighbors. Our measure of maximum neighbor education is potentially censored. A small amount of work has been done on the problems of censored independent variables showing that censoring biases the estimated

[1] The assumption that neighbors are missing at random is not as implausible as it may at first seem. The primary reason for missing neighbors is that their names were given on the plat maps with only an initial for the first name leaving multiple possible matches with the census. Whether or not this occurs has nothing to do with the education level of the individual.

coefficient for the censored variable as well as the coefficients for other independent variable (see Austin & Hoch (2004) and Austin & Brunner (2003)). Our case is even more problematic than those considered in the literature, as the level at which maximum neighbor education is censored varies across observations. The likelihood of the variable being censored depends on the observed maximum education, the correlation of education levels between neighbors and the number of missing neighbors.

To get a sense of how this censoring of the maximum neighbor education variable may influence our spillover estimates, we can use Monte Carlo simulations that estimate coefficients for varying levels of missing neighbors. Our simulations estimate income as a function of own education and neighbors' maximum education. We populate a grid with individuals whose education is a function of their location on the grid and a mean zero stochastic term. Making educating dependent on grid location allows us to generate the positive correlation between adjacent individuals' education levels observed in our Iowa sample. We then generate an income for each individual that is a linear function of own education, the maximum education level of all adjacent neighbors (the eight surrounding points on the grid) and a stochastic term that is a random draw from a standard normal distribution. We then choose a level of missing neighbors. The proper number of missing neighbors are randomly selected from the grid and their education levels are set to missing.[2] New maximum neighbor education levels are then calculated and income is regressed on own education and maximum neighbor education. All data is reset to the original state and a new set of missing neighbors is drawn and a new set

[2]Education levels that are set to missing are missing only relative to the neighbors. Own education is always known and is used in the regressions. An individual only drops out of our regressions when all of their neighbors are set to missing.

of coefficients estimated. This process is repeated 1000 times for each level of missing neighbors.

The results of these simulations are shown in Figure B.1 and Figure B.2. It is clear that as the number of missing neighbors increases, it creates a downward bias for the estimated spillover coefficient. As the estimated coefficient on spillovers is biased toward zero, the estimated coefficient for the private returns to education rises. These simulations reinforce our findings that spillovers in agriculture were substantial relative to the private returns to education for farmers. Given that our sample has a substantial number of missing neighbors, the estimated spillovers are likely to be smaller than the true spillover and the estimated gap between the private returns to education and the spillovers from neighbor education is larger than the true gap. In the presence of ideal data with no missing neighbors, we would expect even larger estimates of human capital spillovers.

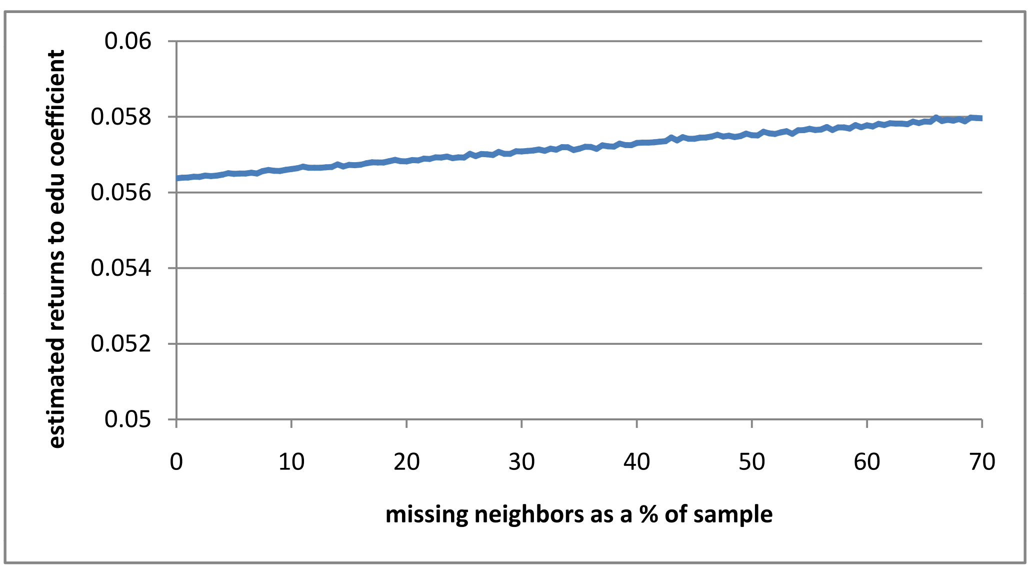


Figure B.1: Estimated private returns to education coefficient by number of missing neighbors

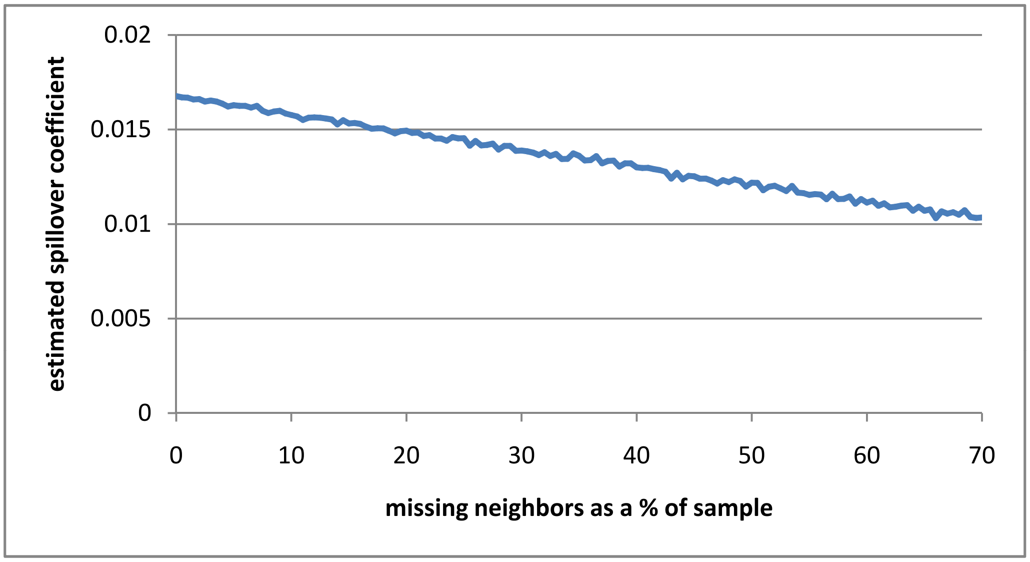


Figure B.2: Estimated spillovers from maximum of neighbors' education by number of missing neighbors

APPENDIX C

Additional Tables and Figures

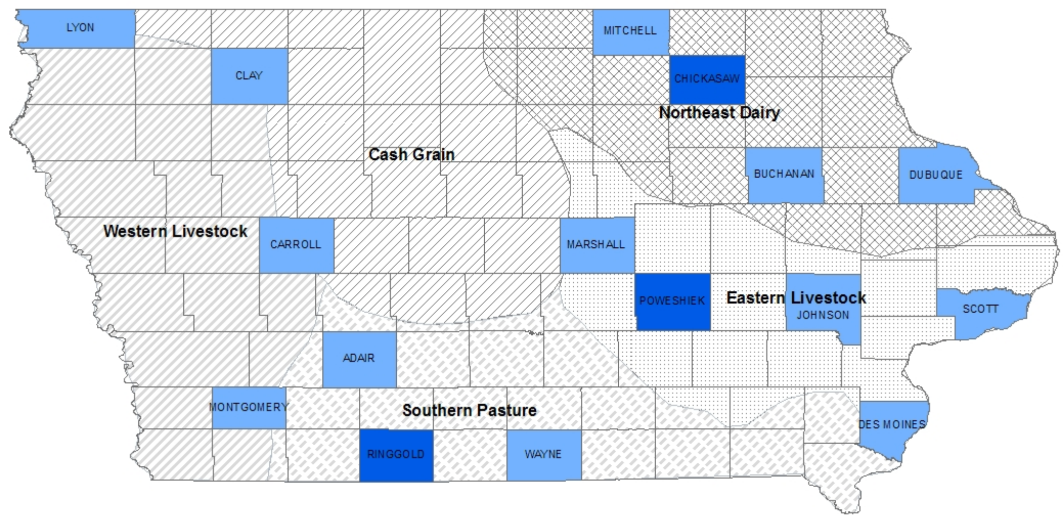


Figure C.1: Map of Iowa with county borders and agricultural regions shown. Counties in the Goldin-Katz sample and in the farm owner sample are shaded (the farm owner sample counties are shaded in the darker color). The borders for the agricultural regions are from Latta (1952).

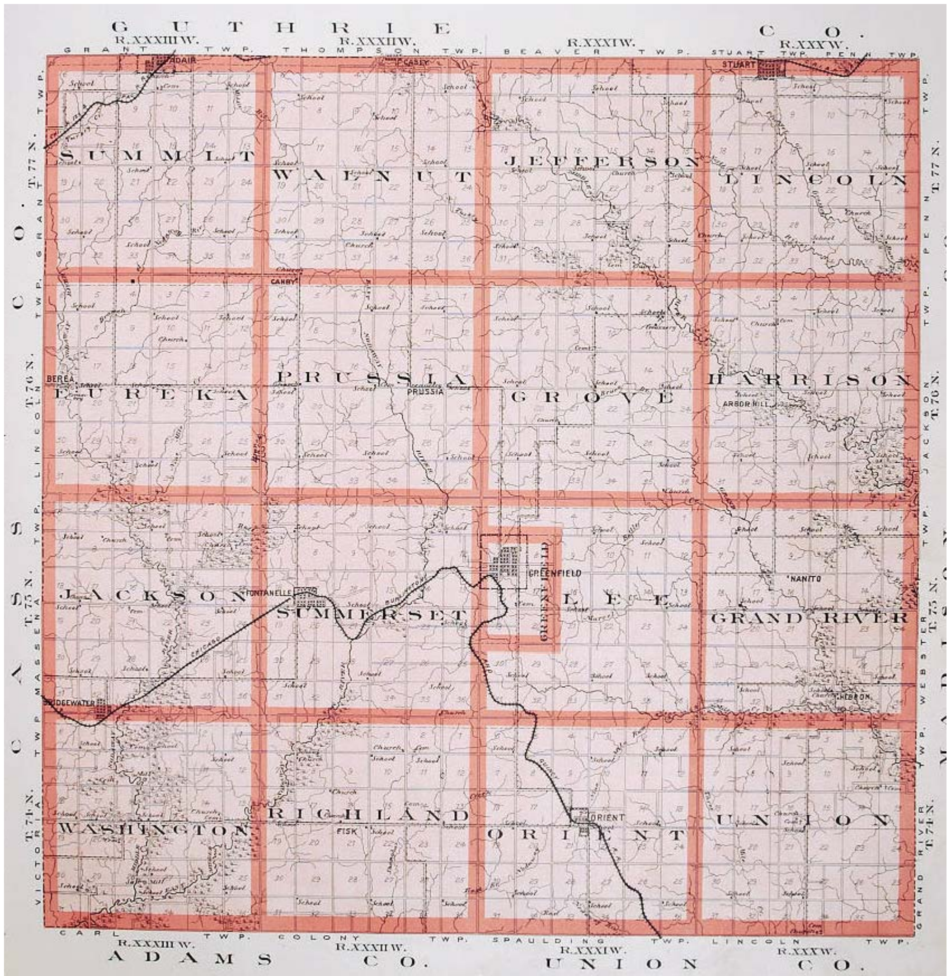


Figure C.2: Map of Adair County, IA with township divisions shown, 1904. Source: Huebinger, Melchoir, "Atlas of the state of Iowa." Davenport, IA: Iowa Publishing Co., 1904. Each township is typically 36 square miles and the default unit for a school district.

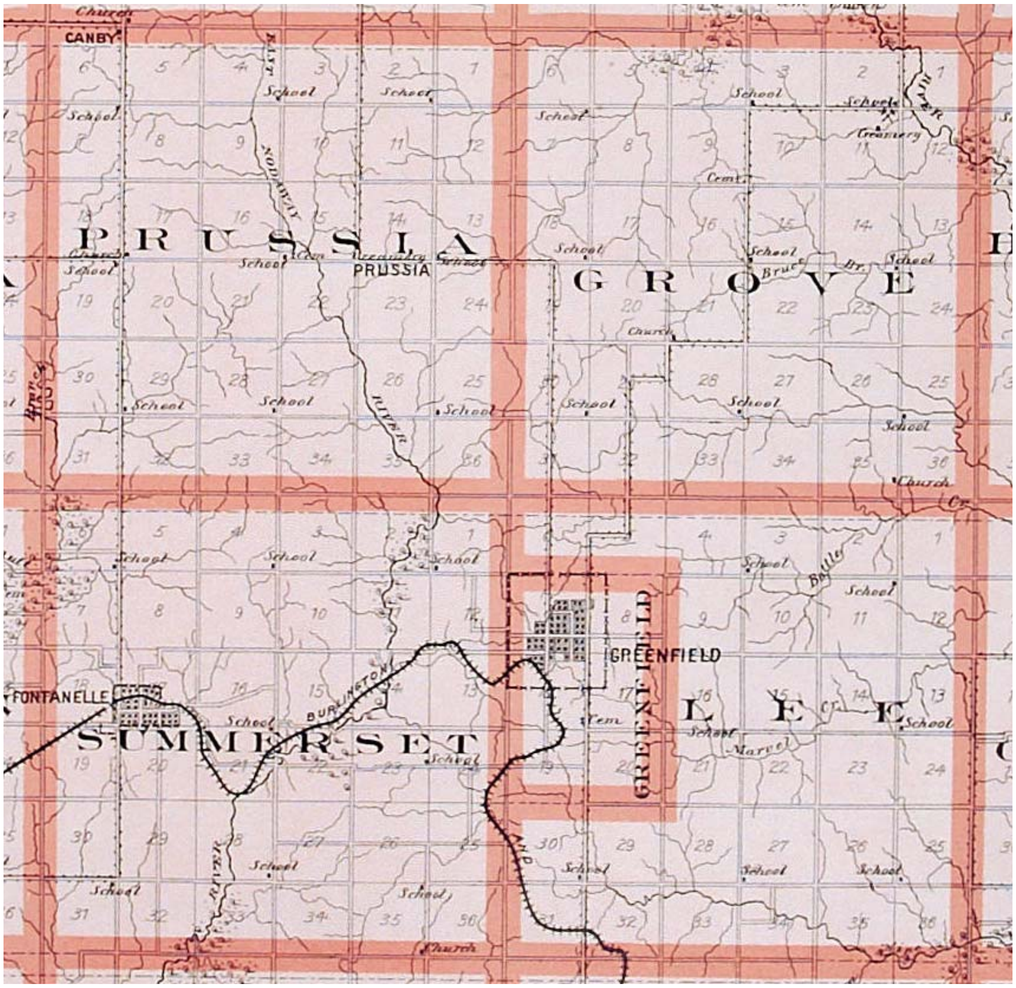


Figure C.3: Detail of Prussia, Grove, Summerset and Lee townships in Adair County. Source: Huebinger, Melchoir, "Atlas of the state of Iowa." Davenport, IA: Iowa Publishing Co., 1904. Each of these townships has a school district for the entire township. However, the towns of Greenfield and Fontanelle have independent schools districts. For the purposes of assigning people to school districts, the Fontanelle independent district and the Summerset township district are aggregated into a single district as are the Greenfield and Lee districts. In these cases, all individuals in the township share the same school district values. The distribution of common schools on a two-mile by two-mile grid is shown on the map. The only graded classrooms in these townships are in the independent school districts of Fontanelle and Greenfield.

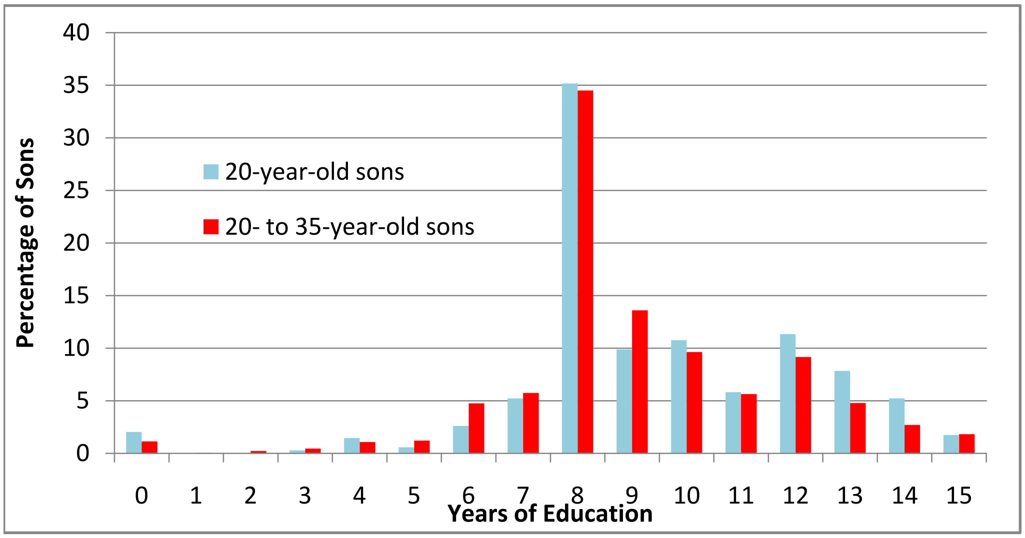


Figure C.4: Distribution of sample sons by total years of educational attainment and age in 1915

Table C.1: Intergenerational income elasticity estimates with and without farmers, Iowa, 1915

Sample used:	Full		Exluding farmer fathers		Exluding farmer sons		Excluding farmer fathers and sons	
Earnings measure used:	Annual	Monthly	Annual	Monthly	Annual	Monthly	Annual	Monthly
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Father's log earnings	0.109***	0.123***	0.151***	0.141***	0.179***	0.175***	0.167***	0.158***
	(0.030)	(0.039)	(0.044)	(0.041)	(0.031)	(0.029)	(0.037)	(0.032)
Father's age	-0.080*	-0.070	-0.061	-0.060	-0.038	-0.040	-0.025	-0.034
	(0.046)	(0.047)	(0.043)	(0.047)	(0.049)	(0.056)	(0.039)	(0.044)
(Father's age)^2	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Son's age	-0.054*	-0.058***	-0.020	-0.012	-0.067*	-0.043	-0.067*	-0.042
	(0.029)	(0.021)	(0.042)	(0.031)	(0.040)	(0.028)	(0.039)	(0.028)
(Son's age)^2	-0.007	-0.005	-0.007	-0.006*	-0.012**	-0.011***	-0.013**	-0.011***
	(0.005)	(0.003)	(0.006)	(0.003)	(0.006)	(0.003)	(0.006)	(0.004)
Son's age x Father's log earnings	0.015***	0.014***	0.009	0.007	0.015**	0.010**	0.015**	0.010**
	(0.004)	(0.003)	(0.006)	(0.005)	(0.006)	(0.004)	(0.006)	(0.004)
(Son's age)^2 x Father's log earnings	0.001	0.000	0.001	0.001	0.001*	0.001**	0.001*	0.001**
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	8.421***	5.826***	7.587***	5.489***	6.711***	4.665***	6.436***	4.656***
	(1.396)	(1.366)	(1.279)	(1.318)	(1.423)	(1.581)	(1.121)	(1.199)
Number of observations	1094	1017	708	658	713	665	619	573
R-squared	0.22	0.20	0.25	0.24	0.26	0.26	0.28	0.29

Standard errors in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Son's age is defined as age minus 30.

Table C.2: Distribution of sons by distance moved from 1900 to 1915

Distance moved (miles)	Number of sons	% of all sons	Cumulative %
0	545	69.43	69.43
10	48	6.11	75.54
20	18	2.29	77.83
30	12	1.53	79.36
40	7	0.89	80.25
50	13	1.66	81.91
60	7	0.89	82.80
70	8	1.02	83.82
80	5	0.64	84.46
90	9	1.15	85.61
100	6	0.76	86.37
110	5	0.64	87.01
120	5	0.64	87.64
130	3	0.38	88.03
140	3	0.38	88.41
150	4	0.51	88.92
160	5	0.64	89.55
170	4	0.51	90.06
180	5	0.64	90.70
190	6	0.76	91.46
>200	67	8.54	100.00
All distances	785	100.00	100.00

Table C.3: Descriptive statistics by distance moved by son between 1900 and 1915

Distance moved:	All	Greater than 20 miles	Did Not Move
Son's log earnings	6.26	6.60	6.31
	(0.67)	(0.57)	(0.67)
Father's log earnings	6.68	6.79	6.70
	(0.76)	(0.63)	(0.73)
Son's months	1.02	0.36	1.16
unemployed	(2.19)	(1.25)	(2.34)
Son's age	25.27	25.46	24.73
	(5.42)	(5.65)	(5.45)
Father's age	57.04	55.54	56.61
	(7.40)	(7.58)	(6.87)
Son's total years of	9.06	10.03	9.33
education	(2.51)	(4.07)	(2.55)
Father's total years of	7.89	9.00	8.22
education	(2.64)	(3.02)	(2.59)
Son's years of	4.05	2.04	2.71
common school	(4.26)	(3.35)	(3.87)
Son's years of	4.00	5.43	5.17
grammar school	(4.01)	(4.31)	(3.96)
Son's years of	0.76	1.71	1.08
high school	(1.40)	(1.78)	(1.68)
Son's years of	0.17	0.67	0.24
college	(0.88)	(1.45)	(0.86)
Number of observations	1094	28	158

Standard deviations given in parentheses. 'All' category corresponds to all individuals included in the intergenerational income elasticity regression sample.

Table C.4: Father's log earnings by school access and quality quartiles

Access:	Mean log earnings	Standard deviation
1st quartile	6.69	0.82
2nd quartile	6.80	0.76
3rd quartile	6.68	0.91
4th quartile	6.79	0.72

Quality:	Mean log earnings	Standard deviation
1st quartile	6.63	0.87
2nd quartile	6.79	0.77
3rd quartile	6.82	0.75
4th quartile	6.62	0.81

Access is measured as the number of graded classrooms per square mile. Quality is measured as the level of spending per student.

Table C.5: Schooling measure correlations, 1900

	Graded schools	Classrooms per student	Taxes per student	Spending per student	Classrooms per square mile	Graded classrooms per square mile	Student-teacher ratio	Subsidy per student
Graded schools	1							
Classrooms per student	.61	1						
Taxes per student	.20	.05	1					
Spending per student	.11	.08	.85	1				
Classrooms per square mile	.30	-.39	.27	.25	1			
Graded classrooms per square mile	.31	-.40	.27	.26	.99	1		
Student-teacher ratio	.24	-.33	.09	.14	.87	.89	1	
Subsidy per student	.30	-.41	.59	.68	.56	.58	.45	1

Subsidy per student is defined as spending per student over an academic year minus the total tuition for an out-of-district student for the academic year.

Table C.6: Intergenerational income elasticity estimates for urban individuals, 1915

Schooling measure	No schooling measure (1)	Classrooms per student (3)	Taxes (4)	Spending (5)	School classroom density (6)	Graded classroom density (7)	Student-Teacher Ratio (8)	Subsidy (9)
Father's log earnings	0.255***	1.023***	-0.586	-0.082	0.390***	0.352***	0.279***	0.290***
	(0.041)	(0.222)	(0.344)	(0.949)	(0.049)	(0.057)	(0.050)	(0.057)
Father's log earnings x	--	-53.708**	0.067*	0.024	-0.033**	-0.027**	-0.000*	0.000
schooling measure	--	(13.371)	(0.030)	(0.068)	(0.009)	(0.008)	(0.000)	(0.011)
Schooling measure	--	367.004***	-0.471*	-0.155	0.241***	0.209**	0.003**	0.020
	--	(77.673)	(0.199)	(0.445)	(0.047)	(0.046)	(0.001)	(0.085)
Father's age	-0.040	-0.034	-0.035	-0.041	-0.040	-0.043	-0.045	-0.053
	(0.095)	(0.095)	(0.096)	(0.095)	(0.097)	(0.096)	(0.097)	(0.095)
(Father's age)^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Son's age	0.057	0.004	-0.017	0.044	0.010	0.019	0.020	0.050
	(0.148)	(0.166)	(0.177)	(0.166)	(0.152)	(0.150)	(0.154)	(0.146)
(Son's age)^2	-0.002	-0.003	-0.006	-0.002	-0.006	-0.006	-0.007	-0.002
	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)	(0.011)	(0.009)
Son's age x Father's log earnings	-0.004	0.004	0.007	-0.002	0.003	0.002	0.002	-0.003
	(0.022)	(0.025)	(0.026)	(0.025)	(0.023)	(0.023)	(0.023)	(0.022)
(Son's age)^2 x Father's log earnings	-0.000	-0.000	0.000	-0.000	0.000	0.000	0.000	-0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
Constant	6.398*	0.909	12.133**	8.549	5.355	5.705*	6.315*	6.246*
	(2.770)	(2.845)	(3.650)	(5.313)	(2.712)	(2.615)	(2.741)	(2.616)
Number of observations	197	197	197	197	197	197	197	197
R-squared	0.40	0.42	0.41	0.40	0.42	0.42	0.41	0.42

Standard errors in parentheses. Son's age is defined as age in 1915 minus 30.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.7: Intergenerational income elasticity estimates for rural individuals, 1915

Schooling measure	No schooling measure (1)	Graded Schools (2)	Classrooms per student (3)	Taxes (4)	Spending (5)	School classroom density (6)	Graded classroom density (7)	Student-Teacher Ratio (8)	Subsidy (9)
Father's log earnings	0.030	0.054*	-0.002	-0.068	-0.086	-0.030	-0.002	0.124***	0.061**
	(0.036)	(0.028)	(0.204)	(0.097)	(0.095)	(0.050)	(0.039)	(0.039)	(0.021)
Father's log earnings x	--	-0.044	1.786	0.014	0.012	0.230*	0.275**	-0.004***	0.017***
schooling measure	--	(0.059)	(7.465)	(0.009)	(0.008)	(0.128)	(0.111)	(0.001)	(0.004)
Schooling measure	--	0.392	-22.125	-0.097	-0.088*	-1.414	-1.670**	0.025***	-0.110***
	--	(0.409)	(50.059)	(0.060)	(0.049)	(0.875)	(0.759)	(0.007)	(0.029)
Father's age	-0.075	-0.086	-0.077	-0.068	-0.070	-0.071	-0.074	-0.084	-0.081
	(0.059)	(0.054)	(0.060)	(0.059)	(0.060)	(0.058)	(0.058)	(0.058)	(0.056)
(Father's age)^2	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Son's age	-0.049	-0.039	-0.057	-0.086**	-0.085*	-0.072	-0.075	-0.048	-0.091**
	(0.051)	(0.053)	(0.053)	(0.039)	(0.041)	(0.048)	(0.047)	(0.044)	(0.039)
(Son's age)^2	-0.008	-0.008	-0.009	-0.007	-0.007	-0.009	-0.009	-0.009	-0.007
	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Son's age x Father's log earnings	0.015*	0.013	0.016*	0.020***	0.020***	0.018**	0.019**	0.014**	0.021***
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)
(Son's age)^2 x Father's log earnings	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	8.810***	8.888***	9.334***	9.340***	9.524***	9.052***	8.990***	8.405***	8.825***
	(1.754)	(1.744)	(1.226)	(1.512)	(1.620)	(1.670)	(1.748)	(1.813)	(1.780)
Number of observations	469	469	469	469	469	469	469	468	468
R-squared	0.18	0.19	0.19	0.19	0.19	0.18	0.19	0.19	0.21

Standard errors in parentheses. Son's age is defined as age in 1915 minus 30.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.8: Logit estimates for moving to the bottom income quintile and persistence in the bottom income quintile

	Movement into bottom			Persistence in bottom		
Variable	Coefficient	St. Error	dP/dx	Coefficient	St. Error	dP/dx
Son's age	-0.193**	0.025	-0.027	-0.242**	0.042	-0.042
Sons years of schooling	-0.030	0.044	-0.004	-0.192**	0.084	-0.033
Occupational transitions (father-son):						
white collar - white collar	-0.377	0.550	-0.052			
white collar - service						
white collar - farm	0.532	1.182	0.074			
white collar - blue collar	0.006	0.484	0.001			
service - white collar	0.166	0.527	0.023	2.222	1.532	0.383
service - service	-1.348	1.055	-0.188			
service - farm	0.372	0.727	0.052			
service - blue collar	0.211	0.617	0.029	1.018	0.797	0.176
farm - white collar	-0.053	0.845	-0.007	2.544**	1.285	0.439
farm - service				-0.429	1.282	-0.074
farm - farm	1.795**	0.288	0.250	0.822*	0.478	0.142
farm - blue collar	0.940**	0.452	0.131	0.727	0.715	0.125
blue collar - white collar	-0.885	0.583	-0.123	-1.058	0.678	-0.182
blue collar - service	-0.786	1.075	-0.109	-0.409	0.935	-0.071
blue collar - farm	0.524	0.858	0.073	0.468	0.706	0.081
Moved across counties	-0.116	0.284	-0.016	-0.383	0.543	-0.066
Moved to a city	-1.039*	0.607	-0.145	0.860	0.793	0.148
Constant	3.085**	0.696		6.415**	1.228	
Number of observations	749			220		
pseudo-R^2	0.218			0.2485		

* indicates significance at 10%, ** indicates significance at 5%.

Dependent variable for movement into the bottom equals one if son is in bottom income quintile and father was not and zero if neither the son or father was in the bottom quintile.

Dependent variable for persistence in the bottom equals one if both father and son were in bottom income quintile and zero if the father was in the bottom quintile but the son was not.

Table C.9: Logit estimates for moving to the top income quintile and persistence in the top income quintile

	Movement into top			Persistence in top		
Variable	Coefficient	St. Error	dP/dx	Coefficient	St. Error	dP/dx
Son's age	0.175**	0.020	0.018	0.174**	0.054	0.033
Sons years of schooling	0.121**	0.044	0.012	0.220**	0.094	0.042
Occupational transitions (father-son):						
white collar - white collar	1.524**	0.455	0.158	0.247	1.220	0.047
white collar - service	2.430**	0.685	0.251	-1.838	2.157	-0.348
white collar - farm	0.929	1.221	0.096			
white collar - blue collar	0.748	0.483	0.077	0.463	1.701	0.088
service - white collar	0.965**	0.492	0.100			
service - service	1.455**	0.478	0.150	0.601	1.275	0.114
service - farm	1.120	0.742	0.116			
service - blue collar	0.027	0.622	0.003			
farm - white collar	0.122	0.782	0.013			
farm - service	1.126*	0.659	0.116			
farm - farm	0.205	0.346	0.021	-0.703	1.029	-0.133
farm - blue collar	-1.484	1.057	-0.153			
blue collar - white collar	0.788*	0.418	0.081	0.573	1.716	0.109
blue collar - service	1.414**	0.504	0.146			
blue collar - farm	1.297	0.516	0.134			
Moved across counties	0.231	0.351	0.024	0.776	0.627	0.147
Moved to a city	-0.417	0.469	-0.043	-1.812	1.402	-0.343
Constant	-7.943**	0.761		-7.215**	1.981	
Number of observations	856			123		
pseudo-R^2	0.2003			0.229		

* indicates significance at 10%, ** indicates significance at 5%.

Dependent variable for movement into the top equals one if son is in top income quintile and father was not and zero if neither the son or father was in the top quintile.

Dependent variable for persistence in the top equals one if both father and son were in top income quintile and zero if the father was in the top quintile but the son was not.

Table C.10: Returns to education, conditioning on father's income quartile (son's log earnings as dependent variable)

Son's occupational sector:	All		Agricultural		Non-agricultural	
	(1)	(4)	(2)	(5)	(3)	(6)
Common School	0.042***	0.044***	0.058***	0.063***	0.031***	0.030***
	(0.007)	(0.007)	(0.014)	(0.014)	(0.008)	(0.008)
Grammar School	0.065***	0.065***	0.054***	0.052***	0.063***	0.063***
	(0.007)	(0.007)	(0.018)	(0.018)	(0.008)	(0.008)
High School	0.109***	0.106***	0.116***	0.102***	0.106***	0.106***
	(0.008)	(0.009)	(0.028)	(0.029)	(0.008)	(0.008)
College	0.126***	0.131***	0.161***	0.254***	0.120***	0.121***
	(0.013)	(0.013)	(0.057)	(0.067)	(0.012)	(0.012)
Common x Q2	--	-0.036***	--	-0.044**	--	-0.006
	--	(0.014)	--	(0.022)	--	(0.023)
Common x Q3	--	-0.011	--	-0.031*	--	0.021
	--	(0.010)	--	(0.016)	--	(0.014)
Common x Q4	--	-0.009	--	-0.010	--	0.004
	--	(0.008)	--	(0.012)	--	(0.015)
Grammar x Q2	--	-0.007	--	0.069	--	-0.010
	--	(0.010)	--	(0.154)	--	(0.009)
Grammar x Q3	--	0.005	--	-0.024	--	0.006
	--	(0.010)	--	(0.051)	--	(0.009)
Grammar x Q4	--	0.012	--	0.025	--	0.004
	--	(0.017)	--	(0.042)	--	(0.019)
HS x Q2	--	0.050	--	0.079	--	0.030
	--	(0.056)	--	(0.355)	--	(0.052)
HS x Q3	--	-0.017	--	0.166	--	-0.037
	--	(0.034)	--	(0.160)	--	(0.032)
HS x Q4	--	0.015	--	-0.080	--	0.037
	--	(0.046)	--	(0.112)	--	(0.050)
Coll x Q2	--	-0.017	--	-0.202	--	0.025
	--	(0.132)	--	(0.342)	--	(0.134)
Coll x Q3	--	0.013	--	0.000	--	0.025
	--	(0.080)	--	(0.000)	--	(0.071)
Coll x Q4	--	-0.081	--	-0.257*	--	-0.066
	--	(0.053)	--	(0.142)	--	(0.055)
Number of observations	2711	2711	718	718	1993	1993
R-squared	0.21	0.22	0.16	0.18	0.26	0.26

Standard errors in parentheses, independent variables also include a native born dummy, years in the US for foreign born
* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.11: Returns to education using a linear spline for years of schooling, conditioning on father's income quartile (son's log earnings as dependent variable)

Son's occupational sector:	All		Agricultural		Non-agricultural	
	(1)	(2)	(3)	(4)	(5)	(6)
Common up to 9	0.030***	0.032***	0.027	0.033*	0.031***	0.030***
	(0.009)	(0.009)	(0.019)	(0.019)	(0.009)	(0.009)
Common > 9	0.093***	0.092***	0.127***	0.123***	0.053*	0.046
	(0.020)	(0.022)	(0.032)	(0.035)	(0.032)	(0.033)
Grammar up to 9	0.056***	0.055***	0.029	0.029	0.064***	0.064***
	(0.008)	(0.008)	(0.021)	(0.022)	(0.009)	(0.009)
Grammar > 9	-0.003	-0.013	-0.045	-0.803	-0.016	-0.022
	(0.043)	(0.044)	(0.499)	(0.702)	(0.038)	(0.039)
High School up to 4	0.116***	0.115***	0.117***	0.107***	0.113***	0.113***
	(0.009)	(0.010)	(0.030)	(0.032)	(0.009)	(0.009)
High School > 4	-0.076	-0.084	-0.064	-0.061	-0.076	-0.081
	(0.068)	(0.069)	(0.316)	(0.316)	(0.063)	(0.063)
College (HS>0)	0.120***	0.125***	0.198**	0.291***	0.113***	0.115***
	(0.014)	(0.015)	(0.079)	(0.089)	(0.013)	(0.014)
College (HS=0)	0.021	0.025	-0.081	-0.076	0.027	0.022
	(0.030)	(0.032)	(0.115)	(0.137)	(0.029)	(0.030)

Table is continued on the next page.

Table C.12: Returns to education using a linear spline for years of schooling, conditioning on father's income quartile (son's log earnings as dependent variable), continued

Son's occupational sector:	All		Agricultural		Non-agricultural	
	(1)	(2)	(3)	(4)	(5)	(6)
Com<9 x Q2		-0.042***		-0.059**		-0.008
		(0.016)		(0.027)		(0.023)
Com<9 x Q3		-0.011		-0.029*		0.018
		(0.011)		(0.018)		(0.016)
Com<9 x Q4		-0.012		-0.017		0.002
		(0.010)		(0.015)		(0.016)
Com>9 x Q2		0.053		0.092		0.000
		(0.129)		(0.172)		(0.000)
Com>9 x Q3		0.004		-0.053		0.056
		(0.109)		(0.215)		(0.127)
Com>9 x Q4		0.034		0.057		0.420
		(0.070)		(0.094)		(0.505)
Grm<9 x Q2		-0.006		0.084		-0.010
		(0.010)		(0.155)		(0.009)
Grm<9 x Q3		0.004		-0.029		0.005
		(0.010)		(0.052)		(0.009)
Grm<9 x Q4		0.008		0.003		0.003
		(0.018)		(0.051)		(0.019)
Grm>9 x Q2		0.329		0.000		0.305
		(0.558)		(0.000)		(0.492)
Grm>9 x Q3		0.150		0.000		0.152
		(0.330)		(0.000)		(0.292)
Grm>9 x Q4		0.381		1.429		0.343
		(0.411)		(1.076)		(0.508)

Table is continued on the next page.

Table C.13: Returns to education using a linear spline for years of schooling, conditioning on father's income quartile (son's log earnings as dependent variable), continued

Son's occupational sector:	All		Agricultural		Non-agricultural	
	(1)	(2)	(3)	(4)	(5)	(6)
HS<4 x Q2		0.039		0.149		0.021
		(0.058)		(0.361)		(0.053)
HS<4 x Q3		-0.020		0.168		-0.039
		(0.036)		(0.161)		(0.034)
HS<4 x Q4		0.007		-0.061		0.029
		(0.048)		(0.132)		(0.051)
HS>4 x Q2		0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)
HS>4 x Q3		0.398		0.000		0.411
		(0.566)		(0.000)		(0.502)
HS>4 x Q4		0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)
Col(HS) x Q2		0.205		-0.100		0.124
		(0.258)		(0.352)		(0.235)
Col(HS) x Q3		-0.029		0.000		-0.011
		(0.099)		(0.000)		(0.088)
Col(HS) x Q4		-0.057		-0.278		-0.053
		(0.059)		(0.219)		(0.057)
Col(no HS) x Q2		-0.297		0.000		-0.155
		(0.297)		(0.000)		(0.287)
Col(no HS) x Q3		0.129		0.000		0.113
		(0.171)		(0.000)		(0.152)
Col(no HS) x Q4		-0.124		0.005		-0.094
		(0.142)		(0.291)		(0.503)
Number of observations	2711	2711	718	718	1993	1993
R-squared	0.22	0.22	0.17	0.19	0.27	0.27

Standard errors in parentheses, independent variables also include a native born dummy, years in the US for foreign born
* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.14: Ordered probit coefficients, years of education as dependent variable

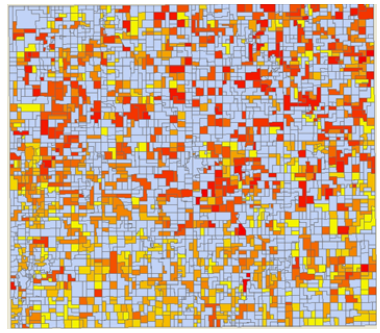
Dependent variable:	Total Schooling	High School
	(1)	(2)
School Quality	-0.079	0.097
	(0.089)	(0.083)
School Access	-0.270	-0.381
	(0.183)	(0.252)
Tuition	0.105	-0.037
	(0.981)	(1.130)
Father's log earnings	0.059	0.346
	(0.261)	(0.454)
Father's log earnings	0.044*	0.066**
x School Access	(0.024)	(0.033)
Father's log earnings	0.014	-0.008
x School Quality	(0.013)	(0.013)
Father's log earnings	-0.051	-0.009
x Tuition	(0.122)	(0.154)
Urban-Rural Dummy	0.127	-0.024
(urban = 1)	(0.125)	(0.139)
Number of observations	976	976

Standard errors in parentheses. * significant at 10%; ** significant at
Total schooling is measured as years of schooling completed beyond the 8 year minimum. Years of high school is measured as completed years of high school.
School quality is measured as spending per student. School access is measured as the number of graded schools per square mile.

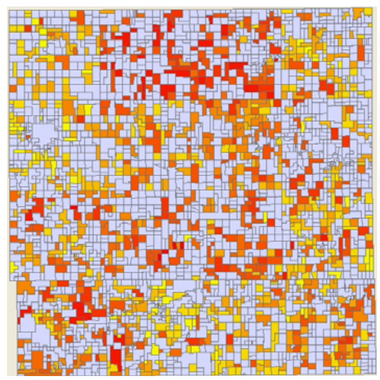
Table C.15: Agricultural statistics for Chickasaw, Poweshiek and Ringgold counties, 1915

	Chickasaw	Poweshiek	Ringgold	State average
Number of farms	1905	2142	1854	1996
Average size of farms	152	160	168	160.7
Total acreage of farms	289658	342489	311814	320711
Acreage in pasture	90488	115002	117683	97601
Ave. monthly wage paid farm help, summer months	30.8	33	28.43	32.7
Ave. monthly wage paid farm help, winter months	20.69	25.72	28.77	24.61
Corn, acres	63194	110557	69328	98463
Corn, bushels per acre	3	38	23	27.5
Oats, acres	64068	42748	24330	50354
Oats, bushels per acre	25	37	19	37.8
Winter wheat, acres	179	860	13245	5929
Winter wheat, bushels per acre	16	23	9	18.5
Spring wheat, acres	1607	780	6	1495
Spring wheat, bushels per acre	12	14	7	13.8
Barley, acres	4043	608	55	2049
Barley, bushels per acre	9	39	13	31.3
Horses (all ages)	12819	18228	13703	14484
Swine	78547	124161	59604	94564
Cattle, Cows and heifers kept for milk	17367	9877	7987	11053

Statistics are complied from the 1915 *Annual Iowa Yearbook of Agriculture* .



(a)



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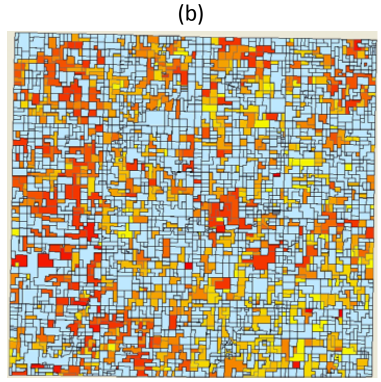

(c)

Figure C.5: The distribution of annual earnings for (a) Chickasaw, (b) Poweshiek and (c) Ringgold counties, 1915. Darker shadings represent higher earnings levels. The unit of observation on the maps is an individual farm.

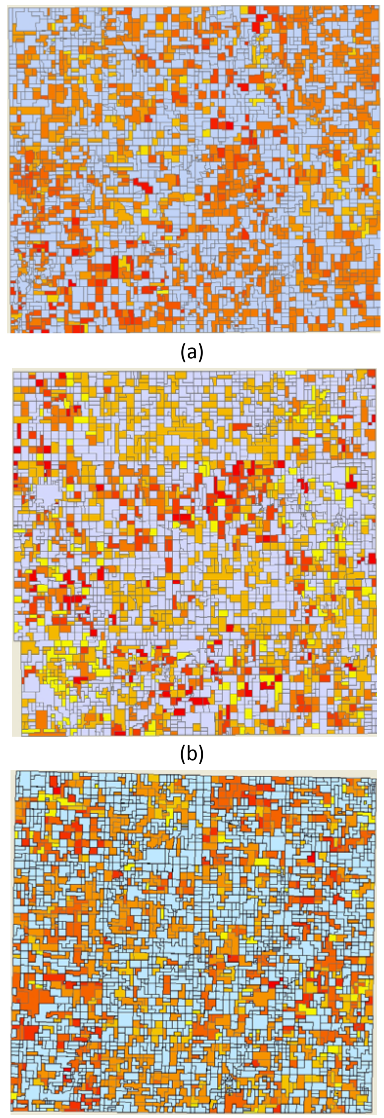

Figure C.6: The distribution of educational attainment for (a) Chickasaw, (b) Poweshiek and (c) Ringgold counties, 1915. Darker shadings represent higher years of education. The unit of observation on the maps is an individual farm.

Table C.16: Private returns to education estimates, log annual earnings as dependent variable

	All land owners				Farmers			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foreign born (yes=1)	-0.075	-0.098	-0.081	-0.080	-0.122	-0.136	-0.119	-0.121
	(0.114)	(0.114)	(0.114)	(0.114)	(0.112)	(0.112)	(0.112)	(0.112)
Years in US x	0.004	0.004	0.004	0.004	0.005*	0.005*	0.005*	0.005*
foreign born	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Ln(farm value per acre)	0.099***	0.100***	0.100***	0.100***	0.121***	0.122***	0.121***	0.122***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.026)	(0.026)	(0.026)	(0.026)
Total schooling	0.017***				0.013**			
	(0.005)				(0.006)			
Graded schooling		0.022***				0.010		
		(0.008)				(0.010)		
Common school			0.011*	0.010*			0.010*	0.011*
			(0.006)	(0.006)			(0.006)	(0.006)
Grammar school			0.005	0.005			-0.004	-0.004
			(0.014)	(0.014)			(0.015)	(0.015)
High school				0.046**				0.052**
				(0.020)				(0.022)
College				0.064**				0.009
				(0.025)				(0.029)
High school and college			0.053***				0.035**	
			(0.014)				(0.016)	
Constant	5.533***	5.624***	5.565***	5.565***	7.385***	7.444***	7.391***	7.382***
	(0.750)	(0.750)	(0.749)	(0.750)	(0.748)	(0.748)	(0.748)	(0.748)
Observations	2410	2410	2410	2410	2219	2219	2219	2219
R-squared	0.32	0.32	0.32	0.32	0.35	0.35	0.35	0.35

Standard errors in parentheses. All regressions include controls for age, religion and township.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.17: Returns to education by location where education was received, log annual earnings as dependent variable

	All land owners				Farmers			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foreign born (yes=1)	-0.024	-0.011	-0.009	-0.030	-0.063	-0.030	-0.030	-0.068
	(0.119)	(0.124)	(0.123)	(0.119)	(0.118)	(0.123)	(0.123)	(0.119)
Years in US x	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.004
foreign born	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Ln(farm value per acre)	0.099***	0.100***	0.100***	0.100***	0.015***	0.015***		
	(0.022)	(0.022)	(0.022)	(0.022)	(0.006)	(0.006)		
Total schooling (Iowa)	0.019***	0.019***			0.122***	0.123***	0.123***	0.122***
	(0.006)	(0.006)			(0.026)	(0.026)	(0.026)	(0.026)
Total schooling (non-Iowa)	0.013**				0.122***	0.123***	0.123***	0.122***
	(0.006)				(0.026)	(0.026)	(0.026)	(0.026)
Total schooling (non-US)		0.015*				0.014		
		(0.008)				(0.009)		
Total schooling (non-Iowa, US)		0.012*	0.012*			0.006	0.006	
		(0.007)	(0.007)			(0.007)	(0.007)	
Total schooling (US)			0.019***				0.015***	
			(0.005)				(0.006)	
Common (Iowa)				0.012**				0.013**
				(0.006)				(0.006)
Common (non-Iowa)				0.006				0.006
				(0.007)				(0.007)
Grammar (Iowa)				-0.002				-0.007
				(0.016)				(0.019)
Grammar (non-Iowa)				0.018				0.016
				(0.026)				(0.030)
HS (Iowa)				0.059***				0.057**
				(0.022)				(0.023)
HS (non-Iowa)				-0.002				0.014
				(0.046)				(0.063)
College (Iowa)				0.045				-0.013
				(0.029)				(0.032)
College (non-Iowa)				0.107**				0.089
				(0.052)				(0.064)
Observations	2410	2410	2410	2410	2219	2219	2219	2219
R-squared	0.32	0.32	0.32	0.32	0.35	0.35	0.35	0.35

Standard errors in parentheses. Control included for age, religion and township.* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.18: Private returns to education for farmers by distance to nearest town, log annual earnings as dependent variable

	Distance to nearest town is at least:					
	0 miles	1 mile	2 miles	3 miles	4 miles	5 miles
Common school	0.011*	0.008	0.016*	0.014	-0.021	-0.012
	(0.006)	(0.007)	(0.009)	(0.014)	(0.025)	(0.045)
Grammar school	-0.004	-0.011	0.000	0.002	-0.033	-0.015
	(0.015)	(0.017)	(0.022)	(0.031)	(0.041)	(0.060)
High school	0.052**	0.052**	0.078**	0.126**	0.117	0.056
	(0.022)	(0.026)	(0.033)	(0.057)	(0.082)	(0.122)
College	0.009	-0.015	-0.050	-0.041	-0.012	0.273
	(0.029)	(0.034)	(0.040)	(0.060)	(0.083)	(0.294)
Observations	2219	1764	1159	647	287	126

Standard errors in parentheses. All regressions control for age, religion land value per acre and township.* significant at 10%; ** significant at 5%; *** significant at 1%

Table C.19: Private returns to education and spillovers for farmers, log annual earnings as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Foreign born (yes=1)	-0.110	-0.092	-0.115	-0.116	-0.114	-0.112	-0.115	-0.115
	(0.113)	(0.113)	(0.113)	(0.113)	(0.113)	(0.113)	(0.113)	(0.113)
Years in US x	0.005*	0.005	0.005*	0.005*	0.005*	0.005*	0.005*	0.005*
foreign born	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Ln(farm value/acre)	0.119***	0.124***	0.122***	0.124***	0.122***	0.125***	0.122***	0.124***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Own schooling:								
Common school	0.009	0.008	0.009	0.009	0.009	0.008	0.009	0.008
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Grammar school	-0.007	-0.008	-0.008	-0.008	-0.007	-0.007	-0.007	-0.008
	(0.016)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
High school	0.055**	0.052**	0.057***	0.057***	0.056**	0.055**	0.057***	0.056**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
College	0.021	0.021	0.023	0.023	0.021	0.021	0.022	0.023
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Neighbors' schooling:								
Mean total years	0.023***							
	(0.008)							
Max total years		0.026***						
		(0.006)						
Mean graded years			0.010					
			(0.011)					
Max graded years				0.011**				
				(0.005)				
Mean HS/college					0.027			
					(0.020)			
Max HS/college						0.023***		
						(0.008)		
Mean high school							0.038	
							(0.029)	
Max high school								0.028***
								(0.011)
Constant	6.682***	6.610***	6.966***	6.943***	6.957***	6.936***	6.961***	6.945***
	(0.734)	(0.728)	(0.728)	(0.727)	(0.728)	(0.727)	(0.728)	(0.727)
Observations	2158	2158	2158	2158	2158	2158	2158	2158
R-squared	0.35	0.36	0.35	0.35	0.35	0.35	0.35	0.35

Standard errors in parentheses. All regressions control for age, religion and township.
* significant at 10%; ** significant at 5%; *** significant at 1%