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Keywords

Great Depression, market-based agriculture, agriculture-based economy

Disciplines

Agribusiness | Economic History | Labor History | United States History

Comments

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1 Introduction

The reallocation of labor across sectors is an important part of economic development and growth. In the case of structural change from agriculture to industry, this process is generally accompanied by both an increase in agricultural productivity as well as large-scale urbanization, as workers leave the agricultural sector and migrate to cities (Lewis 1954; Ranis and Fei 1961; Matsuyama 1992; Gollin 2010). Periods of economic crisis, however, have witnessed substantial declines in the rate of migration from farms to cities, as well as increases in the rate of so-called reverse migration back to farms. This pattern has been observed during the Great Depression (Spengler 1936; Thompson 1937; Boyd 2002), during the East Asian crisis of the late 1990s (World Bank 2007; Li 2009), as well as during the recent financial crisis of 2008-2009 (Kong et al. 2010; Huang et al. 2011). The process of structural change is also relevant for advanced economies like the contemporary United States, which in recent decades has suffered large employment declines in routine occupations and in the manufacturing sector. There is evidence that this structural change has contributed to worse labor market performance (Acemoglu 1999; Delli Gatti et al. 2012; Autor and Dorn 2013; Chodorow-Reich and Wieland 2018; Charles et al. forthcoming; Jaimovich and Siu forthcoming).

In this paper we study the migration between agriculture and the nonfarm sector in the United States during the Great Depression, including the movement out of towns and cities and onto farms, as well as the reallocation of labor within the farm sector. We show that the ability to move to farms serves as a source of informal insurance in the early years of the crisis, during a time when formal insurance is not widely available. We also demonstrate an important relationship between the migration flows and productivity on farms: while the farm sector overall absorbs a large number of in-migrants, the bulk of this movement is to low-productivity farm areas. In fact, mechanized farm areas experience agricultural employment declines and net out-migration during the crisis, with many of their residents moving to lower-quality farms. Figure 1 shows this substantial divergence in population trends during the 1930s between places with the lowest and highest levels of farm mechanization.

Our results highlight the importance of interactions between short-term macroeconomic fluctuations and the longer-run process of structural change. We show how the agricultural job losses associated with technological change are concentrated during the initial economic downturn. This

finding has parallels to the literature studying the more recent effects of technological change, which has demonstrated the importance of economic downturns for the timing of job losses in routine occupations.[1] Moreover, instead of releasing labor to the nonfarm sector, as predicted by models of structural transformation, the workers driven off of mechanized farms actually reallocate into the lower-productivity subsistence agricultural sector. Thus the "normal" process of sectoral reallocation is obstructed by the crisis. It is not simply that the process slows down or stalls, but instead it takes a perverse form that may actually impede both the economic recovery and the longer-run development process.[2]

Our empirical strategy in this paper relies on two main sources of spatial variation. First, we make use of variation across U.S. counties in the initial nonfarm industrial composition, which affects the depth of the economic downturn during the Great Depression. Second, we construct a novel instrument for farm mechanization based on the ruggedness of the land. We use data from a number of sources, including the population and agricultural censuses, and we create an individual-level data set that links respondents in the 1930 population census to their records in the 1940 census. As the 1940 census also contains information on each person's location in 1935, this data set allows us to track people's location and farm status over the course of the Great Depression, from 1930 to 1935 to 1940.[3] This data set provides new insights into the patterns of migration during the depression, a topic that has long been of considerable interest.

Our main results are as follows. We begin by confirming the prevailing narrative that the migration to farms is driven at least in part by the crisis in the nonfarm economy. In order to obtain causal impacts of the decline in local-area industrial employment, we construct two instruments,

[1] Jaimovich and Siu (forthcoming) document that the longer-term disappearance of routine jobs in the U.S. economy in recent decades is fully accounted for by the job losses that occur during economic downturns.

[2] We view our study of the sectoral reallocation of workers in the farm sector as complementary to the macro literature examining the relationship between sectoral reallocation and the business cycle. Chodorow-Reich and Wieland (2018) show that sectoral reallocation that takes place during economic downturns leads to higher unemployment in the local labor market, and Jaimovich and Siu (forthcoming) explicitly argue that the loss of routine jobs during recessions helps explain the subsequent jobless recoveries. These results together imply that the process of structural change in the U.S. in recent decades—driven in part by productivity increases in manufacturing and in routine occupations—may have macroeconomic consequences by contributing to a weaker national labor market. This argument is explicitly made by Delli Gatti et al. (2012); regarding the Great Depression, they argue that positive productivity shocks in agriculture and interruptions to the process of sectoral reallocation contributed to the depth and persistence of the downturn. Our empirical results for the depression are consistent with the predictions of their theoretical model.

[3] We also make use of data from the 1935 U.S. Census of Agriculture, which reported county-level statistics on the number of farm residents in 1935 who had previously lived in a nonfarm residence in 1930, providing an additional independent measure of the migration to farms. The data are described in detail in Section 3.

both of which are based on the initial industrial composition in the county in 1930. The first is the percentage of all manufacturing workers in the county in 1930 who are employed in industries classified as producing durable goods, and the second is the Bartik-predicted change in nonfarm employment between 1930 and 1940.[4] We find that people living in areas hit by more negative shocks to their nonfarm industries are more likely to leave their town or city and move to a farm. By examining data on home production, farm labor, and characteristics of the farm areas, we argue that people are moving to farm areas not because there are explicit market-based employment opportunities available there, but because the farmland offers some other means of subsistence.[5]

When we examine the characteristics of the places that people are migrating to, we observe that much of the movement is to less-productive farm areas.[6] This variance in the rate of migration across counties reflects differing levels of modern production technology within the agricultural sector. We interpret this result as evidence that farm mechanization reduces the ability of the land to provide a direct means of basic subsistence, a potentially important source of informal insurance. While the average productivity of labor in mechanized areas is high, the *marginal* productivity appears quite low, with the "surplus" labor being driven towards the subsistence economy. Our empirical strategy relies on spatial variation in agricultural endowments that affect the suitability of the land for modernized production. We show how land topography—specifically the average slope, or *ruggedness*, of the land—influences the suitability for large-scale mechanized agriculture. Farm areas with smoother, less-rugged land have higher land values and more capital-intensive production. These farm areas, however, are far less likely to attract in-migrants compared to their more rugged (and less mechanized) counterparts. While the ruggedness of the land makes it less amenable to modernization in agriculture, it also preserves the ability of these lands to provide a means of subsistence during the downturn.[7] This insurance function appears to be quite

[4]Romer (1990) has shown that the national consumption decline in durable goods was much greater than for nondurables, and our results confirm that higher employment in durable industries translates into much larger job losses at the county level. On this topic, see also Rosenbloom and Sundstrom (1999) and Bernstein (1987). The Bartik-predicted change in county-level employment is obtained by weighting the national-level change in each nonfarm industrial sector by the initial county-level employment shares in those sectors (Bartik, 1991; Blanchard and Katz, 1992). See Section 4.1.

[5]For example, this subsistence value could include shelter, the ability to grow your own food, or informal risk-sharing via family networks.

[6]This is true across a variety of measures: people are moving to places with lower land values, lower values of farm equipment, lower measures of crop suitability, and lower levels of output per farm resident. See Appendix Table A1.

[7]One potential mechanism operates through the interaction between land endowments and the institutions of ownership and control over the land. Increasing the suitability for commercial agricultural production may also increase the incentive to restrict access to others. Because of the large decline in agricultural prices during the crisis,

valuable, especially during the worst years of the crisis, which occurred prior to the provision of New Deal relief programs. Since mechanization in agriculture reduces access to informal insurance, one important policy implication is that as the economy modernizes there may be a greater need for alternative insurance mechanisms like state-sponsored social insurance. These findings are consistent with the literature suggesting that exposure to markets and new technologies affects social relations and can erode traditional forms of social protection (Polanyi 1944; Scott 1977).[8]

Our paper contributes to a number of existing literatures, including the large literature on informal insurance and individual and household coping strategies in response to economic shocks. Klasen and Woolard (2009) look at changes in the dynamics of household formation in response to high unemployment in South Africa. In the U.S., Wiemers (2014) examines how individuals use shared living arrangements with family and friends to cope with job loss, and Kaplan (2010) finds that the option to delay leaving home or to move back in with parents serves as an important source of insurance for the young. Yagan (2014) finds large migration responses to labor market shocks.[9] In our case we observe a large movement into the subsistence farm sector and away from the market-based (farm and nonfarm) sectors.[10]

Our results also add to the literature examining the relationship between the agricultural sector and the Great Depression. Some early analyses of the causes of the Great Depression focused heavily on the shock to agricultural prices (Ohlin 1931). More recently, Madsen (2001) argues that the agricultural price decline contributed to the international transmission of the depression, and Hausman et al. (forthcoming) show that much of the U.S. recovery in 1933 was attributable to

additional agricultural workers have a low marginal revenue product, giving owners little (pecuniary) incentive to accept in-migrants. This remains true even though the non-market value of farming the land—in terms of utility to the migrants themselves—might be high.

[8]See, for example, Scott (1977, p. 199): "In the course of its development a commercialized economy tends both to strip away traditional structures of protection that characterized the earlier society and to create a floating labor force that is wholly dependent on the cash nexus. So long as the price of rice rose and the market for labor remained buoyant, the erosion of these traditional securities might occasion little alarm.... But when a crisis strikes there are fewer retreats for this population."

[9]Gröger and Zylberberg (2016) examine migration patterns among rural households in response to a typhoon in Vietnam and find that households cope by moving to urban areas. We see something of the converse: urban households hit by the downturn cope by moving to rural areas. Rural households also face shocks in our sample, but because of the broader economic downturn, the option of moving to urban areas is less available; instead there is substantial migration within the rural sector. See Gröger and Zylberberg (2016) and the references therein for a thorough discussion of the literature on household coping strategies in the face of aggregate shocks.

[10]Li (2009) discusses the rural migration during the East Asian crisis of the late 1990s, and she draws attention to the tension between inequality in access to land for the poor and the promotion of modernization in agricultural production. Our data from the historical U.S. reveal this same tension. While much of the existing literature focuses on this inequality as a source of political conflict, our focus here is on the economic consequences and what they tell us about how markets function.

the rise in agricultural prices after leaving the gold standard.[11] Using the case of agriculture in the Great Depression as their guiding example, Delli Gatti et al. (2012) argue that the long-run process of structural transformation can contribute to deep and prolonged economic contractions as a result of barriers to labor mobility across sectors. Our contribution to this literature is twofold. First, we offer evidence of the displacement of agricultural workers as a result of improved productivity on farms, and we show that many of these workers were driven into "non-employment," by which we mean non-(market-based)-employment. Second, we highlight the heterogeneity within the agricultural sector, in the sense that the subsistence agricultural sector should be viewed as significantly distinct from the market-based commercial sector. While a naive reading of the agricultural population data might suggest a relative resurgence of "agriculture" during the depression, we demonstrate how the increase in the agricultural population is in fact consistent with a large *negative* shock to that sector.[12]

Much of the existing literature on the Great Depression studies the New Deal period beginning after the dramatic downturn; indeed, a number of these papers exploit spatial differences in the intensity of New Deal fund disbursements as a source of identifying variation.[13,14] In contrast, our paper examines the movement to farms during the economic crisis, most of which occurred during the initial downturn and prior to the introduction of New Deal policies. An important prerequisite for interpreting the findings discussed in earlier papers is to understand how the enormous shock

[11] Also see Temin and Wigmore (1990) and Rothermund (2002), and for a skeptical view, Federico (2005).

[12] That is, in the aggregate data, the flight to subsistence masks the distress in the market-based agricultural economy. Delli Gatti et al. (2012) also draw explicit comparisons between the decline of agricultural employment in the U.S. economy in the 1920s and 1930s and the much more recent decline in manufacturing employment. Our results suggest that comparisons between agriculture in the depression and the manufacturing sector today should focus explicitly on market-based agriculture.

[13] While the wealth of literature on the Great Depression is vast and impossible to survey here, there are several papers focused on migration that are especially relevant. Boustan et al. (2010) note that home economy shocks resulted in out-migration. Using variation in New Deal program generosity and weather shocks, they study the effect of migration on local labor markets. Fishback et al. (2006) document a positive in-migration response to New Deal public works and relief grant spending. On the other hand, they find that payments made to farmers under the Agricultural Adjustment Act (to reduce production) were associated with out-migration on net. On the effects of the AAA, see also Depew et al. (2013) and Alston (1981). Long and Siu (2016) study the migration patterns of people displaced by the dust bowl of the 1930s. Like us, they match between the 1930 and 1940 census to examine individual migration during the depression years. But their study is focused on migration in response to a particular shock (the dust bowl), while our paper examines migration patterns in response to the downturn more generally, as well as the relationship to farm technology.

[14] There are also a number of papers examining the growth and diffusion of tractors in the first half of the twentieth century. Sorensen et al. (2008) study the effects of New Deal programs on tractor adoption in the 1930s. They document an increase in the share of farms owning tractors between 1930 and 1940, from 16.8 percent to 32.4 percent. Lafortune et al. (2013) look at the interaction between migration flows and technological change. They study the effect of immigration flows (and hence, access to labor) on technological choice, organizational form, and output between 1910 and 1940 using data from the Census of Agriculture.

of the downturn affected the distribution of population going into the New Deal. In particular, two implications follow from our results. First, we demonstrate that there were systematic migration patterns occurring between the population censuses of 1930 and 1940, some but not all of which were reversed by 1940. See for example Figure 2, which shows the dramatic rise and fall in the farm population, all of which occurred between 1930 and 1940. This means that we do not have great measures of local population levels *within* the 1930s, and simply interpolating between the census years is unlikely to provide an accurate measure. Second, because of the nature of this migration—much of which looks like "surplus labor" in search of subsistence—special care must be taken when using spatial variation across local labor markets to test the effects of policies or study macroeconomic outcomes. We show how unemployment is higher in areas with a greater "subsistence value," at least in part because unemployed people are moving there, and thus the local unemployment figures do not necessarily reflect the macroeconomic performance of the local economy.

The remainder of the paper proceeds as follows. The next section provides a brief discussion of the historical background (Section 2). We follow with a description of our data (Section 3) and empirical specifications (Section 4), and then we discuss our main empirical results (Section 5). Section 6 concludes.

2 Agriculture and the Structural Transformation of the U.S. Economy: Historical Background

The settlement of America's West was completed by the turn of the 20th century. The closing of the frontier meant that the U.S. could no longer rely on westward expansion to increase agricultural production or to absorb a growing farm population. Nevertheless, the early 20th century saw continued increases in the farm population and in the amount of land under cultivation, as farmers increased acreage by expanding onto marginal lands. By around 1916, however, the farm population reached its peak; it then declined throughout the 1920s, as higher birth rates in farm areas no longer kept up with the increasing rates of farm-to-city migration. The country continued to urbanize,

and the farm sector continued to modernize.[15]

2.1 World War I and the "farm depression"

One of the factors influencing these changes was World War I and its effects on agricultural prices. The war caused an increase in demand for U.S. agricultural exports and a big increase in the prices farmers received for their crops. However, the end of the war brought a dramatic decline in agricultural prices. The commodity boom during the war coincided with a boom in land values and mortgage debt (Rajan and Ramcharan 2012), but after the war, the agricultural sector went through a period of extreme distress—the so-called "farm depression" of the 1920s. Earlier concerns about the ability of agricultural production to keep up with a growing population (the "food problem") shifted instead towards concerns about the shock to farm incomes and the falling farm population (the "farm problem"; see Baker 1929 and Gray and Baker 1930). In addition to a decline in farm incomes, this decade witnessed large numbers of farm foreclosures and rural bank failures.[16] Altschul and Strauss (1937, p. 2-3) attribute what they call the "long run depression" in agriculture during the 1920s and 1930s to an "accelerated expansion in agricultural production" combined with the "low elasticity of demand for agricultural products."[17] While several factors may have contributed to the farm depression, Altschul and Strauss (1937, p. 2) argue that "one feature stands out from the rest, namely, rapid mechanization and its consequences."

2.2 Farm mechanization

The process of modernization and mechanization in U.S. agriculture had been going on for some time—notably including the introduction and widespread adoption of the reaper in the 19th century. But the 1920s witnessed the rapid expansion of several important agricultural technologies, including the motorized tractor, the automobile, the combined harvester-thresher (or combine), and the corn picker (Gardner 2006). These innovations helped to increase the amount of land that a single worker could cultivate, and they reduced the need for horses and mules as sources of power.

[15] This modernization in agriculture was characterized by an expansion over time in the fraction of acreage in large farms, the use of farm machinery, crop specialization, and commercially-oriented production (Pettet 1942; Olmstead and Rhode 2001; Dimitri et al. 2005).

[16] Alston (1983) investigates the farm foreclosures during the 1920s and 1930s and finds a positive association between farm foreclosures and elevated levels of "mortgage debt, depressed farm earnings, and ex post excessive expansion during the World War I agricultural boom," though the latter is not significant in the 1930s.

[17] These same features are key characteristics of the model developed by Delli Gatti et al. (2012).

As a result, mechanization also served to increase the available farmland: as tractors replaced mules and horses, land that had previously been used for pasture and feed crops was freed up for other uses.[18] By 1930 there were nearly 1 million tractors and another 1 million motor trucks on farms, the vast majority of which were adopted in the previous 10 years. This rapid adoption and its impacts on horses and mules is shown in Figure 3.

The effect of mechanization was not uniform across the country, however; it varied by geographic area and by crop. Altschul and Strauss (1937) note that mechanization initially had the greatest impact on wheat production. Even within crops, there was important geographic variation in physical and climatic characteristics affecting the suitability for adoption of different agricultural technologies. The Great Plains region was the most amenable to mechanization due to such characteristics as "wide extremes of temperature, low rainfall, high winds, a loose loam soil, and comparatively large stretches of level land" (USDA 1932, p. 417)—with sloped land being relatively unsuitable for tractor use. A decade earlier, Baker (1921) had noticed that "[t]he invention and extensive use in the United States of farm machinery, which is constantly becoming more efficient and essential to profitable crop production, has greatly increased the influence of topography in determining the utilization of land"; that is, hilly regions were "poorly adapted to the use of modern farm machinery." More recently, Sorensen et al. (2008) find that the spread of farm tractors in the 1930s was related to a number of soil characteristics as well as the ruggedness of the terrain. We investigate the relationship between farm mechanization and land topography in more detail in Section 4.2.

2.3 The Great Depression

As shown in Figure 2, this process of structural transformation was associated with a decline in the U.S. farm population. During the 1920s, the farm population fell from 32 million at the start of the decade to 30.5 million by 1927, as the growing nonfarm sector absorbed many of the workers no longer needed on farms. With the onset of the Great Depression, however, there was a remarkable reversal. Despite a dramatic fall in farm prices, the farm population *increased* by two million people between 1930 and 1933, reaching a level above that at the start of the 1920s. A decade of

[18] Citing data from O.E. Baker, Altschul and Strauss (1937, p. 31) estimate the displacement of horses and mules on farms between 1915 and 1939 resulting from the introduction of the automobile and tractor freed up about 10% of total cropland and pastureland for other uses (corresponding to about 30 million acres of cropland and 31 million acres of pastureland).

structural transformation was undone in a three-year period. This population growth was a result of an increase in migration to farms from towns and cities, as well as a sudden stop in the flow of migrants from farms to cities. Thus, it is not just that farm population was increasing due to differentially higher rates of fertility; the years 1931-33 were a period when the net flow to farms was positive.[19]

Economists writing at the time, such as Galbraith and Black (1938), noted this reversal of urbanization as well as an increase in the production of agricultural goods for own consumption.[20] During the "great slide" (Chandler 1970) or "great contraction" (Friedman and Schwartz 1965), which lasted from 1929 to 1933, the federal government was reluctant to provide relief to the unemployed, and the relief funds from state and local governments were inadequate for a crisis of such magnitude. Many people instead relied on what Chandler (1970) termed *invisible relief*: "help not from government or organized charity, but from relatives, friends, neighbors, and others" (p. 51-52). Families "huddled" together and shared resources (p. 52). Private charities helped some people meet their needs through extra-market means, by organizing "give-a-job" campaigns, community gardens, and "arrangements through which the unemployed could barter their services among themselves and for products of nearby farms" (p. 47). The increasing turn towards home production among farm residents, as well as the movement of nonfarm residents to farms, were part of this broader reliance on informal strategies to survive the crisis.

[19] See Appendix Figure A1.

[20] Galbraith and Black (1938, p. 311) write, "It is a matter of common observation that the last depression caused many farmers to increase their reliance upon their own foodstuffs. And the farm population increases more rapidly than usual at such times because of a checking or reversing of the farm-to-city migration." This reverse migration became the subject of commentary by politicians and popular authors at the time, with some advocating for policies to help facilitate such moves. In 1931, Franklin Delano Roosevelt, then Governor of New York, gave a radio address in which he asked, "Is it worthwhile for us to make a definite effort to get people in large numbers to move out of cities...? It seems to me that to that question we must answer an emphatic YES" (as quoted in Garraty 1987, p. 199). This goal of resettlement of urban workers into rural areas was not limited to the United States (Garraty 1987, p. 122). Brazil removed 40,000 from cities to rural districts in 1930, a similar commission followed in Argentina in 1932. From 1935, France, whose depression started later, began subsidizing rural return. The Canadian government's response to depression included a back-to-the-farm program (Bowen 1999). The themes around reverse migration are also documented in the literature of the time (Conn 2009). Ralph Bosordi's book, *Flight from the City* (1933) included how-to chapters on "Domestic Production," "The Loom and the Sewing-machine," and "Water, Hot Water, and Waste Water." Other writers approached these topics through fiction. The Pulitzer Prize-winning novel *Now in November* (1934), by Josephine Winslow Johnson, tells of a family's return to the countryside following layoffs at a lumber mill.

3 Data

3.1 County-level data

Our main sources of data at the county level are the U.S. Population Census and the Census of Agriculture. These data were digitized by Haines and ICPSR (2010) and by Haines et al. (2018) and made available on the ICPSR website. We also make use of county-level information on employment, sales, and wages in the retail, wholesale, and manufacturing sectors, originally collected as part of the censuses of manufacturing and distribution, and made available by Price Fishback.[21]

In all, we have information on county-level population every ten years from the decennial census of population for the years 1860 to 1940. We know the population on farms for certain years in which there was an agricultural census, including the decennial census years between 1900-1940, as well as for 1925 and 1935. The agricultural censuses also include information on crop production, land values and farm equipment values. While we do not have county-level information on agricultural wages or total persons employed in agriculture, we do have some information on farm labor, including cash expenditure on farm labor (for the years 1910, 1920, 1925 and 1930) and number of hired workers (for 1935). We also know the value of farm garden vegetables grown for home use (in 1930 and 1935), which we use as a measure of home production. In addition to data on total population and farm population at the county level, we also have a direct measure of the movement to farms from towns and cities. The 1935 agricultural census reported county-level statistics on the number of farm residents in 1935 who had previously lived in a nonfarm residence in 1930, as well as the number of farms reporting at least one such migrant.

Our main independent variable is a measure of terrain ruggedness from the Digital General Soil Map of the United States, also known as STATSGO2, which contains information on soil characteristics as well as topography derived from a combination of detailed soil survey maps, topographic maps, and remote sensing satellite imagery (USDA Soil Survey Staff 2016).[22] We utilize the information on the average slope or gradient of the land (in degrees). We combine the spatially-referenced slope information for the contiguous U.S. with a map of 1930 county boundaries

[21] The original data sources are described in detail in the appendix to Fishback et al. (2011). The data can be downloaded from https://econ.arizona.edu/weather-demography-economy-and-new-deal-county-level-1930-1940.

[22] This is (an updated version of) the same data source used by Sorensen et al. (2008) in their study of tractor diffusion. The correlation between our county-level slope measure and theirs is 0.95, and our findings are robust to using their slope measure.

from the NHGIS project (Manson et al. 2018) and compute the spatially-weighted average slope for each county. Figure 4 displays a map of the slope values for each county.

Finally, we also use the IPUMS individual-level samples from the 1930 and 1940 population censuses in order to construct county-level characteristics that are unavailable in the county-level files, including measures of the shock to nonfarm employment based on industrial composition.

3.2 Individual-level linked census data

To study migration patterns we also make use of individual-level data from the U.S. population censuses of 1930 and 1940. In order to construct a panel data set with information on individuals in 1930 and 1940, we link people between these two census waves. Because the 1940 census includes information on location and farm status in 1935, this linked sample provides information on location and farm status for the years 1930, 1935, and 1940, allowing us to follow individuals over the course of the Great Depression.

The 1930 data set is a 5% sample of the total population and is made available by IPUMS (Ruggles et al. 2018). These data contain information on age, gender, geographic location, place of birth, and farm status, among other characteristics. The data set also has the individual's first and last names, which were originally written on the census manuscript schedules by the enumerators and then (much more recently) transcribed by IPUMS.

For the 1940 census, we use the complete count 100% data set (digitized by Ancestry.com and IPUMS and deposited at the NBER). These data contain much of the same type of information as the 1930 sample, including names, age, location, place of birth, and farm status. The 1940 data also contain information on the person's income, occupation, and employment status, as well as information on where the person lived in 1935, including state, county, and farm status. Since the 1930 data set is only a 5% sample of the population, most people in the 1940 data set will not be present in the 1930 sample.

Unfortunately these data lack unique identifiers that would allow one to easily match individuals between the 1930 and 1940 data sets (social security numbers, for example). Instead, we need to match individuals based on the characteristics contained in the data. To do this, we use first and last names, age, and state of birth. We only include males in the sample, since women are much more likely to change their names (upon marriage), so we are implicitly matching on gender as well.

We do not use a person's current location to find a match, since we are interested in migration patterns and doing so would cause the linked sample to contain a disproportionate number of people who do not migrate. We avoid using race, as well, since people may report different races in different years. Other possible variables to match on include mother's and father's birthplace, but unfortunately in 1940 these questions were only included in the long form questionnaires, so the information is only available for 1% of respondents.

We use a linked sample where individuals are matched on exact place of birth, exact first and last names, and year of birth within a +/-3 year band. First, for the 1930 sample, we drop any duplicate observations, meaning any individuals who share the same names, place of birth, and age. Then, after matching the remaining 1930 observations with potential matches from 1940, we drop any individuals who match with more than one record from 1940. This leaves us with a sample of unique matches only.

We use this conservative matching procedure in order to minimize false positives. One cost is that we are unable to assign matches to the vast majority of individuals. Our final linked data set represents only 18% of the males in the 1930 IPUMS data set; however, because the data sets are large to begin with, our linked sample is still quite large, containing over 550,000 people. In the linked sample, the fraction of the population living on farms increases from 24.9% in 1930 to 26.3% in 1935, and then drops back to 22.3% in 1940; these values are very close to the corresponding statistics using the full 1930 and 1940 (unlinked) data sets. This increase in the farm population mid-decade is consistent with the migration patterns discussed above.[23] (Descriptive statistics for the linked sample, as well as for the subset of people living on farms in 1930, are shown in Appendix Table A2.)

[23] We also compute statistics for the fraction of people who change their county of residence, reported in the table as "% migrate". Recall that the 1940 census includes both 1935 as well as 1940 location, so the migration status between 1935 and 1940 does not rely on the linking procedure, while the 1930-35 and 1930-40 variables do. Any incorrect matches (false positives) produced by the linking procedure are very likely to show up as migrants in the sample, since the falsely linked records will often be located in another county. These errors would inflate the migration statistics shown in the table. 33.1% of people are recorded as changing counties between 1930 and 1935, while only 11.9% report changing counties between 1935 and 1940. Some of this difference could indeed reflect higher rates of migration during the first half of the decade, but much of it is likely due to matching errors. (If we were to assume that the true migration rates aren't much different between the two time periods, that would suggest that the false positive rate for the matching procedure is on the order of 20%.)

3.3 Individual-level vs. county-level data

We make use of individual-level as well as aggregate population and migration data because each type presents its own advantages and disadvantages. The aggregate data allow us to track county-level population changes but only a single explicit measure of migration—from cities to farms—whereas the individual-level data allow us to track migration patterns in much more detail. On the other hand, the linking procedure used to construct the individual-level data is not perfect. It introduces measurement error (via false links), which could affect the internal validity of our estimates. It also completely excludes women, and it is more likely to include people with unusual names or people born in smaller states, all of which could affect external validity.

In addition, note that we have measures of migration to farms from two completely different original sources—the individual-level data come from the decennial censuses, while the county-level measure comes from the 1935 Census of Agriculture. In general we find consistent results using both measures, which enhances confidence about the quality of the underlying data sets.

4 Empirical Strategy

This section details our main empirical specifications. First we examine the effect of the negative shock to nonfarm employment on population and migration, with a particular focus on the movement out of towns and cities and onto farms. Then we examine the relationship between rural migration and the suitability of the land for mechanized farm production.

4.1 The shock to industry

In order to study the causal impact of the decline in nonfarm employment opportunities on migration outcomes, we need to isolate exogenous variation in the change in nonfarm employment.[24] We construct two instruments for the size of the nonfarm shock and show that they are strongly related to the local decline in manufacturing employment.[25] Our first instrument exploits the fact that

[24] One possibility might be to look at the impact of the change in local manufacturing employment, since manufacturing industries are more likely than the retail or wholesale sectors to be producing tradable goods, and thus less likely to be influenced by local demand. However it is still possible that the employment change in manufacturing is influenced by local economic conditions.

[25] Appendix Figure A2 displays the distribution of county-level changes in log manufacturing employment between 1929 and 1933. While virtually all counties witnessed a decline in manufacturing employment during this period, there is substantial variation in the depth of the shock.

the consumption decline for durable manufactured goods was much greater than for nondurable manufactured goods (Romer 1990). Rosenbloom and Sundstrom (1999) have demonstrated how this translated into lower employment growth for regions specialized in the production of durables, a result that we confirm using county-level variation. We take as our instrument the percentage of manufacturing employment in the county that is in durable industries, using the 1930 census 5% IPUMS sample and the IPUMS industry classifications that categorize manufacturing industries into either durable and non-durable. In a county-level "first stage" regression, a one standard deviation increase in the percentage of manufacturing workers producing durable goods is associated with a one-third standard deviation decline in manufacturing employment, with an F statistic on the durables variables greater than 100.[26] In order to examine the impact of the nonfarm shock on migration, we run "reduced form" specifications of the following form, where we regress the county-level migration-related outcome y_c directly on the durables instrument and a set of controls:

$$y_{c,1935} = \delta_d \text{durables}_{c,1930} + \gamma_s + \mathbf{X}_{c,1930}\Lambda_1 + \epsilon_c \tag{1}$$

Here γ_s is a fixed effect for state s containing county c; all of our specifications include state fixed effects, and standard errors are clustered at the state level. The vector $\mathbf{X}_{c,1930}$ contains controls for log total population and log farm population in 1930; it also includes the percentage of all workers in 1930 working in the manufacturing sector, which ensures that we are identifying only off of the *composition* of manufacturing employment (durables versus nondurables), and not the initial size of the manufacturing sector. Our outcome variables include a measure of city-to-farm migration between 1930 and 1935, as well as log farm population in 1935. We will interpret a positive coefficient on the durables variable as evidence that the industrial downturn is responsible for some of the growth in the farm population. We also run similar regressions using individual-level data:

$$y_i = \beta_d \text{durables}_{c,1930} + \gamma_s + \mathbf{X}_i\Lambda_2 + e_i \tag{2}$$

[26] Specifically we regress the county-level change in log manufacturing employment between 1929 and 1933 on the durables instrument, controlling for state fixed effects and county total and farm population in 1930.

where y_i is one of several individual-level migration outcomes, including indicators for whether the person moved from a nonfarm to farm residence between 1930 and 1935, or whether they moved to a different county; and the vector $\mathbf{X}_i$ includes controls for age, age-squared, and the percent of workers employed in manufacturing in the county.

As an additional instrument, we construct the Bartik-predicted change in county-level employment, or the "Bartik shock" (after Bartik 1991). Using data from the 1930 and 1940 IPUMS samples, we determine the percentage change in aggregate national employment in each of the available industrial classifications. Using the 1930 IPUMS sample, for each county we determine the share of total county-level nonfarm employment in each industry. Then, we weight the national-level employment growth in each industry by the county-level employment shares, and this gives us the predicted employment change between 1930 and 1940. The Bartik shock has the advantage that it is constructed using data from all nonfarm sectors, unlike the durables instrument (which is based on manufacturing employment only).[27] However, a disadvantage is that the Bartik shock is constructed using the change in employment over the entire decade, even though we are most interested in the shock during the early crisis years. For this reason, the durables instrument may provide a stronger prediction of the depth of the initial downturn. The specifications using the Bartik instrument are analogous to those shown above. Because the Bartik shock is a measure of predicted employment growth, here we expect to see a negative relationship with our measures of city-to-farm migration.

We also show instrumental variables specifications where we instrument the county-level change in log manufacturing employment between 1929 and 1933 with the durables instrument. Doing so reduces the sample size by about one third (because the intercensal manufacturing employment data are not available for all counties), but it helps with interpreting the magnitude of the effect. For the Bartik instrument, the reduced form interpretation is more clear, and we do not show IV specifications.

[27] When we run the same first stage specification mentioned above—relating the change in manufacturing employment to the Bartik instrument—we find a weaker but still strongly significant relationship. A one standard deviation increase in the Bartik-predicted employment growth 1930-40 is associated with a 0.12 standard deviation increase in manufacturing employment between 1929-33, with an F statistic of 24.

4.2 Agricultural modernization and farm migration

For the second part of our empirical analysis, we study how the characteristics of the local agricultural sector relate to farm in-migration and out-migration. We are concerned in particular with the impact of modern agricultural production technologies. To study this, we develop a novel instrument for the suitability of the land for large-scale mechanized agricultural production: the ruggedness of the terrain, which we measure by the average slope (or gradient) of the land within the county. Table 1 displays the results of a series of first stage regressions, where we examine the impact of ruggedness on several measures of county-level farm mechanization. Across each of these measures, ruggedness is strongly and significantly related to farm mechanization: the more rugged the land, the lower the use of equipment and machinery on farms.[28]

We study the effects of farm mechanization by estimating reduced form specifications of the following form:

$$y_{c,1935} = \delta_r \text{ruggedness}_c + \gamma_s + \mathbf{X}_{c,1930}\Lambda_3 + u_c \tag{3}$$

where y_c is a measure of farm migration in county c (such as the percent of farms in 1935 containing residents who had been living in towns or cities 5 years earlier, or the log county farm population in 1935); γ_s is a state fixed effect; and $\mathbf{X}_c$ contains controls for (at minimum) log population and log farm population in 1930. We also estimate individual-level regressions of the following form:

$$y_i = \beta_r \text{ruggedness}_c + \gamma_s + \mathbf{X}_i\Lambda_4 + \nu_i \tag{4}$$

where y_i is a variable characterizing the migration behavior of individual i, for example indicating whether their status as a farm resident changed between 1930 and 1935, or whether they moved counties in that time period; and $\mathbf{X}_i$ contains controls for age and age-squared.

Some care must be taken in interpreting our results causally. The use of ruggedness as an instrument helps alleviate some endogeneity concerns, especially those related to reverse causality or certain relatively contemporaneous omitted variables. This could include, for example, cases where the level of local economic development influences farm mechanization, or where shocks to

[28] The first stage F statistics are all above 10.

a region influence both tractor adoption and the level of nonfarm economic activity.[29] What our instrument does is allow us to isolate the effects of underlying suitability related to farm production.

At the same time, our instrument does not allow us to identify the causal impact of (for example) one more randomly allocated farm tractor, all else equal. Most importantly, because our measure of ruggedness is time-invariant, it ends up being correlated with a number of baseline characteristics. This is to be expected, since mechanization in U.S. agriculture had been going on for some time (including throughout the 19th and early 20th centuries). In this sense, ruggedness is an instrument for the entire package of characteristics that go along with having farmland suitable for mechanized production—something for which there is no perfect measure. To make this point clear, we report reduced form estimates throughout the paper (as in Equations 3 and 4) where we show the direct impact of ruggedness on migration, as opposed to second-stage instrumental variables estimates. In addition, we show that several key characteristics do not vary substantially by ruggedness, which supports our argument that the observed patterns during the depression are related to the downturn; we also show how the patterns during the depression differ from other time periods. Finally, the fact that rugged areas are initially different is part of what makes the observed migration patterns so interesting. For example, these areas have lower land values and lower agricultural output per person precisely because they are less amenable to mechanized farming, and yet we see large inflows of population to these farms. In Section 5.4 we examine the threats to the validity of our results and interpretation in further detail.

5 Results

5.1 Impacts of nonfarm employment shocks on rural migration

We begin by examining the effects of job losses in the nonfarm sector on rural migration, with a special focus on migration from nonfarm to farm residences. Panel (a) of Table 2 displays the results of a series of county-level regressions. The first column shows the results from a regression of the change in county-level log manufacturing employment (between 1929 and 1933) on the percent of manufacturing workers employed in the durable goods sector, our first instrument for the shock

[29] Suppose that farms that are closer to metropolitan areas have higher levels of mechanization due to better access to capital or product markets; if we see differential outcomes in these areas during the crisis, one should be reluctant to attribute the effects to farm mechanization.

to nonfarm employment. This first stage relationship is strongly significant, with an F statistic (on the instrument) of 120.

Column 2 displays the results of a reduced form specification where we regress a measure of nonfarm-to-farm migration directly on the durables instrument (Equation 1). The outcome variable is the percent of farms in the county in 1935 that contain at least one resident who had been living in a nonfarm location 5 years earlier. A higher percentage of employment in durables (which corresponds to a bigger drop in nonfarm employment during the crisis) leads to a statistically significant increase in the proportion of farms *in that same county* reporting a to-farm migrant. The most likely interpretation of this result is that it represents people who stayed within the same county, but moved onto a farm from a town, city, village, or other nonfarm location. To help interpret the magnitude of this effect, we present an IV specification in column 3, where the change in county-level manufacturing employment is instrumented using the durables percentage. While the coefficient is only marginally significant, the point estimate indicates that 10 percentage points additional growth in manufacturing employment is associated with 0.2 percentage points fewer farms reporting to-farm migrants; this corresponds to one standard-deviation increase in manufacturing employment growth being associated with a 0.14 standard-deviation decline in the share of farms reporting to-farm migrants. Column 4 displays another reduced form specification using our alternative instrument: the Bartik-predicted change in total nonfarm employment. We see no significant relationship between our Bartik instrument and this measure of reverse migration.

In Columns 5 through 7 (Table 2, panel a), we display analogous specifications using a different outcome variable: log farm population in 1935. (Recall that all specifications control for the log farm population in 1930, so the regression characterizes the effects on the change in farm population between 1930 and 1935.) As before we see a positive relationship with the durables instrument (column 5) and a negative relationship with the growth in manufacturing employment (column 6). The IV specification in column 5 suggests that a one-standard-deviation increase in manufacturing employment growth reduces the total farm population in 1935 by about 3%. There is also a strongly significant negative relationship between the Bartik-predicted growth in nonfarm employment and the change in farm population. A 10% increase in nonfarm employment over the decade (equivalent to 1 standard deviation) is associated with a drop in farm population of about 1.5%. The results here are consistent with the explanation that counties facing a larger shock to their nonfarm sector

see higher levels of migration out of their towns and cities and onto their farms; that is, people are moving within the county from nonfarm residences to farms. Employment losses in nonfarm industries appear to serve as a "push" factor driving people out of nonfarm areas.

In panel (b) of Table 2 we confirm these findings using our data set of (male) individuals linked across the population censuses. We construct an indicator variable equal to 1 if the person lived in a nonfarm residence in 1930 and a farm residence in 1935. Columns 1 and 2 restrict the sample to people who lived in nonfarm residences in 1930. An increase of 10 percentage points (about 0.5 standard deviations) in the county-level fraction of manufacturing employment in the durables sector leads to a 0.5 percentage point decline in the likelihood of a nonfarm resident moving to a farm (column 1); a 10 percentage point increase in predicted nonfarm employment growth (about 1.4 standard deviations) reducing the likelihood of moving to a farm by 1.8 percentage points (column 2). Since the data set contains information on the individual's own occupation, we can also test whether there is a relationship to actually working in the durable manufacturing sector. We find that being employed in the durable goods sector increases the likelihood of moving to a farm by 1.4% among all nonfarm workers (column 3) and by the same amount when we restrict to manufacturing workers only (column 4).

An additional advantage of the individual-level data is that we are able to track migration across counties. Column 5 shows that there is no statistically significant relationship between either of our nonfarm instruments and the probability that an individual migrates to another county between 1930 and 1935. We do see a significant positive relationship between the Bartik measure for a county and the likelihood that an individual moves in to that county (column 6). Taken together the results in Table 2 indicate that the bulk of the migration that we see in response to these nonfarm shocks consists of people moving to nearby farm residences rather than long-distance migration. There are several possible explanations for the negative relationship between employment in the nonfarm sector and the growth in the farm population. For example, people could be moving to take jobs in the farm sector, or seeking a place to live, or engaging in subsistence farm production. The following sections attempt to shed further light on the reasons for this migration and the mechanisms involved.

5.2 Agricultural modernization and farm migration

5.2.1 Rugged areas experience greater in-migration to farms

Table 3 shows the relationship between migration to farms and our instrument for agricultural modernization. The top panel displays the results of county-level regressions. There is a negative and statistically significant relationship between the ruggedness of the county and nonfarm-to-farm migration between 1930 and 1935 (column 1). The effect is also large in magnitude: a 10 percentage point increase in the average slope of the county (about 1 standard deviation) reduces the fraction of farms reporting a to-farm migrant by 1.5 percentage points (about 1/5 of a standard deviation). In order to confirm that this result is not being driven by a correlation between ruggedness and the shock to nonfarm employment, in column 2 we add additional controls related to the composition of nonfarm employment; these controls include our two instruments for the size of the nonfarm shock, as well as the proportion of total employment in manufacturing. The coefficient on ruggedness remains strongly significant after including these controls, and drops only slightly in magnitude. Columns 3 and 4 look at the effect of ruggedness on the change in log farm population. There is a large positive effect of ruggedness on the farm population, with a 10 percentage point increase in average slope leading to a 5 percent increase in the farm population during the first half of the 1930s (which represents more than 1/3 of a standard deviation of the growth in farm population during that period).[30]

We also confirm these findings using the individual-level data and display the results in panel (b) of Table 3. County-level ruggedness is strongly associated with the likelihood of a 1930 nonfarm resident migrating to a farm during the crisis (columns 1 and 2). In columns 3 and 4 we examine the likelihood of a 1935 farm resident having previously lived in a nonfarm residence in 1930; we see evidence that people on farms in rugged areas in 1935 are more likely to have migrated there from a nonfarm residence (though the result is not quite statistically significant in column 3).

[30] In Appendix Table A3, we display the results of instrumental variables regressions, where we instrument the percent of farms reporting tractors in 1930 with the average ruggedness of the land. The results are highly significant. We do not interpret this estimate as the direct effect of tractors *per se*, since ruggedness affects agriculture and migration in more ways than simply through the prevalence of motorized tractors. Instead, we interpret tractors as a proxy for mechanized agriculture more generally. The estimated magnitudes are useful for interpreting the effects. The point estimate indicates that a 16 percentage point increase in share of farms with tractors (corresponding to 1 standard deviation) results in a 4.8 percentage point decrease (0.7 standard deviations) in the share of farms reporting in-migrants from cities. The table also shows the results of specifications where we use the total value of farm equipment as a proxy for mechanization, and instrument this using ruggedness. Again the results are strongly significant and indicate a relative decrease in population on mechanized farms.

5.2.2 Rugged areas see less out-migration from farms

In addition to the large-scale migration to farms during this time period, there is also substantial movement within the farm sector. Even though the national farm population is increasing, more than a third of counties nevertheless witness declines in their farm population between 1930 and 1935 (Appendix Figure A3). In this section we examine where people are going—to other farms or to nonfarm residences—and whether this out-migration is related to ruggedness.

Table 4 presents results using an alternative measure of migration: whether an individual changes counties between 1930 and 1935. On average there is no relationship between county-level ruggedness and out-migration (column 1). Disaggregating by farm status, however, we see that farm residents in rugged counties are far less likely to out-migrate during the crisis than farm residents in less-rugged counties (column 2). The point estimate implies that decreasing the ruggedness of the local area by one standard deviation—that is, making the land *more* suitable for large-scale mechanized agriculture—increases the probability of an existing farm resident out-migrating by 2.4%. For nonfarm residents, however, we see no statistically significant relationship between ruggedness and out-migration (column 3). Notably, we also see no relationship between our two shocks to nonfarm employment and the likelihood that a nonfarm resident moves to another county.

Out-migration from farm areas can take multiple forms: people could be moving to nearby towns and cities, or they could be moving to other farm areas. Column 4 of Table 4 indicates that there is no relationship between ruggedness and the likelihood that a farm resident transitions to the nonfarm sector. Thus the higher rates of out-migration from the relatively more suitable farm areas do not reflect higher rates of urbanization. Instead many of these farm residents are out-migrating towards other farm areas.

5.2.3 The impacts are driven by the farm sector, and the 1930s are different

Table 5 presents results from regressing a series of county-level population and employment outcomes on ruggedness and our nonfarm employment measures. In addition to higher rates of in-migration to their farms and a bigger increase in their farm population, rugged areas also see relative increases in their total population over the 1930s, and this increase is driven entirely by increases in the rural population. If anything, these rugged counties actually see a relative decline in their

urban population, though the coefficient is only marginally significant (column 5). Accordingly, rugged counties also see a decline in the percent of the population in urban areas and a rise in the percent on farms. Compared to less rugged areas, these counties are de-urbanizing and becoming more agricultural.

Figure 5 presents additional evidence to support our argument that the impact of ruggedness is operating through the farm channel (and not, say, due to a spurious correlation with some feature of the nonfarm economy). The figure shows how the effect of ruggedness on total county population varies with initial percent of the county population living in urban areas.[31] Rural counties see a strong positive relationship between ruggedness and population growth over the 1930s, but this effect is decreasing as percent urban increases. For those counties with most of their population living in urban areas, the estimated effect of ruggedness is negative and statistically insignificant. This is consistent with the argument that rugged *farm areas* are attracting more in-migrants and expelling fewer out-migrants, and perhaps even that people living in cities in more rugged areas are more easily able to move to farms during the crisis.

The left panel of Figure 5 shows that the same effect is not present during the 1920s: we see no relationship between ruggedness and county-level population growth and no evidence that the impact is larger in rural areas. We also compare the 1930s to earlier time periods by estimating the effect of ruggedness on the change in county-level population for each decade between 1860 and 1940. The point estimates generally indicate that rugged areas experience relative population decline (and at times the estimate is significantly different from zero). The only decade between 1860 and 1940 during which there is a positive and significant relationship between population and ruggedness is the 1930s.[32]

We find similar results when we look at the population on farms. Beginning in 1900 we have data on farm population by county, including every 5 years between 1920 and 1940. In Figure 6 we plot the estimated effect of ruggedness on county-level farm population for a number of time

[31] Specifically we regress county-level log population in 1940 on log population in 1930, county-level ruggedness, the fraction of the county population living in urban areas, and an interaction between ruggedness and percent urban (in addition to state fixed effects). Also see Appendix Figure A4 for a less parametric version of this specification.

[32] These estimates are reported in Appendix Table A4. In Appendix Figure A5 we plot these point estimates against the average annual national GDP growth during the corresponding decade. The figure suggests a negative relationship between the effect of ruggedness on population and the health of the overall economy, though the 1930s stands out as an outlier in both dimensions. We adjust for changes in county boundaries over time by spatial averaging the statistics to conform to 1910 counties and weighting by area; we use the correspondences provided by Hornbeck (2012).

periods between 1900 and 1940. In most periods there is no statistically significant relationship between ruggedness and growth in the farm population; the point estimate is negative in all time periods except for the 1930s (and statistically significant for the period 1910-20). When we examine the effects on farm population in the 1930s, we find a positive and strongly significant impact for the first half of the decade, but no significant relationship for the second half. Taken together these results indicate a substantial change in the relationship between ruggedness and population during the worst years of the depression.

5.3 Mechanisms

The results in Section 5.1 suggest that the migration to farms is motivated at least in part by the loss of employment opportunities in the nonfarm sector; the ability to move to farms is likely serving as a form of migratory insurance. In this section we further investigate the motivation for migration in the farm sector and in particular the reasons why ruggedness seems to matter so much.

One open question concerns whether rugged farm areas are attracting in-migrants because the opportunities for agricultural employment are relatively better in those areas, or whether people are moving there in order to engage in non-market or subsistence-type agriculture. From the agricultural censuses of 1930 and 1935 we have information on the value of garden vegetables produced on farms for own consumption, which we use as a measure of home production. The results in Table 6 indicate that rugged counties experience larger increases in home production of garden vegetables (columns 1 and 2). We also look at the use of family labor on farms (as opposed to hired labor), which spiked as a share of the agricultural labor force with the onset of depression (Appendix Figure A6). Unfortunately there are no county-level data available on the use of family labor in 1930, so we cannot compare the *change* in family labor over this time period. But we do find that the use of family labor on farms in 1935 is relatively higher in rugged areas (columns 3 and 4). For hired farm labor, we have information for both 1930 and 1935, so we can look at the change over time; the result in column 5 indicates that, controlling for total days of farm labor employed in 1930, there is no significant relationship between ruggedness and the number of people hired to work on farms in 1935. These results strongly suggest that the relative increase in farm population in rugged areas is not driven by a greater demand for market-based farm labor; instead

these areas see higher levels of home production and family-based farm production.[33]

Even though we do not observe differential declines in farm labor expenditure between rugged and less-rugged areas, it is still the case that less-rugged places may be more integrated into the formal economy and thus more affected by the negative shock to markets during the depression. In addition to higher levels of mechanization, less-rugged farms are initially larger, employ more hired labor, and produce less output for own consumption. This higher level of market integration means that, even conditional on observable factors like employment and crop mix, the negative shock to agricultural prices during the downturn may have more negative effects on these farms.[34] However, while the less-rugged areas have a comparative disadvantage in small-scale production, there is no reason to believe that the farmland in these areas is somehow less suitable for subsistence production in an absolute sense. Nonetheless we see farm residents out-migrating from less-rugged areas and far lower rates of in-migration, which suggests that institutions of land ownership are playing a role. Farmers and farm workers do not simply remain on their farms and engage in subsistence production; instead they leave. People are moving to rugged areas in greater numbers and engaging in subsistence production because they are more easily able to *access* those lands and more likely to be excluded from higher-productivity areas.

The results in Table 7 provide support for this interpretation. We look at the relationship between land tenancy and farm migration. Tenancy is a pervasive feature of the agricultural labor market at the time. Rather than hire laborers and pay them wages, many landowners rent land to tenants, who pay in cash, or with a share of farm output, or by working on the owner's land. When the crisis hits, areas with a higher prevalence of tenant farms see the lowest levels of to-farm migration and the biggest drops in farm population, as many existing tenants leave (or are forced off) their farms. In contrast, places with many owner-operated farms are more likely to absorb in-migrants (columns 1 and 2) and less likely to see declines in population (columns 3 and 4). We also see a relationship between migration and tenancy at the individual level. Among farms residents in

[33]We also find evidence that places with a higher employment share in durables see relative increases in home production, though the coefficient is only significant in column 1. This result indicates that the shock to market-based work leads people to substitute into home production, which is consistent with the findings of Aguiar et al. (2013) for the contemporary U.S. We also see a significant relationship in column 4 between the durables share and family labor on farms.

[34]In Appendix Table A5 we show that the initial level of farm labor expenditure in 1930 is negatively related to the average slope. We also show that places with higher levels of 1930 farm expenditure see lower rates of nonfarm-to-farm migration and smaller increases in the farm population. In Section 5.4 below we show that crop mix does not explain our findings.

1930, those who own their farm residence are much less likely to move out of their county by 1935 (column 5), and they are also less likely to migrate to a nonfarm residence (column 6). These results suggest that the migration patterns are affected by property rights and the consequent impact on access to the land.

5.4 Threats to validity and alternative interpretations

Since ruggedness is not randomly assigned, an important empirical concern is that our estimates are picking up a correlation between ruggedness and some other feature of the economy separate from the impact of ruggedness on the organization of agricultural production. One potential concern is that ruggedness is correlated with the composition or performance of the nonfarm economy, perhaps because terrain can influence the location of business activity or infrastructure. Above we discussed several results that help alleviate this concern, including the finding that our estimates of the impact of ruggedness are robust to the inclusion of several control variables related to local employment in the nonfarm sector (Tables 3 and 5). In addition, the impact of ruggedness is concentrated in rural counties (Figure 5). A remaining concern, however, is that while the effect of ruggedness may be operating through an agriculture-related channel, it could be one much different from the mechanisms related to agricultural modernization discussed above. We address three such possibilities—related to climate, crop mix, and farm policies—and display the results in Table 8.

The depression years are notable for the extremes of temperature and precipitation faced by much of the country. During our main time period of focus (1930-35), the years 1932-34 were most severely affected. In Table 8 we show that our main results are robust to a number of weather-related controls. Column 1 repeats our baseline estimates from earlier. In column 2 we add a number of control variables for temperature and precipitation, including each of the following variables separately for each of the years 1932 through 1934: the number of days that the high temperature exceeded 90°F; the number of days the high temperature was between 80 and 90; and the number of months of extreme drought, of severe drought, and of moderate drought. Including these 15 variables for temperature and precipitation has very little effect on our estimated ruggedness parameter. In column 3 we include an indicator for whether the county was classified as being impacted by the Dust Bowl in 1934, while the specification in column 4 controls for the

fraction of the county experiencing medium and high levels of erosion.[35] Our estimates are very robust to the inclusion of these weather-related controls.

Because ruggedness affects the suitability for large-scale, commercial, mechanized agriculture, less rugged areas are likely to be more integrated into the market-based agricultural economy. To the extent that ruggedness influences the crop mix, one possibility might be that farms in these areas are specializing in crops that experience larger price declines. The results in columns 5-7 of Table 8 suggest that this explanation is unlikely to fully account for our results. We add to our main county-level specifications a number of variables intended to control for the crop mix and the magnitude of exposure to the price decline.[36] The estimated effect of ruggedness remains highly significant in all specifications and declines in magnitude only slightly. While the mechanized farm areas may be more affected by the negative shock to the agricultural economy, this is not simply a function of the composition of crop production but likely due to their overall level of market integration more broadly.

A final concern relates to the agricultural policies that were implemented in response to the Great Depression. Most importantly, previous research has argued that the Agricultural Adjustment Act (AAA) had an impact on migration patterns (Fishback et al. 2006; Sorensen et al. 2007; Barreca et al. 2011; Depew et al. 2013). There is overlap between our sample period (1930-35) and the implementation of the AAA (passed in 1933), and AAA payments were more likely to be directed to the less rugged areas. Nonetheless we present several pieces of evidence that indicate that our results do not simply reflect the allocation of government spending. First, we show that there is a statistically significant negative relationship between ruggedness and farm out-migration for farm owners as well as tenants (column 5 of in Table 7). The literature on the AAA argues that the policy led to out-migration from farm areas because many farm owners preferred to evict their tenants rather than share the AAA payments. This phenomenon would not explain our results

[35]The weather variables used in columns 2 and 3 are from Fishback et al. (2011), while the erosion measures in column 4 are from Hornbeck (2012).

[36]Our measures of the magnitude of the crop price shock are area-weighted averages based on the average annual growth rate in crop-specific prices between 1928 and 1932 and the county-level area reported in the 1920 agricultural census, following the procedure used by Rajan and Ramcharan (2012). We construct two alternative measures that differ based on the price series and crops covered. The first measure uses international prices provided by Blattman et al. (2007) for seven crops (cotton, wheat, maize, rice, tobacco, small fruits and sugar cane); the second uses U.S. prices from the Historical Statistics of the United States (see Olmstead and Rhode 2006a and Tables Da661-1062) for a larger number of crops (16 in all).

for farm owners.[37] Second, we see a correlation between the overall performance of the national economy and the effects of ruggedness on population (Appendix Figure A5), which is consistent with the argument that the changing nature of the relationship between ruggedness and migration is driven by economic conditions as opposed to idiosyncratic policies of the 1930s. Third, national-level estimates of migration indicate that much of the movement to farms from towns and cities occurred during the earliest and deepest years of the crisis, before falling off substantially after 1933, when the recovery and the New Deal began (Appendix Figure A1). Finally, we include the total county-level AAA payments as a covariate in our regressions and display the results in column 8 of Table 8. We continue to see a very strong relationship between ruggedness and our migration outcomes, albeit with a substantial decline in magnitude in panel (b).

5.5 Local labor markets and 'surplus labor'

The results above point to a substantial impact of ruggedness on migration flows: rugged areas witness gains in population, driven by gains in the farm areas as a result of higher rates of in-migration and lower rates of out-migration. Given the magnitude of these migration flows, it is possible that there were subsequent impacts on local labor markets. In this section we investigate the relationship between ruggedness and county-level labor market outcomes and consider whether the findings are consistent with the analysis so far. We look at changes in local area unemployment as well as sales, employment, and wages in the retail, wholesale, and manufacturing sectors.

Across a variety of specifications we see labor markets indicators suggesting that rugged counties perform more poorly during the depression, despite serving as a sink for migration. While there is initially no relationship between ruggedness and county-level unemployment in 1930, we find a strong relationship by 1937: rugged areas have significantly *higher* levels of unemployment.[38] We find similar results when we examine performance in the nonfarm sectors. Because of the economic crisis, employment and output were falling almost everywhere. But these declines were even larger in more rugged areas, which saw greater declines in aggregate employment in the retail and wholesale sectors, as well as a greater decline in aggregate sales in the wholesale sector.[39]

[37] It is also not the case that our results are driven by farm owners using AAA payments to finance their own move out of agriculture, since we show in column 6 of Table 7 that ruggedness has no impact on the propensity to move to a nonfarm residence—for either tenants or owners.

[38] These results are displayed in Appendix Table A6.

[39] These results are displayed in Appendix Table A7.

This is despite the fact that these areas experience relative population growth and greater rates of in-migration. At the same time we find no relationship between ruggedness and performance in the manufacturing sector (which is arguably less dependent on local demand).

These results are consistent with the idea that rugged areas have greater ease of access to the informal migratory insurance provided by available farmland; nonfarm residents in these areas, as well as newly arriving in-migrants, are more likely to engage in subsistence production and thus less likely to engage in market-based consumption or employment.[40] The higher levels of unemployment reflect the fact that unemployed people are choosing to locate in these areas for non-market (subsistence) purposes. In addition to providing a way for people to survive the downturn, the farm sector may be absorbing "surplus labor" (Lewis 1954), especially in the rugged areas where there is easier access to available land.[41]

6 Concluding Remarks

The relationship between technological change and labor markets has received substantial attention in the academic literature as well as the popular press, but nothing close to a consensus has been reached. There is little question that labor-saving technological change can reduce employment within a particular industry or sector. The relevant debate concerns whether this effect is large enough to have aggregate impacts on wages or employment. Authors who are skeptical that there have been (or will soon be) large negative effects of technology on wages or employment often point out that anxiety over this issue is nothing new. They may even point to the experience of U.S. agriculture as a reassuring example.[42] Indeed the introduction of machinery on farms contributed to a massive shift in the composition of the U.S. workforce over the 20th century as millions of people transitioned out of agriculture and into the nonfarm sector. Much of this reallocation occurred during the remarkable postwar boom, suggesting that the economy is capable of accommodating a substantial amount of sectoral change while maintaining rapid growth in employment and wages.

[40] The results are also reassuring in that they provide further evidence that the migration flows to rugged areas are not driven by economic performance in the nonfarm sectors.

[41] See Schultz (1945, ch. 4) for a discussion of "excess labor in agriculture" during the interwar period.

[42] See for example Mishel and Bivens (2017) who point out that the technology-induced "increase in the demand for other goods and services will create jobs to generate those additional goods and services. Where these jobs will appear is unknowable, but history affirms that they do show up. The easiest illustration is what happened to agriculture." And a report from the McKinsey Global Institute points to the rapid decline in the U.S. agricultural employment share and concludes that "the historical record is largely reassuring" (Manyika et al. 2017, p. 4).

But the structural transformation out of agriculture did not begin in 1945. The farm population reached its peak as early as World War I, and the large-scale adoption of motorized tractors began around the same time. In contrast to the postwar experience, evidence from the earlier interwar period is far less reassuring: the first two decades of the "tractorization" of American agriculture coincide with a period of distress for the farm sector. When the entire economy is struck by depression in 1929, we see the mechanized agricultural sector shed workers. Many of those workers are not successfully transitioning into the nonfarm economy; instead they are reallocating into a form of non-employment: subsistence agriculture. Comparing our findings from the Great Depression to the generally more positive experience of the postwar agricultural economy, we might conclude the following: sectors experiencing structural declines in employment will lose jobs in good times and bad, but the state of the macroeconomy influences how quickly and successfully those workers transition into other sectors.

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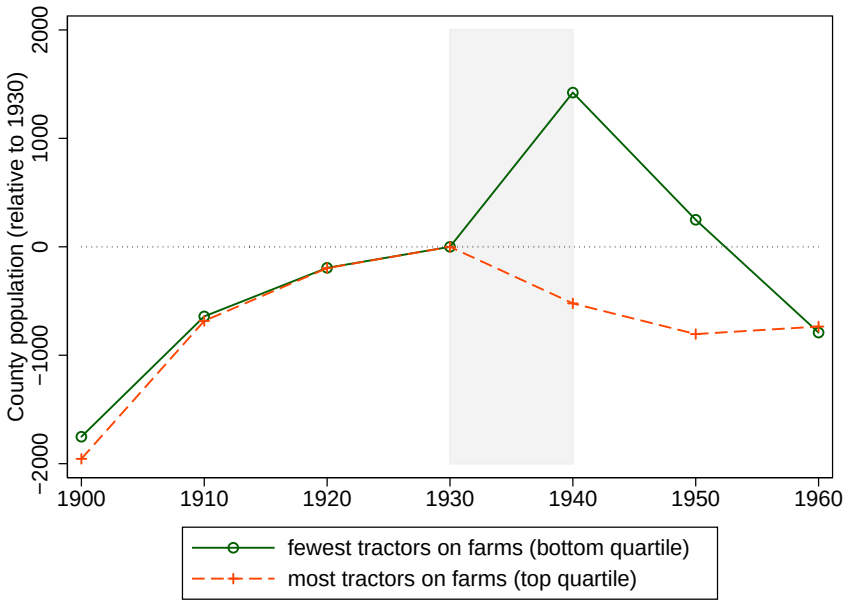
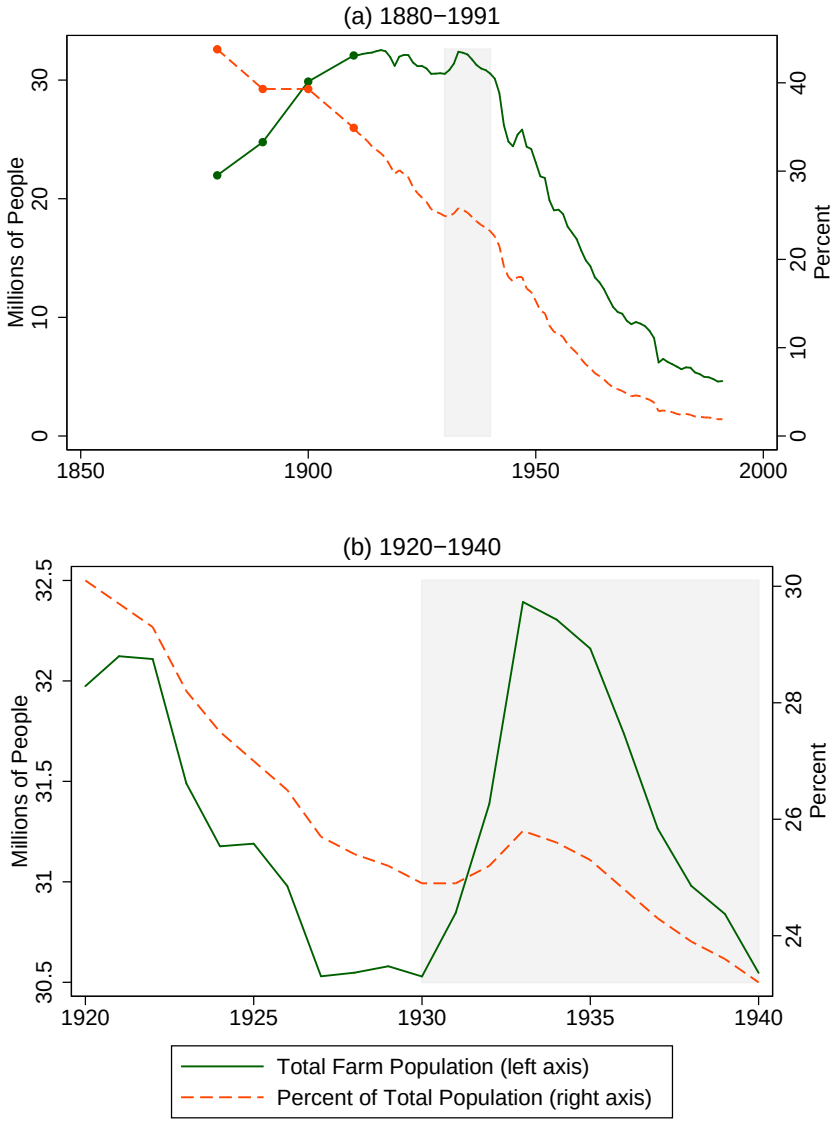
Figure 1: Average county-level population by least- and most-tractor-intensive farm areas



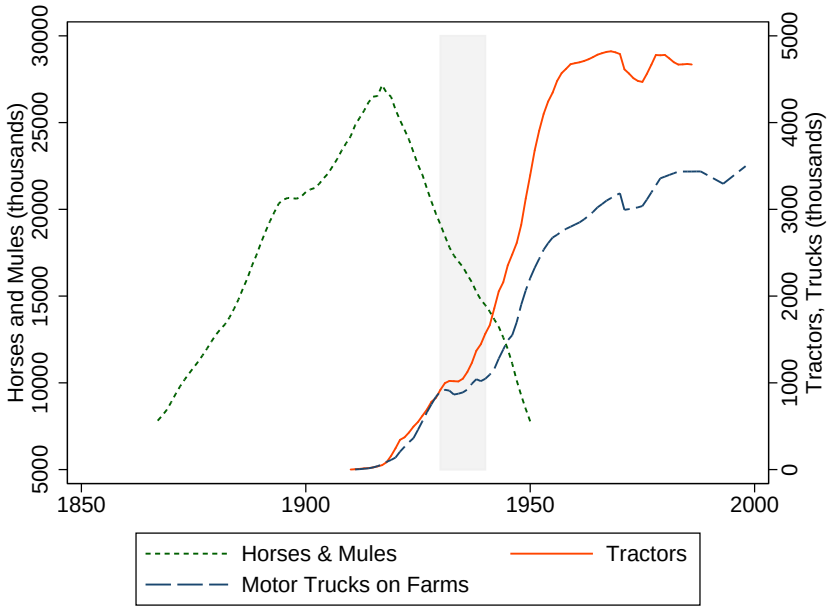
Notes: "Top quartile" represents the 25% of rural counties with the highest percentage of farms reporting tractors in 1930; "bottom quartile" represents the corresponding least-tractor-intensive counties. Average county-level population for each group is plotted relative to the value in 1930 (by subtracting the 1930 level). The sample is limited to only those counties reporting no population residing in urban areas in 1930. To get a consistent series over time, counties are adjusted to 1910 county boundaries using area weights. The shaded region indicates the period 1930-1940, our main period of interest.

Figure 2: U.S. farm population over time



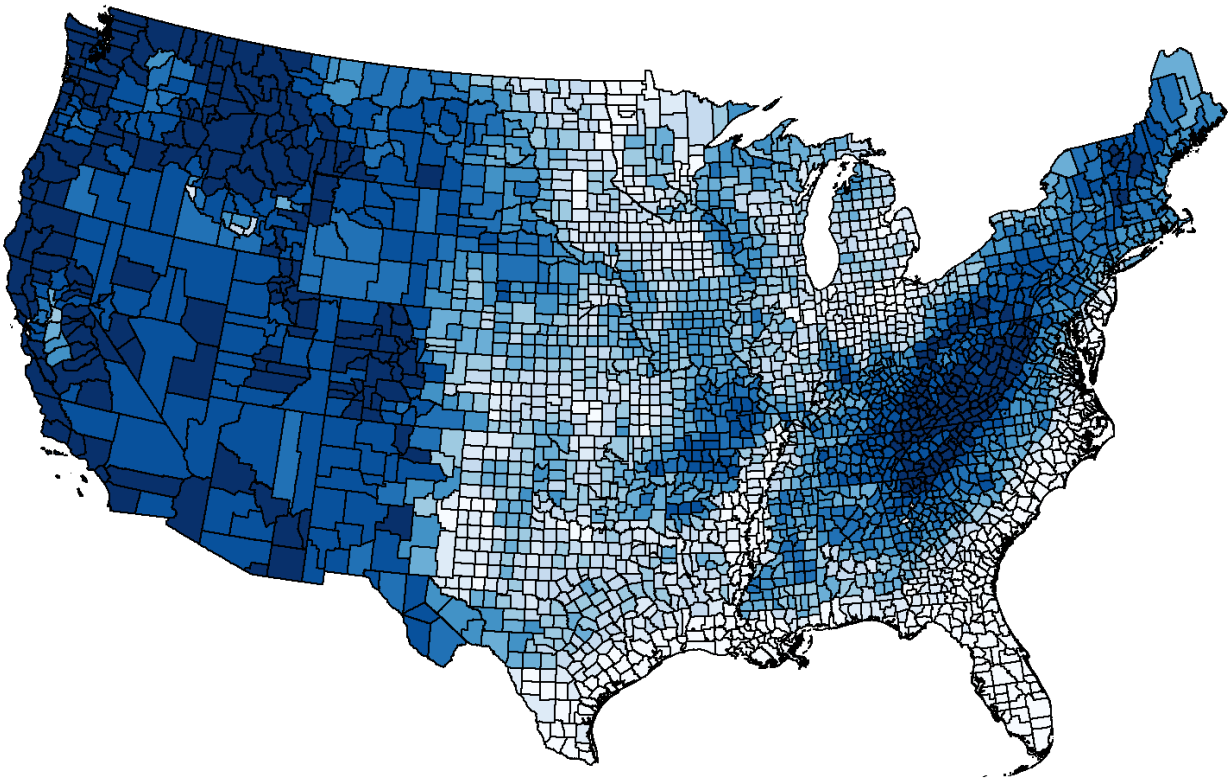
Notes: The figures display the total U.S. farm population over time, and the farm population as a share of total population. Data are available for 1880, 1890, and 1900, and then for each year beginning in 1910. Panel (b) restricts the series to the years 1920-1940. The shaded region indicates the period 1930-1940. The farm population reached its peak level in 1916. *Source:* Series Da1, Da2, Da14, and Da15 from Olmstead and Rhode (2006b).

Figure 3: Horses and mules, tractors, and motor trucks on farms



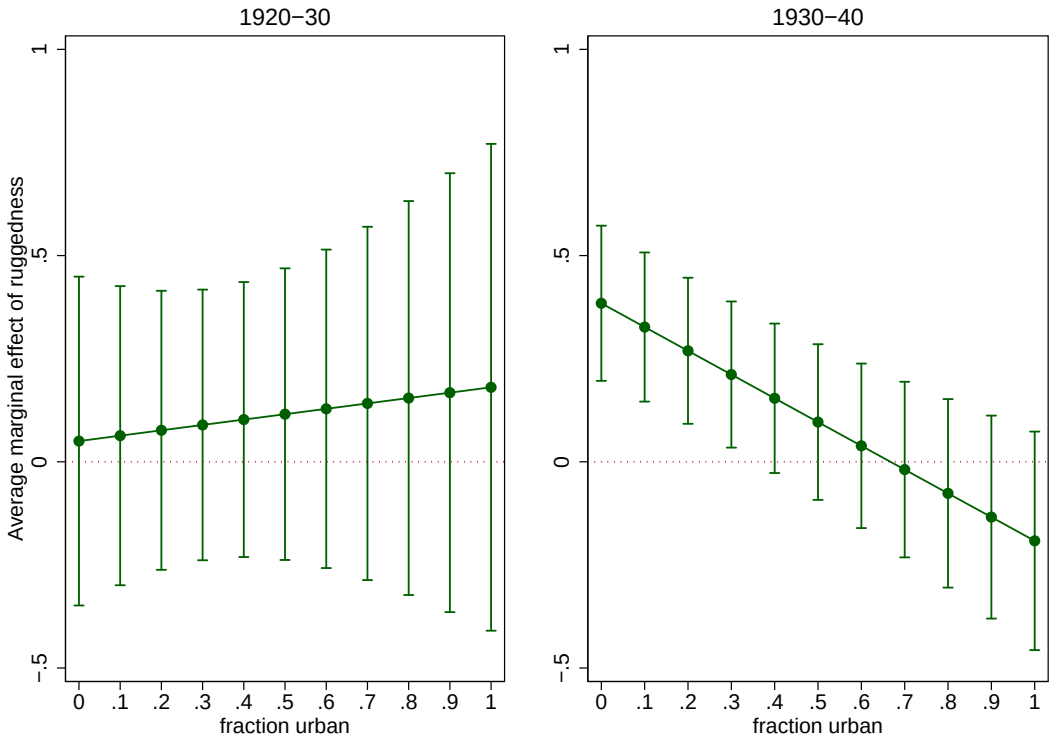
Notes: This figure displays the total number of horses and mules on farms (left axis) and the number of tractors and motor trucks on farms (right axis). The shaded region indicates the period 1930-1940.

Figure 4: County-level ruggedness



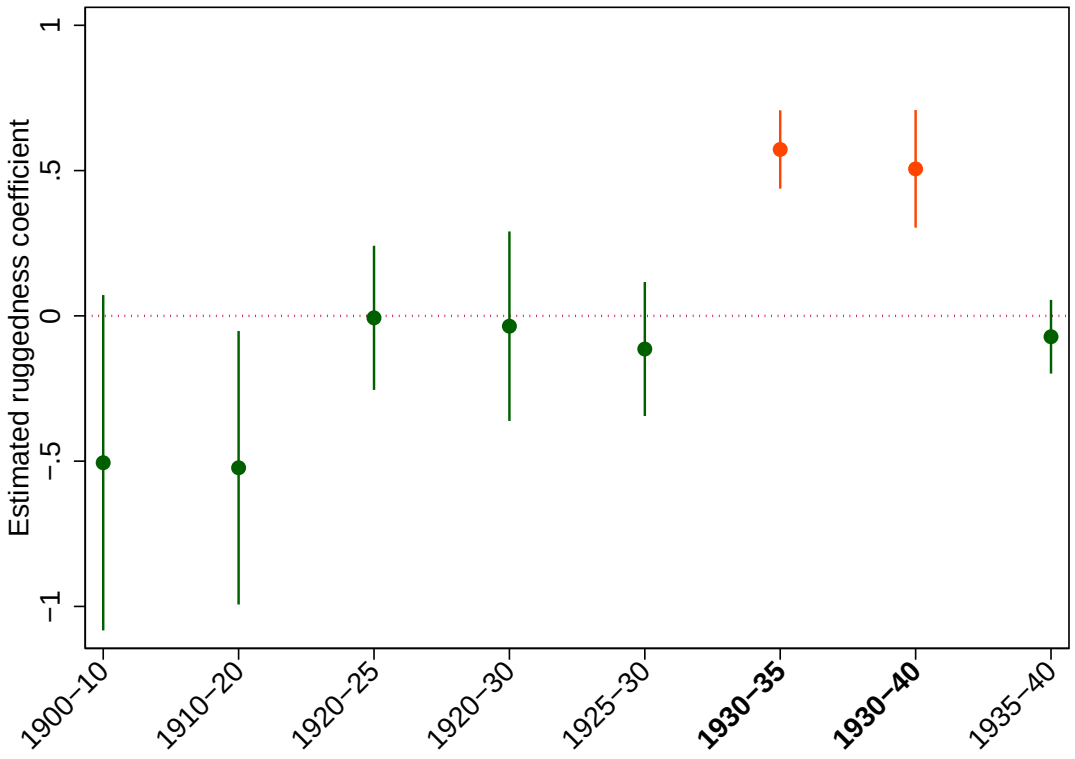
Notes: Darker color indicates more rugged terrain. The measure of ruggedness is the county-level average gradient or slope (in percent) of the land. See Section 3.1 for details.

Figure 5: Effect of ruggedness on change in county-level total population, by percent urban



Notes: This figure displays the estimated marginal effect of ruggedness on (log) total county population by the initial fraction of county population residing in urban areas. The specification in the left panel regresses log county population in 1930 on log population in 1920, county-level ruggedness, the fraction of the county population living in urban areas, and an interaction between ruggedness and urban fraction, in addition to state fixed effects. The specification in the right panel is analogous. Standard errors are adjusted for clustering at the state level, and 95% confidence intervals are displayed. Also see Appendix Figure A4 for a related (and less parametric) specification.

Figure 6: Effect of ruggedness on change in county-level total farm population, selected time periods



Notes: Each marker represents the point estimate from a separate specification. For each period indicated, we regress county-level log farm population in the end year on log farm population in the initial year, log total population in the initial year (or, for 1925 and 1935, when this is not available, in the previous decennial census year), state fixed effects, and county-level ruggedness. The figure displays the point estimate and 95% confidence interval on ruggedness. Only the periods 1930-35 and 1930-40 show positive and significant effects of ruggedness on county farm population. Standard errors are adjusted for clustering at the state level.

Table 1: Rugged farm areas have lower rates of mechanization

	(1) log tractors	(2) log tractors per acre	(3) % farms with tractors	(4) log equipment value	(5) log equipment value per acre
Ruggedness	-5.863***	-5.521***	-0.412***	-2.768***	-2.333***
	(1.568)	(1.584)	(0.122)	(0.676)	(0.684)
Observations	2114	2114	2129	2129	2129
F stat	13.98	12.15	11.36	16.75	11.63
Sample	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties

Notes: County-level regressions. The column headers indicate the dependent variable for each specification, representing alternative measures of farm mechanization. All specifications additionally control for log population and log farm population in 1930, along with state fixed effects. The reported F-stat is the F-statistic for the ruggedness variable. The sample is restricted to counties with less than 30% of the population living in urban areas in 1930. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Movement to farms vs. nonfarm employment shock

(a) County-level specifications

	Δ Mfg Emp	% Farms w/ Movers 1935			Log Farm Population 1935		
	(1) OLS	(2) OLS	(3) IV	(4) OLS	(5) OLS	(6) IV	(7) OLS
Δ Mfg emp 1929-33			-0.0201*			-0.0724**	
			(0.0115)			(0.0353)	
% Mfg in durables 1930	-0.569***	0.0123**			0.0314*		
	(0.0518)	(0.00556)			(0.0169)		
Bartik 1930-40				0.000186			-0.151***
				(0.0152)			(0.0421)
% Emp in mfg 1930	0.348***	0.101***	0.109***	0.103***	0.0789*	0.0689	0.0532
	(0.128)	(0.0258)	(0.0214)	(0.0244)	(0.0448)	(0.0595)	(0.0488)
Observations	1990	2907	1990	3058	2907	1990	3058
F stat on instrument	120.8						
Sample	All counties	All counties	All counties	All counties	All counties	All counties	All counties

(b) Individual-level specifications

	Nonfarm to farm move 1930-35				Leaves county	Moves in to county
	(1)	(2)	(3)	(4)	(5)	(6)
% Mfg in durables, 1930 county	0.0532***				0.0168	
	(0.0110)				(0.0300)	
Bartik, 1930 county		-0.184***			-0.0389	
		(0.0461)			(0.0485)	
Works in durable goods sector			0.0137***	0.0138***		
			(0.00315)	(0.00292)		
% Mfg in durables, 1935 county						-0.00925
						(0.0176)
Bartik, 1935 county						0.0538**
						(0.0257)
% Emp in mfg, 1930 county	-0.213***		-0.207***		-0.219***	
	(0.0342)		(0.0351)		(0.0333)	
% Emp in mfg, 1935 county						-0.164***
						(0.0281)
Observations	324665	323818	300832	61884	397345	526477
Sample	Nonfarm in 1930	Nonfarm in 1930	1930 nonfarm labor force	1930 mfg workers only	Nonfarm in 1930	All males

Notes: Panel (a): The dependent variable in column (1) is the change in manufacturing employment 1929-1933; in columns (2)-(4), it is the percentage of farms in the county reporting at least one to-farm migrant (defined as a person living on a farm in 1935 who resided in a non-farm area 5 years earlier); in columns (5)-(7), it is the log farm population in 1935. All county-level specifications include controls for log population and log farm population in 1930, as well as state fixed effects. Columns (4) and (7) instrument for the change in manufacturing employment using the durable percentage, and column (1) displays the corresponding "first stage" relationship and the F-statistic for the durables variable. Panel (b): The dependent variable in columns (1)-(4) is an indicator for whether the person moves from a nonfarm to farm residence; in columns (5) and (6) it is an indicator for whether the individual changes counties. "Works in durable goods sector" is an individual-level variable; the other independent variables in panel (b) are the same county-level measures as in panel (a), but may be relative to the person's county in 1930 or 1935. All individual-level specifications include controls for age and age-squared, as well as state fixed effects. Robust standard errors in parentheses, adjusted for clustering at the state level. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 3: Farm mechanization and the movement to farms

(a) County-level specifications

	% Farms w/ Movers 1935		Log Farm Population 1935	
	(1)	(2)	(3)	(4)
Ruggedness	0.151***	0.139***	0.546***	0.523***
	(0.0355)	(0.0348)	(0.0550)	(0.0534)
% Mfg in durables 1930		0.00879**		0.0229
		(0.00394)		(0.0141)
Bartik 1930-40		0.0172		-0.110***
		(0.0163)		(0.0347)
% Emp in mfg 1930		0.0789***		0.0811
		(0.0251)		(0.0538)
Observations	2127	1967	2127	1967
Sample	Rural counties	Rural counties	Rural counties	Rural counties

(b) Individual-level specifications

	Move to Farm 1930-35			
	(1)	(2)	(3)	(4)
Ruggedness, 1930 county	0.221***	0.120**		
	(0.0664)	(0.0574)		
Ruggedness, 1935 county			0.0904	0.176**
			(0.0542)	(0.0847)
Bartik 1930-40		-0.148***		0.255***
		(0.0473)		(0.0652)
% Mfg in durables 1930		0.0416***		-0.0269
		(0.0112)		(0.0266)
% Emp in mfg 1930		-0.204***		1.153***
		(0.0328)		(0.0917)
Observations	325248	322968	112215	110448
Sample	Nonfarm in 1930	Nonfarm in 1930	On farm in 1935	On farm in 1935

Notes: In panel (a) the dependent variables are the percentage of farms in the county in 1935 reporting at least one person living on the farm who had resided in a non-farm area 5 years earlier (columns 1 and 2) and the log of the county-level farm population in 1935 (columns 3 and 4). All county-level specifications include controls for log population and log farm population in 1930, as well as state fixed effects. The sample is restricted to rural counties only, defined as those with less than 30% of the population located in urban areas in 1930. In panel (b) the dependent variable is an indicator variable for whether the person resides on a farm in 1935, and the sample is restricted to males living in a nonfarm residence in 1930. The ruggedness measure is based on the person's county of residence in either 1930 or 1935, as indicated; the nonfarm employment variables are based on the 1930 county of residence. All individual-level specifications include controls for age and age-squared, as well as state fixed effects. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Out-migration and off-farm migration 1930-35

	moved out of 1930 county			off-farm mover
	(1)	(2)	(3)	(4)
Ruggedness, 1930 county	-0.0748	-0.330***	0.0352	-0.0250
	(0.0561)	(0.0596)	(0.0757)	(0.0473)
% Mfg in durables 1930	0.00463	-0.00327	0.0154	-0.000858
	(0.0208)	(0.0115)	(0.0314)	(0.00673)
Bartik 1930-40	-0.0142	-0.0277	-0.0354	-0.0189
	(0.0324)	(0.0251)	(0.0485)	(0.0213)
% Emp in mfg 1930	-0.154***	-0.140***	-0.217***	0.171***
	(0.0276)	(0.0245)	(0.0314)	(0.0211)
Observations	526401	129116	397285	135861
Sample	All males in 1930	On farm in 1930	Nonfarm in 1930	On farm in 1930

Notes: Individual-level specifications. The dependent variable is an indicator for whether the person changed counties (columns 1-3) or an indicator for whether the person moved from a farm to nonfarm residence (column 4) between 1930 and 1935. The independent variables are based on the 1930 county of residence. All specifications include controls for age and age-squared, as well as state fixed effects. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: County-level population outcomes vs. ruggedness and non-farm employment shock

	1935		1940					
	(1) % Farms w/ to-farm movers	(2) Log Farm Population	(3) Log Total Population	(4) Log Rural Population	(5) Log Urban Population	(6) Percent Urban	(7) Percent Farm	(8) Percent Employed
Ruggedness	0.162***	0.562***	0.286***	0.370***	-0.121*	-0.0694***	0.0721**	-0.111***
	(0.0356)	(0.0599)	(0.0982)	(0.0959)	(0.0712)	(0.0246)	(0.0301)	(0.0146)
% Mfg in durables 1930	0.00945*	0.0175	0.000888	0.0312**	-0.0705***	-0.0213***	0.0215***	-0.0179***
	(0.00474)	(0.0156)	(0.0139)	(0.0134)	(0.0226)	(0.00482)	(0.00528)	(0.00274)
Bartik 1930-40	0.00915	-0.0791**	0.0990***	0.0897***	0.166***	0.0168	-0.0400***	0.0200*
	(0.0141)	(0.0317)	(0.0270)	(0.0310)	(0.0482)	(0.0174)	(0.00901)	(0.0107)
% Emp in mfg 1930	0.0970***	0.0527	0.0584	0.0709	0.0113	-0.0171	-0.0262	0.0190
	(0.0241)	(0.0435)	(0.0416)	(0.0479)	(0.0583)	(0.0136)	(0.0171)	(0.0146)
Observations	2907	2907	2924	2892	1658	2924	2923	2924
Sample	All counties	All counties	All counties	All counties	All counties	All counties	All counties	All counties

Notes: County-level regressions. The column headers indicate the dependent variable for each specification. The specifications in columns (2)-(8) control for the initial 1930 value of the outcome variable. This table shows how rugged counties experience a relative increase in population; this increase is driven entirely by the gain in the farm population. All specifications include controls for log population and log farm population in 1930, as well as state fixed effects. The sample includes all counties (i.e., both rural and urban). Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Home vegetable garden production and family farm labor in 1935 vs. ruggedness

	Value of Garden Vegetables		Family Labor		Hired Labor
	(1) log total	(2) per farm pop	(3) % farms	(4) % days	(5) log persons
Ruggedness	1.326***	4.466***	0.0458***	0.292***	-0.339
	(0.445)	(1.299)	(0.0119)	(0.0578)	(0.380)
% Mfg in durables 1930	0.155***	0.248	0.00161	0.0198**	0.0135
	(0.0573)	(0.186)	(0.00173)	(0.00756)	(0.0451)
Bartik 1930-40	0.134	0.803*	-0.000383	0.00246	-0.244
	(0.154)	(0.417)	(0.00704)	(0.0492)	(0.185)
% Emp in mfg 1930	0.838***	1.882**	0.0283**	0.184***	-0.0128
	(0.274)	(0.873)	(0.0111)	(0.0382)	(0.159)
Farms 1930	-0.0562	0.0720	0.00741	0.155**	
	(0.194)	(0.556)	(0.00782)	(0.0608)	
Value garden vegetables 1930	0.461***	1.150***			
	(0.0802)	(0.160)			
Days of farm labor employed 1930					0.586***
					(0.0466)
Observations	1962	1964	1967	1967	1967
Sample	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties

Notes: County-level regressions. The dependent variables are 1935 values for (1) log of total county-level value (in dollars) of garden vegetables produced on farms for home use; (2) the value of garden vegetable production per 1935 farm persons; (3) the percentage of farms reporting using family labor out of all farms reporting family or hired labor; (4) the percentage of farm labor days by family members out of of total days of (family or hired) farm labor; and (5) the log total number of persons hired to work on farms in the first week of January 1935. All specifications include controls for log population and log farm population in 1930, as well as state fixed effects. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Farm tenancy and migration 1930-35

	% Farms w/ to-farm movers 1935		Log Farm Pop 1935		Leaves county 1930-35	Off-farm mover 1930-35
	(1)	(2)	(3)	(4)	(5)	(6)
% Owner-operated farms 1930	0.0603***	0.0438***	0.170***	0.106**		
	(0.0108)	(0.0128)	(0.0481)	(0.0489)		
Ruggedness		0.125***		0.484***		
		(0.0382)		(0.0670)		
Ruggedness, 1930 county					-0.295***	0.0497
					(0.0839)	(0.0606)
Owner					-0.138***	-0.0359***
					(0.0113)	(0.00564)
Owner × ruggedness					0.119	-0.0552
					(0.0802)	(0.0432)
Observations	2127	2127	2127	2127	131382	138228
Sample	Rural counties	Rural counties	Rural counties	Rural counties	On farm in 1930	On farm in 1930

Notes: Columns (1)-(4) are county-level regressions, and include controls for log population and log farm population in 1930, as well as state fixed effects. The sample is restricted to counties with no more than 30% of the population in urban areas. Columns (5) and (6) are individual-level regressions, and include controls for age and age-squared, as well as state fixed effects. The sample is restricted to people living on farms in 1930. "Owner" is an indicator variable equal to 1 if their household owns their farm and 0 if they rent the farm. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Dependent variable: % Farms w/ Movers 1935								
Ruggedness	0.139***	0.142***	0.140***	0.141***	0.102***	0.115***	0.104***	0.109***
	(0.0348)	(0.0407)	(0.0358)	(0.0350)	(0.0328)	(0.0332)	(0.0337)	(0.0377)
1934 Dust Bowl			-0.0142***					
			(0.00237)					
Medium Erosion				-0.0140*				
				(0.00821)				
High Erosion				-0.0129				
				(0.00767)				
Crop price shock (1)					0.223**		0.210**	
					(0.0860)		(0.0879)	
Crop price shock (2)						0.118**		
						(0.0550)		
Fraction wheat acreage							-0.0108	
							(0.0100)	
Fraction corn acreage							0.00156	
							(0.00921)	
AAA spending 1933-35								-0.00327**
								(0.00136)
Panel B. Dependent variable: Log farm population 1930								
Ruggedness	0.523***	0.475***	0.491***	0.529***	0.520***	0.510***	0.518***	0.317***
	(0.0534)	(0.0628)	(0.0620)	(0.0525)	(0.0479)	(0.0553)	(0.0469)	(0.0817)
1934 Dust Bowl			-0.0852**					
			(0.0329)					
Medium Erosion				-0.0231				
				(0.0172)				
High Erosion				-0.0219				
				(0.0173)				
Crop price shock (1)					0.242		0.166	
					(0.281)		(0.318)	
Crop price shock (2)						0.184		
						(0.177)		
Fraction wheat acreage							-0.0189	
							(0.0262)	
Fraction corn acreage							0.0316	
							(0.0355)	
AAA spending 1933-35								-0.0168**
								(0.00694)
Observations	1967	1794	1941	1965	1774	1945	1774	1894
Nonfarm employment	X	X	X	X	X	X	X	X
Temperature and Precip		X						
Sample	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties

Notes: County-level regressions. All specifications include three "nonfarm employment" variables as controls (the percent of manufacturing employment in durables, the percent of employment in manufacturing, and the Bartik measure), as well as log population in 1930, log farm population in 1930, and state fixed effects. The sample is restricted to counties with no more than 30% of the population in urban areas. "Temperature and Precip" controls include 15 weather controls for the years 1932-1934; see Section 5.4 for details. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

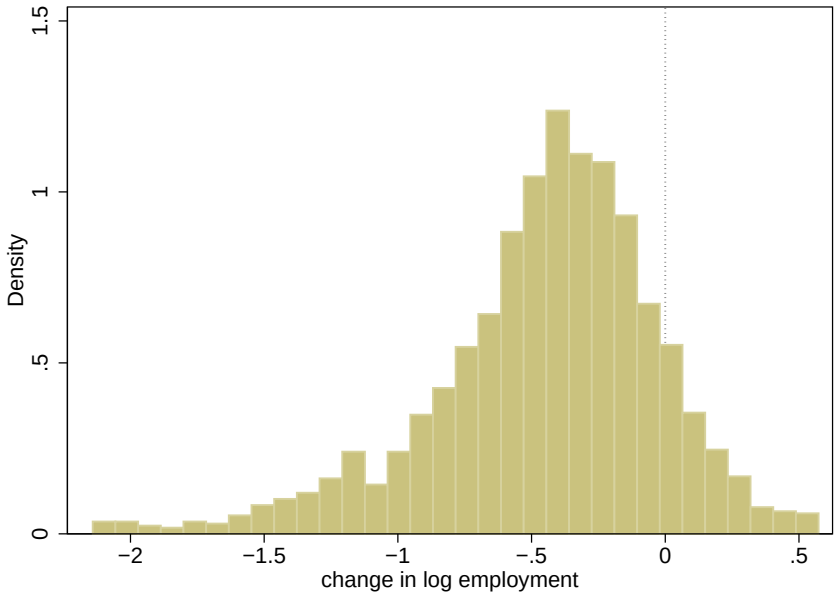
Appendices For Online Publication Only

Appendix A Additional Figures and Tables

Figure A1: Migration between farm and nonfarm residences

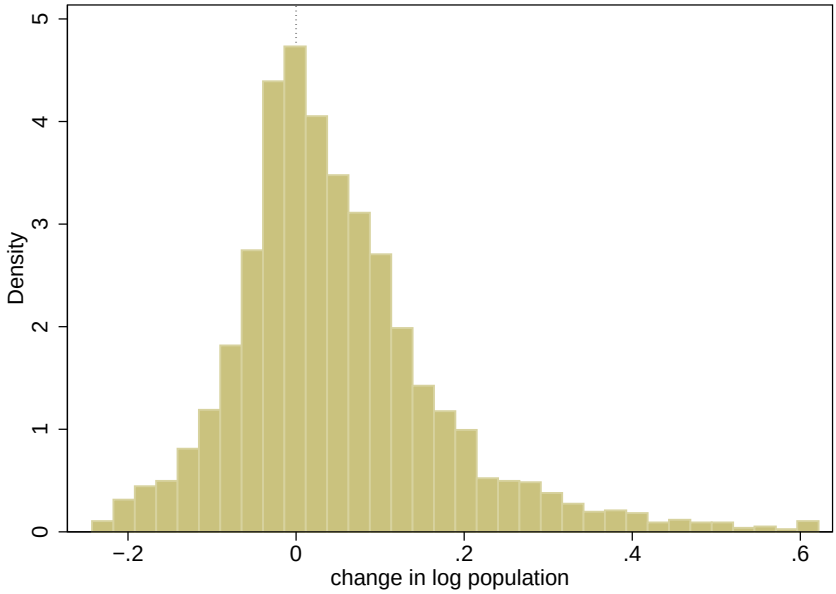
Notes: This figure shows the yearly change in the farm population resulting from internal migration between farms and nonfarm residences. The series labeled "from farms," for example, represents the number of people (in thousands) who move from a farm to a nonfarm residence in that year. *Source:* Series Ac416, Ac417 and Ac418 from Ferrie (2006).

Figure A2: County-level change in log manufacturing employment, 1929-1933



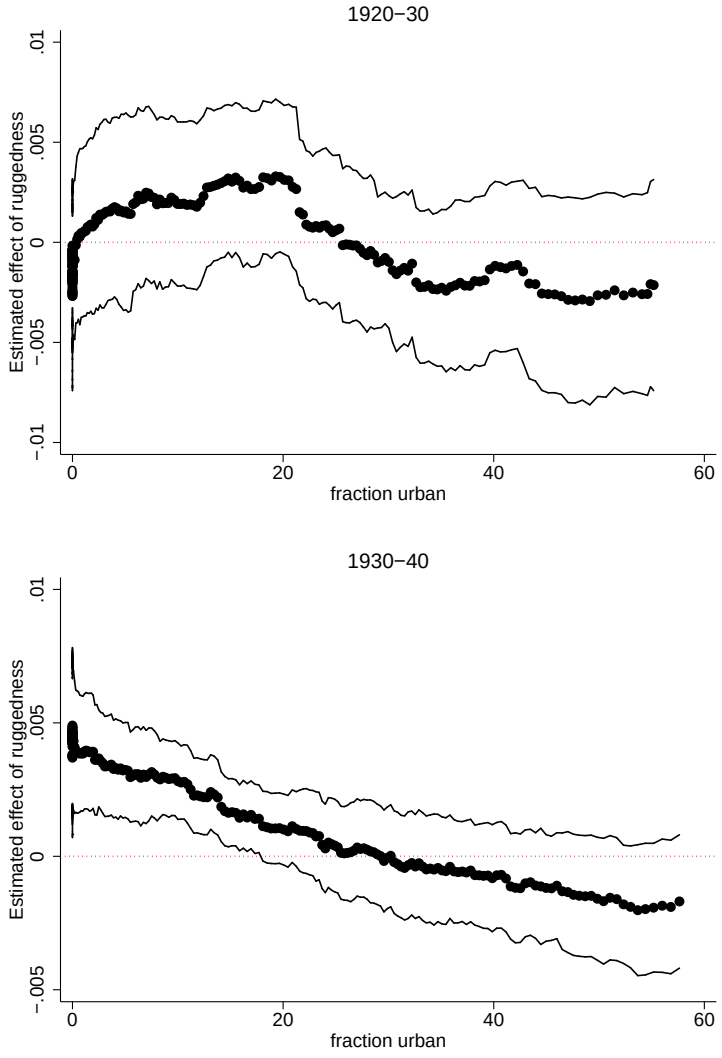
Notes: Histogram of the county-level changes in log manufacturing employment between 1929 and 1933 (i.e., log employment in 1933 minus log employment in 1929). Most counties witness a decline in manufacturing employment, but there is substantial variation in the size of the shock. The upper and lower 1% of counties are dropped (trimmed).

Figure A3: County-level change in log farm population, 1930-1935



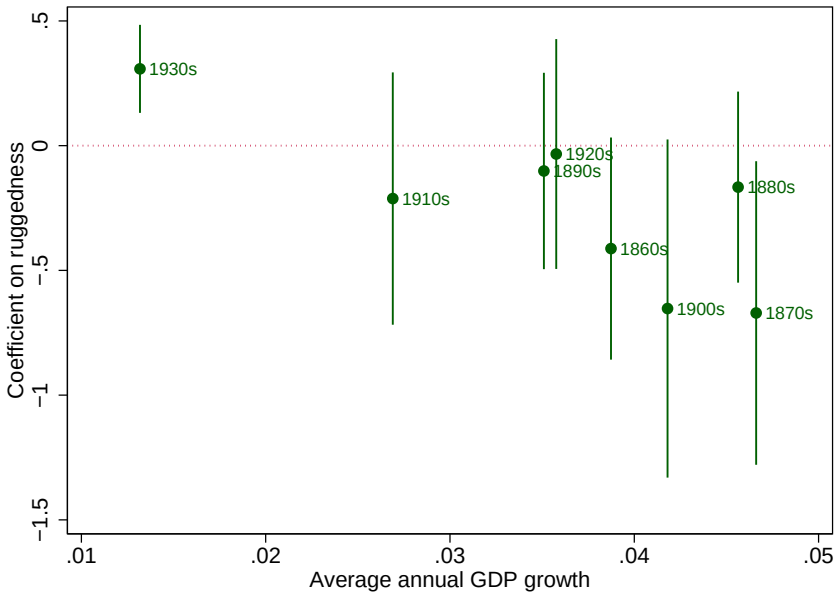
Notes: Histogram of the county-level changes in log farm population between 1930 and 1935 (i.e., log farm population in 1935 minus log farm population in 1930). While many counties witness an increase in their farm population over this time period, a substantial portion (37%) see a decline. The upper and lower 1% of counties are dropped (trimmed).

Figure A4: Effect of ruggedness on change in county-level total population 1920-30 and 1930-40, by percent urban



Notes: This figure reports the coefficients from a series of regressions of county-level log population in 1930 (top panel) or 1940 (bottom panel) on ruggedness of nearby areas, controlling for log population 10 years earlier. Counties are first ordered according to percent urban, and then a series of regressions are run using adjacent subsamples, ranging from the 800 least urban counties to the 800 most urban counties. The coefficient on ruggedness is then plotted against the average percent urban value of the 800 counties in the estimation sample. (There are actually 1578 counties that are 0% urban, hence the large collection of estimates at 0.) The ruggedness measure used here is the simple average of own-county ruggedness and the average of all neighboring counties, or $\frac{\text{own+nbr\_avg}}{2}$. The regression specification includes census division fixed effects, and standard errors are adjusted for clustering at the state level; 95% confidence intervals are displayed. The bottom panel indicates a strong relationship between ruggedness and population during the 1930s, with the effect concentrated in rural counties; the effect is decreasing in percent urban and becomes negative (though not statistically significant) for the most urban areas. In contrast, we see no relationship during the 1920s (top panel). Also see Figure 5 for a similar result.

Figure A5: Effect of ruggedness (on population) vs. national GDP growth



Notes: The figure plots the estimated effect of ruggedness on the change in total county population in each decade between 1860 and 1940. Each marker represents the point estimate (and 95% confidence interval) on ruggedness from a separate specfication, plotted against the average national-level GDP growth during the corresponding decade. Each specification regresses log county population at the end of the decade on ruggedness, initial log population, and state fixed effects; standard errors are clustered at the state level. The results suggest that the effect of ruggedness on population movement may be related to the performance of the overall economy.

Figure A6: Percent farm workers that are family members

Notes: This figure displays the percentage of all workers on farms who are related to the farm operator. Workers are classified as either hired or family. This percentage increases during the early years of the Depression, as the total number of paid workers falls while the total number of family workers increases. *Source:* Farm Employment and Wage Rates 1910-1990. National Agricultural Statistics Service, Estimates Division, U.S. Department of Agriculture. Statistical Bulletin No. 822 (March 1991). Available at http://usda.mannlib.cornell.edu/.

Table A1: Movement to farms vs. county-level agricultural characteristics

	% Farms w/ Movers 1935				Log Farm Population 1935			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log value per acre 1930	-0.00818**				-0.0310**			
	(0.00343)				(0.0124)			
Log value farm equipment 1930		-0.0108***				-0.0724***		
		(0.00391)				(0.0137)		
Log crop value per farm pop 1930			-0.0154***				-0.0676***	
			(0.00525)				(0.0143)	
Average suitability, 8 crops				-0.0459***				-0.102
				(0.0134)				(0.112)
Observations	2127	2127	2125	2118	2127	2127	2125	2118
Sample	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties

Notes: County-level regressions. All specifications include controls for log population and log farm population in 1930, as well as state fixed effects. The sample is restricted to rural counties only, defined as those with less than 30% of the population located in urban areas in 1930. "Log value per acre" is the value of land and buildings on farms, and "Average suitability, 8 crops" is the simple average of the crop suitability index (rainfed, intermediate inputs, baseline time period) for cotton, maize, oats, sugar beet, sugar cane, tobacco, wet rice, and wheat; these data were obtained from the Global Agro-ecological Zones project (http://www.gaez.iiasa.ac.at/). Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A2: Descriptive statistics

Variable	Mean	Std. Dev.	n
Counties			
% Manufacturing in durables 1930	.521	.303	2,935
% Employment in manufacturing 1930	.12	.124	3,092
Bartik 1930-40	.159	.104	3,087
Change in log manufacturing employment 1929-33	-.456	.467	2,002
Ruggedness (average slope of the county)	.0958	.0816	3,100
% Farms in 1935 with to-farm mover	.104	.0686	3,070
% Change in farm population 1930-35	.0648	.176	3,069
1930 5% IPUMS Sample			
On farm in 1930	.249	.433	6,101,000
Age in 1930	28.8	19.8	6,103,822
Female	.494	.5	6,103,822
Ruggedness of 1930 county	.0894	.0743	6,081,557
1940 Complete Count 100% Sample			
On farm in 1935	.262	.44	92,806,497
On farm in 1940	.225	.417	132,400,000
Linked Sample			
On farm 1930	.249	.433	554,740
On farm 1935	.263	.44	440,279
On farm 1940	.223	.416	554,938
Migrate 1930-35 (changes county)	.33	.47	531,921
Migrate 1930-40 (changes county)	.374	.484	554,938
Migrate 1935-40 (changes county)	.104	.305	531,921
Age in 1930	27.3	18.3	554,938
Female	0	0	554,938
Ruggedness of 1930 county	.0888	.0738	553,374
Linked Sample: 1930 Farm Residents Only			
Migrate 1930-35 (changes county)	.331	.471	131,412
Migrate 1930-40 (changes county)	.384	.486	138,325
Migrate 1935-40 (changes county)	.119	.324	131,412
Age in 1930	26.2	19	138,325
Ruggedness of 1930 county	.0867	.0738	138,228
Ruggedness of 1935 county	.0876	.0753	131,376
Ruggedness of 1940 county	.0886	.0765	138,120
Owned dwelling 1930	.535	.499	138,325

Notes: Descriptive statistics for the county-level data set as well as the individual-level data set containing linked 1930 and 1940 census records for 554,000 people, as well as for the subset of 138,000 people living on farms in 1930. For comparison purposes, also displayed are statistics for the 5% 1930 sample and the 100% 1940 data set used to create the linked sample.

Table A3: Movement to farms vs. tractors and farm equipment

	% Farms w/ Movers 1935				Log Farm Population 1935			
	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV	(7) OLS	(8) IV
% farms w/ tractors 1930	-0.0615***	-0.366***			-0.243***	-1.324***		
	(0.0201)	(0.103)			(0.0361)	(0.452)		
log value farm equipment 1930			-0.0108***	-0.0546**			-0.0724***	-0.197***
			(0.00391)	(0.0218)			(0.0137)	(0.0444)
Observations	2127	2127	2127	2127	2127	2127	2127	2127
F statistic on ruggedness		11.38		16.78		11.38		16.78
Sample	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties

Notes: County-level regressions. The dependent variable in columns (1)-(4) is the percentage of farms in the county reporting at least one to-farm migrant and in columns (5)-(8) it is the log of the farm population in 1935. All specifications include controls for log population and log farm population in 1930, as well as state fixed effects. Even-numbered columns instrument for tractors or farm equipment using county-level ruggedness. The sample is restricted to rural counties only, defined as those with less than 30% of the population located in urban areas in 1930. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: County population and farm population growth: comparison with earlier periods

(a) County-level log population

	1860-70	1870-80	1880-90	1890-1900	1900-10	1910-20	1920-30	**1930-40**
ruggedness	-0.413*	-0.671**	-0.166	-0.101	-0.653*	-0.212	-0.0335	0.308***
	(0.227)	(0.310)	(0.195)	(0.201)	(0.346)	(0.258)	(0.235)	(0.0900)
Observations	2247	2531	2692	2858	2863	2946	2947	2947

(b) County-level log population, adding control for lagged log farm population

	1900-10	1910-20	1920-30	**1930-40**
ruggedness	-0.475	-0.187	0.0386	0.310***
	(0.338)	(0.255)	(0.174)	(0.0981)
Observations	2815	2879	2891	2942

(c) County-level log farm population

	1900-10	1910-20	1920-25	1920-30	1925-30	**1930-35**	**1930-40**	1935-40
ruggedness	-0.505*	-0.523**	-0.00676	-0.0356	-0.114	0.573***	0.506***	-0.0718
	(0.294)	(0.240)	(0.127)	(0.166)	(0.118)	(0.0688)	(0.103)	(0.0647)
Observations	2770	2853	2890	2891	2927	2909	2941	2909

Notes: County-level regressions of the log value of the dependent variable at the end of the period specified on the log initial value at the beginning of the period, ruggedness, and state fixed effects. Panel (b) includes controls for log farm population in the initial period (which is only available after 1900). In panel (c), the specifications additionally control for log total population in the initial period (or, in the 5th and 8th specifications, the immediately preceding decennial census year). The periods 1930-40 and 1930-35, containing the initial crisis of the depression, are in bold. To get a consistent series over time, counties are adjusted to 1910 county boundaries using area weights. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Farm labor

	Farm Labor 1930	% Farms w/ to-farm movers 1935		Log Farm Population 1935	
	(1)	(2)	(3)	(4)	(5)
Ruggedness	-4.273***		0.137***		0.373***
	(0.425)		(0.0371)		(0.0829)
Days of farm labor employed 1930					
Cash expenditure on farm labor 1930		-0.00723**	-0.00336	-0.0511***	-0.0405***
		(0.00300)	(0.00254)	(0.00863)	(0.0112)
Observations	2128	2126	2126	2126	2126
Sample	Rural counties	Rural counties	Rural counties	Rural counties	Rural counties

Notes: The dependent variable in column (1) is the log of total cash expenditure on farm labor in 1930. All specifications include controls for log population and log farm population in 1930, as well as state fixed effects. The sample is restricted to rural counties only, defined as those with less than 30% of the population located in urban areas in 1930. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: County unemployment vs. ruggedness

	Log unemployed people 1930	Log number of unemployed people 1937		
	(1)	(2)	(3)	(4)
Ruggedness	-0.0778	2.293***	2.231***	1.699***
	(0.547)	(0.359)	(0.352)	(0.335)
Log unemployment 1930			0.0141	0.0194
			(0.0394)	(0.0337)
Log Farm Pop 1935				0.691***
				(0.215)
Log Population 1940				0.515***
				(0.104)
Observations	2109	2127	2107	2107
Sample	Rural counties	Rural counties	Rural counties	Rural counties

Notes: County-level regressions. All specifications include controls for log population and log farm population in 1930, as well as state fixed effects. The dependent variable in column (1) is the log total number of unemployed people in the county in 1930; in columns (2)-(4) it is the log number of unemployed people in the county in 1937 (from the census of unemployment in that year). While there is initially no difference in unemployment rates by ruggedness (column 1), by 1937 rugged areas have higher rates of unemployment; this is despite the fact that these areas are experiencing faster population growth and greater in-migration. The sample is restricted to rural counties only, defined as those with less than 30% of the population located in urban areas in 1930. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A7: Non-farm sectors performance (retail, wholesale, manufacturing) vs. ruggedness

(a) Retail and Wholesale Sectors

	Retail			Wholesale		
	(1) Sales	(2) Emp	(3) Avg Wage	(4) Sales	(5) Emp	(6) Avg Wage
1933 × ruggedness	-0.117					
	(0.104)					
1935 × ruggedness	-0.206	-0.436**	0.143*	-0.576***	-1.213***	0.255
	(0.150)	(0.208)	(0.0826)	(0.191)	(0.207)	(0.156)
1939 × ruggedness	-0.143	-0.248	0.0382	-0.868**	-1.090**	0.141
	(0.207)	(0.211)	(0.246)	(0.346)	(0.411)	(0.182)
Observations	12123	9103	9095	8166	8041	8010
Number of counties	3083	3081	3079	2823	2818	2817

(b) Manufacturing

	(1) Emp	(2) Value Added	(3) Output	(4) Avg Wage
1931 × ruggedness	-0.334	-0.261	-0.155	
	(0.257)	(0.274)	(0.218)	
1933 × ruggedness	-0.465	-0.250	-0.142	
	(0.286)	(0.410)	(0.353)	
1935 × ruggedness	-0.226	-0.225	-0.225	-0.0257
	(0.251)	(0.326)	(0.296)	(0.190)
1937 × ruggedness	0.0104	0.0289	-0.233	
	(0.679)	(0.421)	(0.294)	
1939 × ruggedness	0.238	0.00247	-0.121	-0.109
	(0.870)	(0.570)	(0.389)	(0.117)
Observations	13524	12806	12805	6858
Number of counties	2557	2557	2557	2557

Notes: The dependent variable is (a) the log of county-level employment, log sales, or average wage (total wages divided by total employment) in the retail or wholesale sector, or (b) log of county-level employment, log value added, log total output, or average wages in the manufacturing sector. The specifications are panel regressions with county fixed effects and include data for 1929 in addition to the years displayed. The coefficients displayed are the estimates on the interaction between county-level ruggedness and year fixed effects; the first year is omitted, so coefficients should be interpreted as the change *relative to 1929*. All specifications include controls for log population and log farm population in 1930, as well as the initial 1929 level of the dependent variable, all of which are interacted with year fixed effects. Robust standard errors in parentheses, adjusted for clustering at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.