The New Deal and the Diffusion of Tractors in the 1930s

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For Presentation at the NBER-DAE Summer Institute in Cambridge, MA, July 11, 2005.

June 30, 2005

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I. Introduction

The large-scale adoption of tractors in American agriculture might well be considered one of the most important technological trends of the 20th century. William White (2001, 2000) describes the tractor as an "unsung hero," producing social savings that were substantially larger than the railroads of the late 19th century. As the share of farms with tractors rose from 3.6 percent in 1920 to 80 percent in 1960, the agricultural requirements for labor, land, and animal stocks dropped dramatically, freeing these resources for alternative uses in the economy.[1]

Despite a number of highly informative studies on the diffusion of tractors, scholars to date often could only offer indirect assessments of the New Deal policies on the adoption of this important invention during the 1930s.[2] The 1930s were an important decade for tractor diffusion. During a decade of terrible depression the share of farms owning tractors rose from 16.8 percent in 1930 to 32.4 percent in 1940. Sally Clarke (1994) suggests that the Agricultural Adjustment Administration and the New Deal farm loan programs might well have promoted the adoption of tractors in the corn belt by reducing the risk of downward fluctuations in farm market prices, improving the terms of loans, and putting more cash into the hands of farmers. Warren Whatley (1985, 1987) shows that the presence of share tenancy and cropping was associated with slowed adoption of tractors in the cotton South prior to 1930, while Lee Alston (1981) finds that tractors are inversely related to the extent of tenancy between 1930 and 1960. Whatley (1983) also shows that New Deal programs were associated with a reduction in tenancy during the 1930s. Thus, we might infer that the reduction in tenancy associated with AAA payments in the south was associated with faster adoption of tractors. However, as yet no one has had access to direct information on the extent of New Deal spending and loans across counties; therefore, scholars have had to rely on indirect inference to draw their conclusions.

In recent studies of the impact of New Deal spending on retail sales and migration at the county level, Fishback, Horrace, and Kantor (2005 and forthcoming) find that AAA spending (in contrast to public works and relief spending) had virtually no impact on retail sales and

contributed to net out-migration. Fishback, Haines, and Kantor (2001) also find that the AAA was associated with higher infant mortality for both blacks and whites in the South. These findings are consistent with suggestions that farm owners gained directly from the provision of the AAA rental and benefit payments and that farm workers, tenants, and croppers might have lost income and job opportunities through a decline in demand for their services. The decline in demand may have been driven by a simple fall in demand or by reorganizing the tenancy structure in ways that increased the payments to farm owners at the expense of tenants and croppers (See Alston 1981, Holley, Winston, and Woofter, 1971; Saloutos, 1974; Mertz, 1978; Whatley, 1983; Biles, 1994, pp. 39-43). The AAA might also have influenced adoption of tractors through its impact on farm failures. Randal Rucker and Lee Alston (1987) find that the New Deal farm loan programs and the AAA, along with state moratoria on farm mortgage foreclosures, saved between 28,000 and 120,000 farms from failing during the 1930s. The reduction in failures could have increased or decreased the diffusion of tractors depending on the nature of farms saved and the alternative farm structure that would have developed in the absence of the New Deal programs and the state moratoria.

In this paper we use data reported by the U.S. Office of Government Reports (1940) on the distribution of New Deal funds across counties to examine directly the impact of the AAA rental and benefit grants, the Farm Credit Administration and Farm Security Administration loans, and public works and relief grants on the adoption of tractors between 1930 and 1940. In the process we describe the New Deal programs, describe their anticipated impact, perform OLS estimations that show the basic relationships between tractor adoption and New Deal programs, and then use instrumental variables to work to reduce endogeneity in the estimates of the impact of New Deal programs on tractor adoption. The analysis suggests that all three New Deal programs served to stimulate the adoption of tractors, although the precision of the estimates is weaker for the AAA programs than for the farm loan and public works and relief programs.

II. Prior Cliometric Analysis of the New Deal and Tractors

Cliometric studies by Whatley (1983, 1985, 1987) and Clarke (1991) can be used to infer ties between the New Deal and tractor adoption. Both were based on threshold models of the adoption of tractors similar to Paul David's (1975) threshold model of reaper adoption. Both used cost minimization structural models that compared the relative fixed and variable costs of farming with mules and horses and farming with tractors. They then parameterized the models after collecting substantial information on labor and land requirements, depreciation rates, wage labor costs, interest rates, horse and mule prices, and tractor prices to develop threshold sizes at different times and in different settings. The threshold sizes were then compared with the actual distribution of farms to make statements about factors influencing the adoption of tractors.

The Whatley papers focus on the South. Whatley (1985, 1987) estimates optimal threshold sizes for 1930 by comparing a series of separate regressions of the share of farms with tractors as a function of the share of farms in different size categories. He chooses the threshold farm size based on the fit of the models as measured by the R-squared. For 1930 the regression with the highest R-squared of .66 (or .70) uses the share of farms larger than 259 acres; therefore, Whatley chooses 260 acres as the threshold farm size. He then finds that the share of farms with tractors in the cotton South is strongly correlated with the share of farms greater than 260 acres and that the share of farms above the threshold is negatively related to the extent of share tenancy (1985). When Whatley (1987) considers the tenure structures in the plantation South, the average size of share tenant farms is negatively related with the share of farms above the threshold, although the coefficient is statistically significant only when it is confined to the Delta region (1987). Thus, he argues that tractors were used primarily on large farms using wage labor or on the wage labor segments of plantations and not plantation-wide. He argues that this structure was dictated by a shortage of farm wage labor in areas away from cities during harvest.[4] Share tenancy and cropping came about to prevent workers from leaving farms for better wages during the harvest. Once the tenant and cropping structure was in place, tractors only saved on pre-

harvest labor and the labor of share tenants and croppers was already fully accounted for because they were harvesting their own crops. Given that use of tractors required both large amounts of land and access to farm wage labor, he suggests that tractor adoption was slower in areas where tenancy and cropping was dominant. Whatley (1983) also shows that the structure of AAA payments to landowners under different tenancy arrangements gave landowners incentives to shift away from share tenancy and towards larger farms using wage labor. Although Whatley to our knowledge has not directly tied the New Deal's impact on tenancy to the diffusion of tractors in print, the combination of the results in his series of papers suggests that the AAA payments might well have led to greater adoption of tractors.

Lee Alston (1981) also find that tractors and share cropping and tenancy were negatively related in studies of southern agriculture (see also Day, 1967). Alston, however, argues for an alternative direction of causation. Tractors were improving rapidly in the 1930s (see White 2001, 2000), expanding the range of land on which tractors could be used. The use of tractors, in turn, lowered the costs of monitoring wage labor and thus reduced the reliance on share cropping and tenancy. Alston (1981, pp. 228-230) uses quotes from Musoke (1976), Hoffsomer (1950) and Street (1957) to suggest that crop limitations under the AAA might not have had much impact on the extent of share tenancy or share cropping. Alston argues that the tenure contracts were malleable when economic conditions changed. Landlords could easily bargain with croppers and tenants, who faced much worse alternatives during the Depression, to either sign over their AAA benefits or accept lower shares. In areas where tractors were introduced, landowners charged tenants fees for the use of tractors or reduced shares. Thus, the landlord could still capture the AAA payments without having to change the tenure structure and the potential rise in transactions costs associated with such a change.[5] Determining what happened to individual tenants and croppers has been difficult due to lack of evidence. Alston and Ferrie (forthcoming) found one study of a group of plantations with individual data in Jefferson County, Arkansas, a county with general farm characteristics that appear similar to the means for southern

cotton agriculture. In the Office of Government Report data Jefferson county received about $59.4 dollars per rural farm person in AAA spending, which is more than the Arkansas average of $45.[6] Their analysis suggests that during the period 1930 to 1937 that wage workers moved up to cropper status, croppers tended to stay in that status, while tenants tended to move down to cropper status. To the extent that Jefferson County is representative of southern cotton plantation counties, there appears to be a shift toward greater use of croppers. Alston suggests that the AAA likely had a more direct effect on tenants and croppers by reducing the demand for labor, while the improved terms of lending from the New Deal farm loans increased the diffusion of tractors.[7]

Sally Clarke (1991) focuses on the adoption of tractors in the Corn Belt in Illinois and Iowa. She also calculates a threshold model for the economic viability of the tractor in the Corn Belt county by county. Based on these calculations she shows that there was a substantial gap in 1929 between the number of farms that passed the threshold size for tractor adoption and the number of farms that actually adopted tractors. Although the USDA and county extension agents encouraged farmers to consider the cash prices of farm output and farm inputs in making decisions, Clarke argues that farmers themselves found it optimal in many cases to think in terms of non-cash opportunity costs of mules, horses, and other factors. Farmers with low income were risk averse and had to consider subsistence as well as marketing of goods. They were particularly sensitive to downward price fluctuations. A number of farmers continued to rely on horses instead of tractors, even though the horses would require that acreage be set aside to grow feed, because the farmers could avoid market price risk. Buying a tractor, however, would mean that the farmer would have variable costs in dollars, not acres. Additionally, if a tractor was not bought outright, the loan payments would represent a significant increase in a farmers cash expenses for a year.

Clarke argues that the gap between the percentage of farms above the threshold and farms owning tractors fell considerably during the 1930s.[9] Using evidence from a broad range of

sources, she finds that New Deal programs such as the Commodity Credit Corporation (CCC), the Farm Credit Administration (FCA), and, to a lesser extent, the Agricultural Adjustment Administration (AAA), would have made farmers more likely to adopt tractors by lowering price risk, lowering interest rates, and by putting cash in the hands of farmers (Clarke, 1991).

In developing the farm size threshold models Whatley and Clarke have brought to bear an extensive amount of useful information. Although everybody agrees that the microeconomic model underlying the empirical threshold models is useful, many have criticized the emphasis on farms reaching the empirically measured thresholds as a critical determinant of tractor adoption. William White (2001, 2000) suggests that the New Deal threshold story told by Clarke might be misleading because she did not have enough evidence available on the quality improvements in tractors. In contrast to Clarke's story that the threshold size did not change much between 1930 and 1940, and thus the New Deal was an important factor, White suggests that the quality of tractors improved substantially making tractor adoption more desirable for a much larger range of farms than Clarke had thought. [10]

Alan Olmstead and Paul Rhode (2001) examined the diffusion of the tractor between 1910 and 1960 using a panel of state level data for the Census years. The key assumption that they challenged in the threshold model was the treatment of farm size as exogenous in the decision process. Farm size might be treated as exogenous during the growing season, or within time frame of a year or two if the individual farmer faces a borrowing constraint, the farmer can't move, or he is unable to expand because he is at the limit of his current farmable acreage and cannot find land to rent or purchase close enough to expand. In their state level panel study of Ag Census years they allow for both farm size and tractor choice to be endogenous and find that larger farm sizes contribute to more adoption of tractors but also that the adoption of the tractor leads farmers to choose larger farm sizes. In our empirical modeling, will show the results both with and without controls for farm size in the analysis.

III. The New Deal Programs for Farms. Relief, and Public Works

The New Deal programs that were likely to directly affect agricultural input choice were the broad array of farm programs through grants and loans and the public works and relief programs through their impact on work opportunities for potential farm workers, croppers, and tenants. The county-level evidence reported by the Office of Government Reports on farm programs includes information on AAA Rental and Benefit payments aggregated for the period from 1933 through 1935, AAA Soil Conservation Allotment payments aggregated for the two years 1936 and 1937, the Farm Credit Administration loans to farmers, loans through the Farm Security Administration, and loans through the Rural Electrification Administration for the period March 1933 through June 1939.[11]

III.1 Farm Programs

The largest farm grant program was the Agricultural Adjustment Administration payments to take land out of production of designated crops.[12] The AAA payments we use in the analysis are the Rental and Benefit payments under the first version of the AAA from 1933 to 1935 and the conservation payments in 1936 and 1937 under the Soil Domestic Allotment Act (SDAA) that recast the AAA program after the U.S. Supreme Court declared the first form of the AAA to be unconstitutional.[13] Both types of payments were distributed to farmers who agreed to participate in a program of controlled production. Farmers voluntarily signed production agreements in which they would curtail the acreage they planted. In the original AAA the benefit payments were financed from special processing taxes on the commodity being curtailed. There was a general belief that most of the burden of the processing taxes would be passed on to consumers of farm products. Under the SDAA the processing taxes were eliminated and the funds were appropriated from the general budget.[14] The goal of the program was to increase the incomes of farmers both through benefit payments and by raising market prices to pre World War I levels (1920s levels for tobacco) through the curtailment of the output of specific crops.[15]

The AAA was administered by the Department of Agriculture, which established state and local committees or associations of producers to help administer the act. The administration of the Act was often done through a series of programs specific to the individual crops. Thus the geographic distribution of the AAA funds across counties was determined by the crop choices made prior to the AAA involvement and by the parameters set for each of the crops. For each crop the actual distribution of funds was determined by a complex interaction between federal administrators, local committees, local extension agents, and the farmers who decided to join the program. Since this was a voluntary program, farmers had to agree to sign up for the acreage reduction program. For signing up to reduce acreage, their payments were based on multiplying the national price set for acreage reduction and their average yield per acre over a base period. Thus, the program had to be made attractive enough for farmers to agree to join. The federal decision makers influenced the attractiveness of the program by the national price they set for acreage reduction and by the acreage that they asked the farmers to take out of production. In the case of tobacco and cotton the federal decision-makers added a degree of coercion to the system by levying heavy taxes on any production beyond designated limits.[16] The local administrators influenced the attractiveness of the program through their decisions upon issues like the base-year yields for the individual farmer and their decisions about the acreage the farmers had had in production. In addition, their actions to market the program and cajole their neighbors into joining helped determine the sign-up rates.

Nourse, et. al. describes substantial variations in sign-up rates for the initial AAA programs across crops and across regions.

> "The major reasons for failure to secure sign-ups as high as 90 percent or more in some areas of concentration are that many of the farms are always involved in leasing arrangements, estate management, or the like in such a way as to make participation difficult, or have been so irregular in their production as to make provision of acceptable bases very difficult or are small farms using family labor

> mainly or entirely and hence not able to curtail expenses in proportion to the reduction in acreage. The reasons for the smaller sign-ups in the regions where production is small and irregular are mainly the difficulties of providing satisfactory bases, the large number of small farms, lack of interest, and preference not to be bothered with the details of participation for the sake of the small benefit payment. Also sign-up campaigns were not prosecuted with the same degree of intensiveness in such areas. Nourse, et. al., 1937, pp. 120-1.

Our sense from reading the documents is that the AAA offers were packages that involved the level of payments and the amount of acreage to be reduced. The package nature of the deal suggests that looking at the total receipt from the AAA is likely to give a good picture of the quality of the deals being offered. There was some variation in the takeup rates on the AAA offers. Cotton signups were 73.2 percent of base acreage in 1933, rising to 94.4 percent in 1935. Wheat had 75 percent of acreage in the base period under contract; 80 percent of peanut base acreage was contracted; and the tobacco signups ranged from 76 to 97.6 percent for many types of tobacco. Maryland tobacco only had a 20.0 percent sign-up rate.[17]

III.2 Farm Loans

The federal government had been involved in the farm lending market since the enactment of the 1916 National Farm Loan Act, which provided capitalization for 12 regional federal land banks and supervision for the establishment of a joint stock land bank (p. 340). In 1923 Federal Intermediate Credit banks were established to rediscount farm loans from the commercial banking system. By 1933 the Federal land banks held about one-seventh of the farm mortgage debt, the joint-stock land bank had been dissolved and the intermediate credit banks were having limited impact on the loan volume. Under the 1933 Farm Credit Act, Congress established the Farm Credit Administration, which reorganized and expanded on the existing federal credit system. The Federal Land Banks received significant federal backing to finance farm mortgages at substantially lower interest rates, with longer repayment periods, and up to

levels reaching 75 percent of the *normal* value of the land to be mortgaged instead of the contemporary depressed value during the Depression. Over $800 million was provided for making Land Bank Commissioner loans that reached beyond the ordinary first mortgage loan up to a maximum of $7500 per farmer. The Land Bank System largely refinanced loans on the new terms and by 1936 held two-sevenths of the farm mortgage debt in the U.S.

The Farm Credit Act of 1933 also provided for a Production Credit System that distributed loans through more than 600 local credit production associations. By June 1934 88,388 loans averaging $792 had been made. In addition, Roosevelt provided funds to finance a series of Emergency Crop and Feed Loans in 1933 and 1934 that were targeted at persons unable to obtain credit from other sources. The small loans were a mixture of credit and relief and it was anticipated that many would not be repaid. A similar program was established for drought relief in 1935.[18]

The New Deal established another set of loan programs for farm families that had been receiving public relief under the FERA relief program. This program provided for small cash loans for low income or needy farm families. The program was eventually transferred to the Resettlement Administration in 1935 and ultimately found a home in 1937 in the Farm Security Administration. The loans were basically character loans to be repaid in cash and in kind by farmers who had no recourse to private or other federal loans but had put together a rehabilitation plan and received training to improve their farming practices. These loans were distributed on similar grounds to those used in distributing relief. Once the farmer's standing was improved, the FSA offered loans through a farm tenant purchase program that aided croppers, tenants, and farm laborers in purchasing their own land.[19]

We combined the FCA and FSA loans into one farm loan category because they all had the same effect of easing credit constraints and lowering interest rates. They were targeted at different groups of farmers but we do not have information on tractor use for individual farmers and thus cannot focus on those specific groups. Further, the information we have available is for

the entire period from 1933 through 1939, such that a number of farmers were likely to have benefited from different loan programs at various times over the decade of the 1930s. The improvement in loan terms on all dimensions provided expanded credit and cash resources that made it easier for farmers to purchase or rent tractors.[20]

III.3 Public Works and Relief

The farm sector was also likely to be influenced by the two largest grant programs, the public works and relief programs. For the farm study we group public works and relief grants together because the programs had broadly similar goals of providing employment for a large number of workers and building a wide variety of public works and providing other public services. Relief grants were primarily distributed under the auspices of the Federal Emergency Relief Administration (FERA) from 1933 through mid 1935, the Civil Works Administration (CWA) from November 1933 through March 1934, the Works Progress Administration (WPA) from mid 1935 through 1942, and the Social Security Administration's Aid to the Blind, Aid to Dependent Children, and Old-Age Assistance programs after 1935. The principal goal of these programs was to provide immediate relief to the unemployed and low-income people, as 85 percent of the grants were used to hire the unemployed on work relief jobs. These relief jobs ranged from make-work activities to maintenance activities to the building of sidewalks, post offices, schools, local roads, and other additions to local infrastructure. The public works grants included expenditures by the Public Works Administration (PWA), Public Buildings Administration, and the Public Roads Administration. These grants were also used largely to employ workers. Many of the workers hired came from the relief rolls, but the public works programs had more freedom to hire a broader class of workers who were not on relief. The public works programs were said to be more focused on building larger scale projects such as dams, roads, schools, and sanitation facilities. The work relief programs also built many major public projects, as relief administrators typically carved large-scale projects into several small

projects that allowed them to avoid administrative limits (Clarke, 1996, pp. 62-68; Schlesinger, 1958, pp. 263-96).

IV. Modeling the Choices of Representative Farmers

To organize thinking about the impact of the New Deal programs and to offer some insights into the issue of whether other contappropriate empirical analysis we develop a theoretical model of a representative farmer. This is a standard one-period model of a risk averse farmer maximizing expected utility.[21] The farmer makes the choices at the beginning of the period and does not discover the prices or harvest outcomes until the period has ended. We assume the farmer is risk averse in making decisions about farm inputs. We have couched the analysis in terms of numerical values, yet some features of Clarke's analysis based on the non-cash part of the farm economy are easily incorporated. Her focus on non-cash opportunity costs might also be incorporated in the model based on whether cash or non-cash opportunity costs are considered to be the more relevant factor.[22] Clarke strongly emphasizes the role of lowering interest rates and giving farmers more access to cash credit would make them more likely to take accept risk. Obviously, if labor and capital are substitutes on the farm, lowering the rental rate of capital should increase demand for capital. However, if Clarke's argument about risk aversion is correct, one should be able to find that a lower interest rate will increase demand for tractors without making any assumptions about the substitution patterns between labor and capital on the farm.

We treat the choice of all farm inputs as endogenous in this model, which is consistent with Olmstead and Rhode's findings that tractors and farm size were simultaneously chosen. We can alter this assumption within the model by fixing the land size or adding credit constraints.

Assume that farmers are expected utility maximizers. Farmers are risk averse and have strictly monotonic preferences with diminishing marginal utility over income:

(1) $U'(\cdot) > 0, U''(\cdot) < 0$

A farmers profits can be represented as follows:

$$(2) \qquad ?(N_A, N, T, CL) = s\, P_A\, Q_A(N_A, T, CL_A - NL, LQ) + s\, P_B\, Q_B(N - N_A, T, NL, LQ) - w\, N - p_T\, r\, T - p_L\, r\, CL + s\, n\, NL.$$

The farmer chooses the quantity of labor used in the production of the AAA designated crop (N_A), the total labor hired or used during the year (N), the amount of land cultivated for the AAA designated crop (CL_A), and whether or not to own a tractor (T). We make this a zero-one choice because the vast majority of farms owned only one tractor. LQ is exogenous land quality; We do not focus on investments in land quality to simplify the analysis, although we do incorporate it in the discussion of benefits from alternative crops below. NL is the amount of land that the AAA allows the farmer to take out of production with a AAA contract and n is the benefit payment. We treat NL as exogenous due to the package nature of the contracts offered by the AAA. Our data allows us to look at only cross-sectional comparisons, so we focus on geographic variation. The farmer was offered an all-or-nothing contract that specified both the benefit payment and the amount of land. The benefit payment varied geographically based on the crop and the prior productivity per acre of the land while the number of acres was determined by historical usage of the land relative to the national target quotas. P_A represents the price of the AAA designated crop, P_B is the benefit of the alternative crop that the farmer switches to with the land taken out of production of the AAA crop. The benefit of the alternative crop (P_B) might come in several forms. In the South, where the farmer could not switch to a cash crop, it might come in the form of a non-market value of feed or food produced or the anticipated future value of higher productivity of the soil. In the Midwest, the value also could include cash prices for the alternative crop. Since before the AAA, the farmers had not been producing the alternative crop, our sense is that the long-term average benefits from the alternative use was lower than for the AAA crop ($P_A > P_B$). To account for the impact of tenancy and cropping, s is the share of the

crop received by the farmer. The share is one for owners and fixed rent tenants and less than one for share tenants and lower still for croppers. We assume that the share croppers and tenants also get the appropriate shares of the AAA payments. This can be reconsidered later in light of the problems tenants and croppers faced in the South in obtaining the appropriate share.

$Q_A(.)$ is output of the AAA designated crop and Q_B is the output of the alternative allowed by the AAA, where both Q functions are strictly increasing at a decreasing rate in labor (N_A or $N - N_A$, respectively),the presence of a tractor T, the amount of land cultivated ($CL_A - NL$ or NL), and LQ. On the cost side, w represents the wage paid to labor, r is the farmer's discount rate, which is strongly influenced by the rate at which he can borrow, p_T is the purchase price of the tractor, and p_L is the purchase price of land. The annual rental price of a tractor or land would then be a multiplicative function of the interest rate and the purchase prices ($r\,p_T$ and $r\,p_L$). For share tenants and croppers we assume that the contract is written so that ultimately the share of output going to the owner is equal to the rental value of the land. We assume that the output price, wages, rental prices of tractors, and land rent are set in markets over which the farmer has no control.

Farmers also faced significant uncertainty. Suppose there is a bimodal outcome in AAA crop production or prices. For example, prices of AAA designated crops can be either "high" with probability a, or "low" with probability $1-a$, where $0 < a < 1$.[23]

The objective function then becomes

$$(4) \qquad E[U(N_A, N, T, CL)] = a(U(p_H) + (1-a)(U(p_L) =$$

$$a\ U(s\,P_A^H\,Q_A() + s\,P_B\,Q_B() - w\,N - p_T\,r\,T - p_L\,r\,C\,L + s\,n\,NL) +$$

$$+ (1-a)\,U(s\,P_A^L\,Q_A() + s\,P_B\,Q_B() - w\,N - p_T\,r\,T - p_L\,r\,C\,L + s\,n\,NL),$$

where p_H and p_L represent profits in the high and low settings, respectively. To reduce the number of parameters we assume that there is no variation in the outcomes for the alternative crop. Thus, the risk for the AAA crop is the greater risk associated with the crop when compared with the alternative.[24]

If we work through the first-order conditions for a maximum in this context, the farmer's choice functions for labor, tractors, and cultivated land will all be functions of the exogenous variables in the equation.

$$(5) \quad N_A = N_A\,(a, LQ, s, P_A^H, P_A^L, P_B, w, r, p_T, p_L\ n, NL)$$

$$N = N\,(a, LQ, s, P_A^H, P_A^L, P_B, w, r, p_T, p_L\ n, NL)$$

$$CL = CL\,(a, LQ, s, P_A^H, P_A^L, P_B, w, r, p_T, p_L\ n, NL)$$

$$T = T\,(a, LQ, s, P_A^H, P_A^L, P_B, w, r, p_T, p_L\ n, NL)$$

This combination of choice functions suggests to us that we should estimate the tractor input equation as a function of the exogenous variables but not the remaining input choices. The impact of the farm loans can be shown in the comparative statics for the interest rate *r* and that the impact of the AAA program can be shown in the comparative statics for *n* and *NL*. It turns out that the comparative statics end up being complex functions, so that the effects of both farm loan and AAA programs are uncertain. Therefore, we discuss the intuitive predictions based on prior research based on the law of demand and past research.

The farm loan programs were likely to increase the adoption of tractors. Some of the credit was specifically targeted at methods for improving production. The improved loan terms on all dimensions gave farmers access to expanded credit. Even if the credit was tied to mortgages for land, the expanded credit allowed farmers to redirect some savings or other resources toward farm machinery. Further, more mortgage credit allowed the farmer to expand acreage under cultivation and thus reach sizes where tractors made sense.

The AAA payments may have had conflicting effects on tractor adoption. On the positive side, the AAA payments did not cut the amount of land on which tractors could be used by much. Farmers in the Corn belt could use the acreage to produce nondesignated crops like soybeans for cash as well as plant their fields in feed, hay, food, or other forage crops. In the South they were restricted to noncash crops to feed themselves and animals as well as forage crops like clover. In both areas tractors could still be used for initial plowing but the labor

demands at harvest time for many of these crops were lower or the harvest times differed enough between the AAA crop and these crops that the peak demands for labor at harvest were lessened, resolving one of the key constraints on tractor use.

On the other hand the production of feed and forage on the acreage released by the AAA payments made it less costly to feed plow mules and horses because the farmer could either avoid transport costs on the cash purchase of these products or because market prices were lower due to increased supply available. For farmers who took the land completely out of production or put it into production where tractors were less useful, the reduction of acreage under cultivation made tractors less appealing.

Finally, there are conflicting opinions on how the AAA would have influenced tenancy and share cropping in the South and the impact of changes in the tenancy structure on tractor choice. Whatley argued that the AAA led to shifts toward larger farms with more wage work away from smaller operations under share tenant and cropping arrangements. His suggestions that larger farm sizes and fewer share and plantation arrangements were associated with tractor expansion in the 1920s, suggests that the AAA might have contributed to rising share tenancy. Alston on the other hand suggest that such a prediction was muted a great deal by the flexibility in contracting on plantations in the South and that the direction of causation runs more from tractors to tenure arrangements than from tenure arrangements to tractors.

The relief and public works programs likely had a variety of effects on farming. For example, the building of roads could alter the prices received for farm output and paid for goods purchased. Most of the literature on tractor adoption focuses on the constraints placed on tractor adoption by the availability of farm labor at harvest time. On this dimension public works and relief might have had opposite effects depending on the policies followed by the agencies. The public works and relief programs might have reduced the availability of farm labor during harvest time, slowing the adoption of tractors, to the extent that the project pay exceeded harvest wages and public works and relief officials penalized their workers if they left the programs for harvest

work. On the other hand, if the public works and relief officials were willing to release workers temporarily during the harvest without prejudice against returning to relief work, having more relief and public works keeps more people in the area and thus provides a ready labor force at harvest time that make tractors more attractive. In reading the archival reports and secondary literature, we have found evidence of both. A number of farmers complained that the WPA pay was so high that they had trouble hiring the normal number of workers during harvests. WPA officials offered different opinions on this issue. Some excoriated the farmers for paying such low wages that WPA pay beat them. Others said that they actively encouraged work relief recipients workers to find available work during peak seasonal demands but did not penalize them when the season ended.

V. Empirical Model

We follow Olmstead and Rhode's (2001) focus and estimate the model for the entire United States. As a starting point, we examine the base relationships between the growth rate in the number of tractors between 1929 and 1939 (measured as the change in the log values) in the county as a function of only the New Deal loans and grant programs by estimating OLS regressions where the New Deal loans and expenditures are treated as exogenous. The AAA grant expenditures per rural farm person describes the cross-county distribution of AAA funds availability of AAA funds. We focus on the total spending rather than the national parameters because the deals offered farmers tended to be packages of the national parameters and the specific acreage allowed to farmers in the county. We see the FCA and FSA loans per rural farm person as a measure of the availability of the loans in the area, which might have differed to the extent that local administrations were effective relatively to other groups. We anticipate that greater availability of the farm loans also influenced local private credit opportunities in these areas. Finally, the public works and relief spending per capita describes the extent of public work available in the area

V.1 The Estimation Equation

To examine the potential for omitted variable bias we then add a series of variables, so that the OLS regressions (and later IV regressions) ultimately take the following form. We estimate the effect of New Deal spending on the level of tractor adoption in 1939, using both OLS and IV. Our OLS model is specified as follows:

$$Ln(T_{39,i}) - ln(T_{29,i}) = ß_0 + ß_1 \ln(T_{29,i}/F_{29,i}) + ß_2 ND_i + ß_3 X_i + e_i$$

where ln is the natural log, $T_{t,i}$ is the number of tractors in year t and county i. and $T_{29,i}/F_{29,i}$ is the number of tractors per farm in 1929. ND_i is a 3x1 vector of New Deal funds per rural farm population and $X_{30,I}$ is a k x 1 vector of explanatory variables. The parameters $ß_0$ and $ß_1$ are coefficients to be estimated, while $ß_2$ and $ß_3$ are 1x3 and 1xk vectors of coefficients to match up with the New Deal and explanatory variables in their respective vectors. Finally, e_i is a stochastic error term that contains random error terms and unobservables. We include the natural log of tractors per farm in 1929 to control for prior propensity to adopt tractors as well as the effects on growth rates of starting at different levels. We focused on using the number of farms in 1929 as a normalization to avoid mixing up changes in the number of tractors with changes in the number of farms during the 1930s. The change in log tractors from 1929 to 1939 will have the same value as the change in log tractors per 1929 farm from 1929 to 1939.

We then add a series of variables that describe the average hydrological quality of the soil in the county, the highest elevations and range of elevation of named places on topographical maps, the dust bowl, and the average and extreme weather patterns experienced during the 1930s. These variables are included to capture the land quality in the area, the extent of fluctuations in the topography, and the risks of bad crop yields. In the next stage we add a series of socioeconomic variables that include the extent of literacy, unemployment and layoffs in 1930, percent urban in 1930, retail sales per capita in 1929, average family size in 1930, and percent black in 1930 in the area to provide information on the relative income in the area, and the ease of

attracting harvest labor. The next grouping of variables included the crop mix in 1929, the value of crops per rural farm person in 1929, and the extent of farm failures in 1929 to control for major AAA crop activity and the success of farms as they entered the depression. Finally, we include a set of state dummy variables that capture a series of features during the 1930s. We know that crop prices, tractor prices, and wages for workers varied substantially across states (see Rhode and Olmstead, Crops and Prices) in part due to transport costs, as well as opportunities in manufacturing and mining. In addition, there are differences in the state policies toward agriculture and the strength of the agricultural extension services. The state dummies serve to control for these factors.

When we model the farmer's decision we assume that farmers chose farm inputs simultaneously, as suggested by Rhode and Olmstead's (2001) findings for tractor choice. This seems a reasonable assumption given that we are examining a 10-year period of adoption. However, at various points in their threshold analyses, Clarke and Whatley treat the size of farms as exogenous and Whatley discusses the impact of the tenancy structure on tractor choice. We have also estimated the models by including the percent of farms run by cash tenants in 1929, the combined share run by share tenants and share croppers in 1929, and Nancy Virts' (forthcoming) index for the share of acreage in plantation farms in 1910.[25] The 1929 farm size and tenancy structure variables might be considered exogenous to the 1930s tractor growth if there is no serial correlation in the size and tenancy structures across the 1930s. To the extent that there is serial correlation, there is increasing bias in the estimates of the effects of size and tenancy structures on tractor adoption. The endogeneity of size and tenancy also creates multicollinearity problems for estimating the coefficients on the New Deal variables.

V.2 Controlling for Endogeneity of New Deal Programs

It is likely that the New Deal spending and loan programs were not exogenous to the situation in agriculture. During the New Deal the grants and loans certainly were not distributed

in a random fashion that would allow us to assume this to be a "natural experiment." The AAA grant and farm loan programs were voluntary programs where farmers themselves chose whether or not to accept the AAA package or to apply for the farm loans. It is true that takeup rates for the AAA contracts were generally quite high, in part due to various production taxes, but even in those settings some farmers chose not to participate. Similarly, with respect to the public works and relief programs, we know from the large number of studies of New Deal spending across states and counties that the Roosevelt administration and the states distributing the funds paid attention to the extent of distress in the local economy.

Both the AAA and farm loan programs can be considered within a supply and demand framework where farmers are demanders choosing whether or not to take advantage of the program. Meanwhile, the availability of the program and the terms of the programs are set by the political administration in response to a series of factors. The factors that likely influenced the farmers' demand to take advantage of the AAA and loan programs were likely the same types of factors that are already included in the tractor growth equations. Thus, we already have a pretty good description of the demand side of the New Deal farm program equation. We are therefore looking for instruments that describe the political supply function that would shift farmers along their demands for the programs.

The AAA program parameters were set at several levels of government. The basic payments per acre for each crop were set at the national level, based on recommendations from state and local farm groups, but these choices were likely to be influenced by national politics. For example, there is a large literature on New Deal programs that suggests that Roosevelt's administration was interested in aiding swing states in the presidential election to a greater extent (See Wright, Fleck, and literature cited in Fishback, Kantor and Wallis, 2003). Congressmen in powerful positions or on key committees, like the Agriculture committee, had incentives to pressure AAA administrators to help their states (Anderson and Tollison 1991). AAA administrators potentially responded to these pressures by choosing crops from these areas to be

covered by the AAA or by setting the payment terms advantageously for some crops. The national administration also set nationwide quotas for land to be removed from production and then distributed quotas to state and local boards. The state and local boards than determined the base acreage for each farmer and established the package of payments and maximum acreage that would be offered to each farmer. The attractiveness of the package to farmers was also determined by how well the board and local officials sold the program within their district.

A similar story can be told for the farm loan programs, where the national administration established the fundamental features and rules for the program. However, the supply of loans in each area was determined in part by how quickly the state and local administrative bodies formed and how effective they were in providing information and monitoring of the loans. Thus access to loans, the marketing of loans, and the ease of obtaining loans were likely to vary across counties.

The public works and relief programs were distributed quite differently from the farm programs. Raw correlations between the public works and relief programs and the AAA and farm loan programs were very close to zero. Fishback, Kantor, and Wallis's (2003) county-level analysis of the major New Deal categories show that the relief and public works grants were higher in more urban areas and in areas with higher unemployment in 1930, while the farm programs had the opposite signs. Given the focus of these programs on more urban areas one might expect that the public works and relief programs were exogenous to tractor choice, yet there may remain some endogeneity because the availability of harvest labor was so important to the adoption of tractors and the success of farms. Therefore, the use of tractors might have influenced the public works and relief decisions made by federal, state, and local decision makers.

In selecting instruments for the distribution of public works and relief grants, farm loans, and AAA grants, we are looking for factors that vary across counties in ways that might have influenced the political and administrative supply of loans and grants but would not have

influenced the farmers' decisions to expand their use of tractors after controlling for all of the factors we have included in the tractor growth equation. To correct for the endogeneity biases of the New Deal variables, we follow a two stage least squares (2SLS) approach. Since the success of this empirical strategy depends on the credibility of the instruments that are chosen, we follow a stringent set of criteria for choosing suitable identifying instruments. First, the instruments must have been either natural features or have been determined prior to the decisions made about New Deal spending and migration to avoid the potential for simultaneity bias. Second, to insure that the variables have power and make sense in the first-stage regression for which they are primary instruments, the coefficients must have reasonable signs in the appropriate first-stage New Deal regression and the effects must be both economically and statistically significant. Third, it must be the case that over-identification tests cannot reject the hypothesis of no correlation between the identifying instruments and the estimated 2SLS error term of the final-stage tractor-growth equation. In other words, we are testing whether the instruments themselves have been inappropriately omitted from the tractor-growth equation.

There is an extensive literature on the geographic distribution of New Deal spending that suggests that New Deal officials responded in part to political considerations when making their allocation decisions.[26] Robert Fleck (1999a), Fishback, Haines, and Kantor (2005), and Fishback, Horrace, and Kantor (2005 and forthcoming) have had success using some of these political variables as instruments in studies of unemployment statistics, infant mortality, migration, and retail sales growth, respectively. In every study the standard deviation of the presidential vote from 1896 to 1928 has turned out to be an effective instrument for at least one New Deal program. Gavin Wright (1974) originally suggested that New Deal officials could reap a relatively larger marginal political benefit by spending an additional dollar in areas where voters were more likely to switch their party loyalties from one presidential election to another. Wright operationalized this idea using the standard deviation of the percent voting Democrat in presidential elections from 1896 to 1932, but to avoid simultaneity problems in our analysis we

calculate the standard deviation through the 1928 election. Nearly every study of New Deal spending has found this swing-voting measure to be an important determinant of the distribution of spending both at the state and the county level and it has an important positive effect on public works and relief spending in the first-stage analysis here.[27] The question remains as to whether it is correlated with the error term of the second-stage tractor growth equation. There is no possibility that tractor choice in the 1930s would have influenced presidential voting prior to 1929. It also is unlikely that the fluctuations in the presidential vote would have influenced farmers' choices to adopt tractors in the 1930s except only indirectly through factors already controlled for in the analysis.

In addition to the presidential swing measure, we have included measures of the influence of key committees in the House of Representatives. We focus on House committee assignments because the Senate assignments are already controlled by the state dummies in the analysis. Gary Anderson and Robert Tollison (1991) suggest that Congressional representatives on key committees were likely to influence the distribution of funds. Fishback, Kantor, and Wallis (2003, 299 note 21) find that members of the Agriculture committee at the start of the session in 1933 had strong effects on the farm loan and grant programs. Meanwhile, members of the Labor committee in the House of Representatives, in particular, influenced the distribution of federal relief monies across counties. The Labor committee was the primary committee that was devoted to unemployment issues during the New Deal.[28] We chose the committee assignments as of the beginning of 1933 before the New Deal programs were introduced to reduce the possibility that members of Congress would have chosen the committees because they would have anticipated influencing the huge amount of monies that were to be distributed. The House rules and competition for committee assignments also would have served to limit the ability of individual congressmen to gain power over the farm programs in this way. Finally, given the large number of correlates describing conditions for farming circa 1929, it is extremely unlikely that tractor adoptions were being driven by the committee assignments in the House in some separate way.

One factor that the USDAand state and local authorities may have considered in their distribution of AAA and FCA funds was the extent to which the area was a frontier area for agriculture. The history of agricultural settlement in the U.S. had always been one of westward movement with some tendencies to later moves northward as well. This was largely true within state boundaries, as well. Farmers in areas of later settlement often ran into more problems in obtaining credit due to the higher costs of monitoring loans in more remote areas and the often greater uncertainty associated with new settlement. Particularly in the western states, the inefficiently small size of farms on the frontier that was a path dependent legacy of Homestead Act acreage restrictions and farming requirements for obtaining free land often meant that many of the frontier farms were in trouble. Part of the American psyche seems to be a strong affinity for the small family farm, particularly on the frontier. Therefore, AAA officials had incentives to set parameters for taking land out of production that favored frontier areas, while FCA officials might have distributed more loans in the more frontier areas within states in anticipation of larger benefits to farmers because loan terms in the frontier districts were worse relative to other areas. To capture this frontier effect, we use the latitude and longitude of the county seat as instruments for the AAA grant and the farm loan variables. The location of county seats was set before the 1930s, so the New Deal programs would not have affected them. Note that latitude and longitude are capturing frontier features after controlling for the state in which the farm was located, a variety of measures of soil quality, typical weather, extreme weather, and the productivity of crops as of 1929. The inclusion of these controls captures nearly all of the channels through which we might expect longitude and latitude to influence tractor growth in the final equation.

The instrument list also includes several factors targeted at the distribution of public works and relief funds. The creation of the programs led to a search for worthwhile public projects. During the 1920s there were significant problems with flooding in many areas that led to a series of proposals by federal agencies like the Army Corps of Engineers and state and local agencies to develop flood control projects along major rivers. Meanwhile, many cities with

harbors had developed plans for improving access to harbor facilities. With the plans already established, these projects were ready-made and could be pulled off of the shelf when the Roosevelt administration started handing out large-scale public works and relief grants. Therefore, we anticipate that the presence of major rivers and harbors in a county added a significant number of ready-made projects not found in other areas that could be proposed to New Deal Administrators.[29] The instruments we developed to capture this affect is a count of the number of harbors located in a county and a count of the number of extremely large rivers that pass through the county. We defined extremely large rivers as ones that passed through 50 or more counties, which includes only the Ohio, Mississippi, and Missouri Rivers. The rivers variable records the number of these three major rivers that passed through the county.[30] Could the rivers have influenced tractor adoption decisions? One possibility is that access to rivers lowered transport costs, which in turn influenced prices of farm inputs and outputs. Note, however, that many of the controls in the tractor growth equation, particularly the state dummies, population, the percent urban, and the extent of retail sales as of 1929 already capture this correlation with transport costs because population centers and strong retail areas tended to locate along rivers and harbors. .

There is reason to believe that each of the instruments influences at least one of the New Deal policies, but there may be concern that there still exists correlation between the identifying instruments and the error term of the second-stage migration equation, even after controlling for the major determinants of tractor growth. We believe that the set of independent variables in the equation foreclose the avenues for such correlation, but since the true error term is unobservable, there is no way to eliminate this concern fully. To mitigate this concern, however, we tested the hypothesis that the group of identifying instruments are uncorrelated with the 2SLS estimates of the migration error term using the Hansen J-statistic reported in the ivreg2 command available as an ado file from STATA.[31]

VI. Results

The data set consists of 3018 U.S. counties that reported information on the New Deal variables for the 1930s and on tractors in both 1929 and 1939.[32] The New Deal variables are measured as FCA and FSA loans from March 1933 through June 1939 per rural farm person in 1930, AAA grants from 1933 through 1937 per rural farm person in 1930, and public works and relief spending from 1933 through June 1939 per person in 1930. We have also estimated the models by normalizing the Farm loans and the AAA grants with number of farms in 1929. The correlations with the per rural farm measures are roughly 0.93 and the basic results are very similar to what we report for the rural farm population, so we do not report both sets here.

Figures 1 through 3 show the relationships between the tractor growth rates and the New Deal measures at the state level. No clear pattern appears to arise out of the figures, except for possibly an inverted U for tractor growth rates and the AAA grants per rural farm person. We plan to explore the possibility of an inverted U-shape later. However, there is tremendous variation even within states for tractor growth rates and the various programs. We don't show the figures where all county information is plotted because it looks like a huge cloud with no discernible pattern.

The first several lines in Table 1 show the basic relationships between the New Deal and tractor growth as we add more and more controls to the analysis and reduce omitted variables bias. The coefficients for the New Deal programs are very sensitive to the inclusion of other correlates. The first line with no other correlates suggests economically small and statistically insignificant effects of the farm loans and the public works and relief programs and negative and statistically significant effects of the AAA on the growth rate of tractors. As we add more correlates, the coefficients on the farm loan and public works variables become negative. Ultimately, when we include state effects, the coefficients tend to be very small in magnitude and statistically insignificant.

Although we have reduced the extent of endogeneity bias to some extent by adding correlates to remove omitted variable bias, there still remains the possibility of simultaneity and endogeneity that might not have been controlled for. To correct for this potential bias, we estimated the model with Two Stage Least Squares incorporating the set of instruments described in the previous section. Tables 2 and 3 contain the results from the first-stage equations with and without controlling for farm size or tenure and plantation structure. In the first-stage equations each New Deal fund category is a function of the identifying instruments and all right-hand side variables in the final tractor growth rate equation. The key variables that we used to instrument for each of the programs have the anticipated signs in the equations for those programs and tend to be statistically significant at the 10 percent level. One or both of the latitude and longitude frontier instruments have statistically significant effects for both the farm loans and AAA grants suggesting that within the same state and controlling for other factors, more northern and western states received more funds. As expected, more representation on the House of Representatives agricultural committee contributed to higher AAA grants per capita, although there is no positive statistically significant effect on farm loans. Public works and relief grants per capita were larger in areas where harbors and large rivers offered more ready-made flood control, dock, and dredging projects that could employ many workers. Counties with higher standard deviations in the percent voting Democrat for president, suggesting more swing voting were more likely to receive public works and relief funds. Representation on the House labor committee also contributed to greater public work and relief spending.[33] When we test the hypothesis that the coefficients of the identifying instruments are all zero in each of the first-stage equations in the model without farm size and tenure structure, the F-statistics are 6.93 for the farm loans per rural farm person, 12.26 for the AAA per rural farm person, and 3.49 for the public works and relief per capita. In the model with farm size and tenure structure, the F-statistics are lower and thus there may be more weak instrument bias. The groupings are all statistically significant at the 0.1 percent level A key question is whether the identifying instruments are correlated with estimates

of the error term in the final tractor growth rate equation. The Hansen over-identification Chi-squared test with four degrees of freedom shows p-values of 0.547 and 0.282 for the two 2SLS specifications, and thus we can not reject the hypothesis of no correlation at standard levels of statistical significance. This is consistent with the view that the identifying instruments have not been inappropriately omitted from the final-stage equation.

Our expectation is that the endogeneity/simultaneity bias in the OLS estimation is likely to be negative for all three New Deal programs that we examine. All three programs were designed to respond to problems in the farm sector during the 1930s, so that areas that faced greater downturns not already captured by weather and other factors would likely have seen increased funding. Meanwhile tractor use was likely to be positively associated with farm success. The combination of the former negative correlation and the latter positive correlation would have imparted a negative bias to the New Deal coefficients.

We start by focusing on the estimation without controls for farm size and tenure. The 2SLS results reported in Tables 1 through 3 are consistent with our expectation of a negative bias for the OLS estimates as the coefficients of all three New Deal programs become positive. The farm loan and public works and relief coefficients are both statistically significant at the 6 percent level or better, while the AAA coefficient is statistically significant at the 16 percent level. We had anticipated that the farm loan programs would have had a positive effect on tractor growth by lowering interest rates on farm mortgages and crop loans, expanding the length of the loans, and raising the share of value on which the farmers could borrow. An additional dollar per rural farm person in farm loans raised the tractor growth rate by 0.47 percent for the 10 year period, holding fixed the prior level of tractors. A difference of one standard deviation is a relatively common difference found within samples and can give us a better sense of the historical importance of the farm programs. As seen in Table 4, a one-standard-deviation increase in rural farm loans per rural farm person of $75.95 would have been associated with a 0.717 standard deviation increase in the growth rate of tractors.

The presence of more public works and relief funds also contributed to greater tractor growth, probably by relaxing the harvest labor constraint in these areas. Public works and relief expenditures had reduce net out-migration in a county-level study by Fishback, Horrace, and Kantor (forthcoming). It appears that the program administrators generally were following practices of releasing workers for harvest without prejudice against their return to the projects when the harvest was over. An additional dollar per person of public works and relief contributed to a 0.19 percent increase in the tractor growth rate, holding the prior log level of tractors per farm constant. This effect is reasonably large, as a one-standard deviation increase in these grants of $107.5 was associated with a 0.45 standard deviation increase in the tractor growth rate.

The AAA grant program had a smaller direct effect than the other two programs even though the size of the subsidy was larger than under the farm loans. An additional dollar per rural farm person raised the tractor growth rate by only 0.12 percent and the effect is statistically significant at the 16 percent level. The smaller impact of the AAA might have been the combination of a series of the offsetting effects we described earlier. Switching the land to alternative uses may have still provided work eased by the use of a tractor while at the same time easing the harvest labor problems that farmers faced. This positive effect might have been at least partially offset, however, by the lower costs associated with using horses and mules as the land was converted to the production of feed and forage production.

We have done some additional robustness testing by re-estimating the model with additional controls for farm size as of 1929, the share of cash tenants, the combined share of renters and tenants , and Nancy Virts' (forthcoming) index of the extent of plantation activity in counties as of 1910. The addition of these controls weakens the F-statistics for the group of identifying instruments in the first stage equations to 2.71 for farm loans, 10.57 for AAA and 3.34 for public works and relief--although the hypotheses that the coefficients of the identifiers are all simultaneously zero in each equation are still rejected at the 1 percent level. The Hansen over-

identification test still cannot reject the hypothesis of no correlation between the identifying instruments and the 2SLS estimate of the error term at a p-value of 28 percent.

In this new specification in Table 3 and the bottom row of Table 1, the coefficient of the New Deal farm loans nearly doubles in size and the impact of the public works and relief grant increases by about 15 percent. In contrast, the AAA coefficient is cut by two-thirds. Some of the changes in the coefficients might be caused by greater weak instrument bias associated with the smaller F-statistics for the public works and relief and the farm loan programs.

Although our emphasis has been on the New Deal farm programs, the analysis also shows the impact of other key variables on the growth in tractors. The coefficients are in Tables 2 and 3 and the one-standard-deviation effects are in Table 4. Better hydrological soil quality on several dimensions—average water content, permeability, and hydric—were associated with faster tractor growth, while more slope reduced tractor growth. Tractor growth was slower in areas with high precipitation, greater variation in monthly temperatures, more months of extreme or severe drought and wetness and in the dust bowl counties. Consistent with the emphasis in the literature on the problems in obtaining harvest labor in more isolated areas, tractor growth was more rapid in counties with more urbanization and larger populations.

Crop mix was also important. Within states, areas with crop mixes focused on more cotton and less corn in 1929 were more likely to see rapid tractor growth within the same state. Meanwhile areas experiencing lower crop values per rural farm person in 1929 experienced more rapid tractor growth. It may be that farmers in less successful areas as the economy peaked in 1929 saw tractors as a way to enhance productivity.

When we include the percentages of farms at different farm sizes in 1929, the OSD effects rise as we move from the percentage of farms with 3-9 acres to the percentage of farms with 100-174 acres, but the only statistically significant effect was for the 100-174 acre groups. The effects beyond these farm sizes are also statistically insignificant. It is not clear how this finding fits with the threshold models. In cotton areas Whatley had suggested that 263 acres

was the threshold circa 1929, such that many farms above this size were likely to have adopted tractors already. The tractor improvements found by White (2001, 2000) might have opened up opportunities for smaller cotton farms that had not adopted tractors prior to 1929, particularly those with farm sizes from 100 to 174 acres. Meanwhile Clarke (1994, p. 290) found optimal threshold sizes of 65 acres in the corn belt in 1929 and 59 acres in 1939. At the same time she suggested that there were a large number of corn farms above the threshold that did not have tractors in both 1929 and 1939. It may be that the tractor improvements opened up more opportunities for corn farmers who had not yet adopted in the 100-174 acre range in ways that Clarke could not capture with her calculations.

The presence of plantations and share tenants and croppers did not appear to be a barrier to the growth of tractors in the 1930s, holding state and crop mix constant. A higher percentage of plantations in 1929 increased the tractor growth rate, such that a one-standard-deviation increase in Nancy Virts' 1910 plantation index raised the tractor growth rate by 0.075 standard deviations. The share of tenants and croppers had a very small negative effect that was not statistically insignificant. Our sense is that the contracting under share tenancy and share cropping and on plantations allowed for significant flexibility in the use of labor and of tractors. For example, Hoffsomer's (1950) study of cotton counties in Mississippi and Arkansas found that croppers and tenants earned 10 to 20 percent of the annual earnings in wage work off of their tract but often on the same plantation. Croppers or tenants were often the tractor drivers, and it seems reasonable that the tenants, croppers, and landlord might have established informal or formal arrangements to have the tractor plow and aid in weeding tenant and cropper fields in return for harvest labor. In fact, it would not be surprising on plantations if the croppers and wage workers aided each other on the plantations.

VII. Future Work

It is certainly possible that the impact of the New Deal programs varied within regions. We plan to re-estimate the tractor equations for key sub-regions of the United States, including

the cotton belt, the corn belt, wheat belt, and tobacco areas. For the cotton belt, we focus on southern states where production is greater than $100,000 in value and cotton is at least 20 percent of crop value. We will also try some analysis limiting the sample to the plantation areas. For corn and wheat we follow the crop value and percentage rules but focus on the Midwestern and Great Plains states. For tobacco we will focus on southern states and counties with tobacco.

Another plan is to look beyond tractor choice and run similar analyses for a variety of farm inputs, structures, and farm outcomes. This would involve similar analysis of the factors influencing the rural farm population, the value of farm land, number of farm trucks, number of farm autos, crop values, crop mix, and tenancy structure.

VIII. Conclusions

Despite a decade of Depression, there was significant expansion in the adoption of tractors during the 1930s. The results here suggest that New Deal programs contributed to the growth rate in the use of tractors between 1929 and 1939. Farm loan programs and the public works and relief programs in rural areas both raised the growth rate of tractor usage in economically and statistically significant ways. The estimated effects for the AAA are also positive but smaller in magnitude and we cannot always reject the hypothesis of no effect on the growth rate in tractors.

The findings in this paper fit in well with other recent studies of the impact of the New Deal. Public works and relief spending contributed to increased economic activity in many areas and were associated with net in-migration into areas. In the farming sectors the presence of public works and relief spending reduced out-migration, which in turn aided the diffusion of tractors by relaxing the harvest labor constraint that had been a problem for tractors in the past.

The findings here suggest that the AAA had complex effects. The program was designed to raise farm incomes relative to nonfarm incomes to levels seen circa 1910-1914. As yet, we have not estimated the AAA's success at achieving this goal. However, we have examined a variety of effects in other areas that suggest that the AAA might well have been highly

redistributive. The results in this paper suggest that the AAA might have contributed to the adoption of tractors, but this possible technological benefit likely came at substantial costs to other some segments of the farm population before the programs were adopted. Other studies in our project show that AAA payments did not lead to a rise in retail sales suggesting that the benefits of the program that accrued to the farmers receiving grants were likely offset by losses to other parts of the farm population. The fact that infant mortality rates for blacks and whites in the South rose and that the AAA was associated with significant out-migration seems to confirm this finding.

Data Source Appendix

New Deal funding information is from the U.S. Office of Government Reports (1940). For the case of the AAA farm payments, we had information for 1933 through 1937. The AAA grants and farm loans were divided by the 1930 rural farm population. New Deal spending on public works and relief was divided by the overall population in 1930. The retail sales information for 1929 is from Historical, Demographic, Economic, and Social Data: The United States, 1790-1970, ICPSR study number 0003, as corrected by Michael Haines. To calculate per capita retail sales information for 1929, we calculated 1929 population as 1930 minus the average change in population between 1930 and 1940; we did not use trends from 1920 to 1930 due to changes in county boundaries during the 1920s. [34]

Population , unemployment, layoffs, percent black, percent urban, percent foreign born, percent illiterate, percent homeowners, county land area, the farm size measures, average family size, percent of acres of farms run by cash tenants and by share tenants, owner-operated, and percent of cultivated acreage that failed from 1929 and 1930 are from the 1930 files in ICPSR study number 0003, as corrected by Michael Haines. The information on crop values, percent cotton, percent corn, percent wheat, and percent tobacco in 1929 are from the 1940 files in ICPSR study number 0003, as corrected by Michael Haines. We loaded information on tractors in 1929 and 1939 from Table 11 in U.S. Census Bureau's Census of Agriculture (1942).

"Dust Bowl" counties were obtained from Hansen and Libecap (2004). The presidential voting variables – standard deviation of the Democratic share of the presidential vote from 1896 to 1928 – were calculated using information from the ICPSR's, United States Historical Election Returns, 1824-1968 (study number 0001). In some cases there were missing values for the percent voting for president, so we used averages from the contiguous counties in their place.

House Committee memberships in 1933 are from U.S. Congress (1933). The latitude and longitude of county seats are from Sechrist, "Basic Geographic and Historic Data" (ICPSR study number 8159).[35]

The climate data are available from the National Climatic Data Center (NCDR). Text files of the data were accessed from ftp://ftp.ncdc.noaa.gov/pub/data/cirs/ (August 2003). The NCDR reports historical monthly data by climate division within each state, so each county's climate information pertains to its respective climate division. In some cases a county was located within two or three divisions. In these cases, the county's climate information was calculated as the average across the climate divisions in which it was located.

Roger Paine and Joe Johnson of the U.S. Geological Survey gave us a list of all the "streams" listed in the GNIS names topographical map database with all of the counties in which each stream was currently located. This information also can be obtained stream by stream through query at http://geonames.usgs.gov/pls/gnis/web_query.gnis_web_query_form as of August 2003. Streams is a broad definition including creeks and rivers. There were over 100,000 stream names in the data base. Each stream name has a numeric feature code as well as the name. Using the numeric feature code, we performed frequencies on the number of counties in which each stream was listed. We then developed a series of variables showing access to streams that ran through different numbers of counties. The riv51up is the number of rivers running through the county that ran through over 50 counties. Only the Mississippi, Missouri, and Ohio Rivers, ran through as many as 50 counties, and they are the major rivers in the Eastern and Midwestern United States. We also experimented with a second variable (riv2150) for access to rivers passing through 21 to 50 counties (includes the Red, Arkansas, Tennessee, Snake, Rio Grande, Canadian, Chattahoochie, Columbia, Brazos, Cumberland, Colorado, White, Cimarron, Des Moines, and James). Another dummy, riv1120, encompasses the next largest 53 rivers. Of the rivers passing through over 10 counties, most are considered navigable by modern definitions

by the Army Corps of Engineers. The ones not listed as navigable are mostly western rivers and include the Niobrara, Sheyenne, Washita, Catawba, Cheyenne, North Canadian, Canadian, Smoky Hill, Alapaha, Big Sioux, Neches, Pecos, Wisconsin, Yellowstone, Des Moines, Rio Grande, Nueces, Platte, Big Black, Rio Brazos, Cimmarron, Wapsipinicon, and Sabine. The variable for riv0510 encompasses 384 rivers. The information on which waterways were navigable was provided by Amy Tujaque, who is a Survey Statistician for the Waterborne Commerce Statistics Center for the U.S. Army Corps of Engineers. We used a relatively coarse measure of access because the Geological Survey staff warned us that sometimes the same river might have multiple feature numbers. On the other hand, there are also quite a few stream names that appear multiple times but are clearly not connected. We examined the situation for the major rivers and found that this was not a significant problem for them.

The data set consists of 3,018 counties and county/city combinations in the United States with information on tractors in 1929 and 1939 and on New Deal spending. The New Deal program information was reported for some combined counties. For example, the New Deal information was reported for all of New York City. Thus, in New York state, Bronx, King, New York, Queens, and Richmond counties were combined into New York City. Similar situations developed in other states. In Missouri the city of St. Louis and St. Louis County were combined. In Virginia we combined the following districts that were reported separately in the Census: Albemarle County and Charlottesville city; Allegheny County and Clifton Forge city; Augusta County and Staunton city; Campbell County and Lynchburg city; Dinwiddie County and Petersburg city; Elizabeth City County and Hampton city; Frederick County and Winchester city; Henrico County and Richmond city; Henry County and Martinsville city; James City County and Williamsburg city; Montgomery County and Radford city; Nansemond County and Suffolk city; Norfolk County with Norfolk city, South Norfolk city, and Portsmouth city; Pittsylvania County and Danville city; Prince George County and Hopewell city; Roanoke County and Roanoke city; Rockbridge County and Buena Vista city; Rockingham County and Harrisonburg city;

Spotsylvania County and Fredericksburg city; Warwick County and Newport News city; Washington County and Bristol city; Arlington County and Alexandria city.

For latitude and longitude we used maps from the 1930s to determine which counties were contiguous to each other; the largest number of contiguous neighbors for a single county was 14. When developing the inverse distance spatial weighting scheme, we used the ICPSR data set 8159 created by Robert Sechrist. We found a number of errors in the latitudes and longitudes in ICPSR data set, which were corrected: Dutchess, NY latitude 41.45, Greene, PA longitude 80.12, Moultrie, IL latitude 39.35, Fulton IN latitude 41.07 longitude 86.15, Rock Nebraska longitude 99.32, Butte, SD latitude 44.38, Campbell, SD latitude 45.44, McCook SD latitude 43.39, Webster, GA latitude 32.04, Greene, NC latitude 35.28, longitude 77.45, Sampson NC latitude 35.0; Wake, NC latitude 35.45; Rains, TX latitude 32.52; Fulton, KY latitude 36.33; Custer, OK longitude 98.57; Carbon, MT longitude 109.2; Santa Fe, NM latitude 35.4; Mendocino, CA latitude 39.09, longitude 123.12; Multnomah, OR longitude 122.4.

We developed a series of variables to describe the elevation range and maximum elevation and information on the number of bays, lakes, beaches, etc., as reported in the USGS's Geographic Names Information System. The information was downloaded from http://geonames.usgs.gov/stategaz/index.html (August 2003). The data set describes features noted on small-scale topographical maps, including mouths of streams, lakes, valleys, summits, cliffs, bayous, beaches, etc.[36] The Geographic Names Information System (GNIS) contains name and location information about almost 2 million physical and cultural features located throughout the United States and its Territories.GNIS was developed by the U.S.Geological Survey in cooperation with the U.S. Board on Geographic Names (BGN) to promote the standardization of feature names. GNIS is being compiled in phases. The first phase is complete for the entire U.S., and entailed the collection of names from Federal sources including large-scale USGS topographic maps, Office of Coast Survey charts, U.S. Forest Service maps, and digital datasets

distributed by the Federal Communications Commission, the Federal Aviation Administration, and the U.S. Army Corps of Engineers. The second phase of data collection is complete or in progress for about 90% of the U.S., and captures names from State, locally, and other published current and historical maps, charts, and texts. The information was downloaded in August 2003 from http://geonames.usgs.gov/stategaz/index.html.

The data set describes features noted on small-scale topographical maps, including mouths of streams, lakes, valleys, summits, cliffs, bayous, beaches, etc. Elevation was listed for a significant number of features in each county. We used this information to determine the maximum and minimum elevation listed and the range between the two figures. We did not try to calculate an average elevation because many of the features did not include information on elevation. Because of the lack of full coverage there may be some measurement error, but our sense from spot checks around the country is that the maximum and minimum elevations are reasonable depictions of those figures.

From the data set we calculated the number of summits and valleys to get a sense of the degree to which there were fluctuations in terrain. The original database includes the number of airports, arches, areas, arroyos, bars, basins, bays, beaches, benchs, bends, buildings, canals, capes, cemeterys, churchs, civils, cliffs, craters, crossings, dams, falls, flats, forests, gaps, guts, harbors, hospitals, islands, lakes, locales, militarys, mines, oilfields, parks, pillars, plains, postoffs, populated places, ranges, rapids, reserves, reservoirs, ridges, schools, springs, mouths of streams, summits, swamps, towers, trails, tunnels, valleys, wells, woods. For the purposes of our research we sought to avoid using man-made features, so we used only summits, bays, lakes, summits, valleys, mouths of streams, swamps, beaches, forests, and woods. Even in these cases there may have been changes wrought since the 1930s, so there is likely to be some measurement error for the natural features as they stood in the 1930s.

When we were working with the geography measures and the river measures, there were some county boundary changes between 1940 and 2000. In situations where new counties were carved from older counties, we have merged the new county information back in with the older counties. La Paz in Arizona was merged back in to Yuma county and Cibola county in New Mexico was merged back into from Valencia. [Broomfield, Colorado was formed in 2001 but had no streams listed.] Virginia developed a new set of independent cities and their information was merged back into the county/city combinations that we developed for the New Deal. We did not pay close attention to situations where parts of some counties were annexed to others, but we do not believe this to be a serious problem. In South Dakota Washabaugh county had been combined into Jackson county and Washington County had been combined into Shannon after 1940. To determine the geographic features for Washabaugh we used any features above latitude of 4.372694 from Jackson county. This may overstate some features in Washabaugh. For Shannon we took all features in Shannon county below latitude 43.30139. Information on county boundary changes since 1970 comes from http://www.census.gov/geo/www/tiger/ctychng.html#1970.

The various measures of soil quality in the database are from the 1990s from the State Soil Geographic (STATSGO) Data Base for the Conterminous United at http://water.usgs.gov/lookup/getspatial?ussoils. Mickey Lynn Reed and Todd Sorensen at the University of Arizona converted the information to county data by using ARC-GIS mapping software to layer county boundaries over the basic data set of 78,518 polygonal land areas and create averages weighted by land area.. When a county boundary split a polygon, they were able to determine the area of that polygon within each county. For each county they then developed weighted averages of the variables with the land area as the weight. This is modern data and there have been some mergers and additions of new counties since 1940. We merged new counties back into their original counties during the 1930s. Three counties in South Dakota, Armstrong, Washabaugh, and Washington had been merged into other counties. In those cases

we gave Armstrong, Washabaugh and Washington the values of the counties into which they had been merged.

According to the U.S. Natural Resources Conservation Service, AWC is “the volume of water released from the soil between the time the soil is at field capacity (the maximum water held in soil against the pull of gravity) until the time it is at the wilting point (the amount of water held too tightly in soil for commonly grown crops to extract). Loamy soils and soils high in organic matter have the highest AWC.” Clay is the percent of soil consisting of clay (in percent of material less than 2mm in size). Kffact is the actual k factor used in the universal soil loss equation to calculate soil loss by water. LL is the liquid limit of the soil layer (in percent moisture by weight). OM is the organic material in the soil (in percent by weight). Perm is the permeability of the soil (in inches per hour). Thick is the depth of soil layers (in inches). Hygrp is a code identifying the hydrologic characteristics of the soil, converted into a numeric code by Bill Battaglin's methods, where 1 is high infiltration, deep soils, well drained to excessively drained sands and gravels, 2 is moderate infiltration rates, deep and moderately deep, moderately well and well drained soils with moderately coarse textures, 3 is slow infiltration rates, soils with layers impeding downward movement of water, or soils with moderately fine or fine textures, 4 is very slow infiltration rates, soils are clayey, have a high water table, or are shallow to an impervious layer. Battaglin subselected certain areas and assign values for hygrp based on the area type. Miscellaneous areas labeled as Dumps, and Gullied Land are assigned the hygrp = 2.5 if the hydgrp value is missing. Areas denoted as Pits, Rock Outcrops, Terrace Escarpments, and Urban land with missing hydgrp are assigned a hygrp of 4. See the documentation of the SAS program "setussoils.sas" at http://water.usgs.gov/lookup/getspatial?ussoils for additional details. The transformed data are averaged across components using the component percentage as weights.

Float is a code identifying the quality of soil drainage, where 1 is excessive, 2 is somewhat excessive, 3 is well drained, 4 is moderately drained, 5 is somewhat poorly drained, 6 is poorly drained, 7 is very poorly drained. Slope is the slope of the map unit in percent. Ifhydric is the share of the map unit with hydric soils, where 1 means the entire map unit has hydric soils). Afldfreq is the annual flood frequency code, where 1 is greater than 50%, 2 is 5% to 50%, 3 is 0% to 5%, and 4 is flood. In all cases the values for each variable are averaged across components using the component percentage as weights. See http://soils.usda.gov/sqi/soil_quality/what_is/glossary.html for more detail.

Table 1

OLS and 2SLS Estimates of Impact of New Deal Programs on Tractor Growth Rates Under Several Specifications

Correlates Included	Coefficients (t-statistics)			R-squared	F-Statistics in First Stage	Hansen p-value
	Farm Loans	AAA	Public Works and Relief			
ORDINARY LEAST SQUARES						
No Other Correlates	0.00014	-0.00042	0.00003	0.001	n.a.	n.a.
	(0.69).	(-5.46)	(0.27).			
log(tractors per farm 1929)	0.00052	-0.00011	0.00012	0.054	n.a.	n.a.
	(2.51).	(-1.29)	(0.88).			
log(tractors per farm 1929); weather and soil	-0.00008	-0.00031	-0.00018	0.293	n.a.	n.a.
	(-0.42)	(-3.36)	(-2.03)			
log(tractors per farm 1929); weather and soil; socio-economic	-0.00015	-0.00023	-0.00025	0.349	n.a.	n.a.
	(-0.78)	(-2.42)	(-2.97)			
log(tractors per farm 1929); weather and soil; socio-economic; crop mix and farm success	-0.00025	0.00021	-0.0002	0.383	n.a.	n.a.
	(-1.38)	(1.76).	(-2.20)			
log(tractors per farm 1929); weather and soil; socio-economic; crop mix and farm success; state effects	-0.00003	-0.00001	-0.00005	0.485	n.a.	n.a.
	(-0.17)	(-0.13)	(-0.45)			
log(tractors per farm 1929); weather and soil; socio-economic; crop mix and farm success; state effects; farm size and tenure	0.00001	0.00017	0.00002	0.519	n.a.	n.a.
	(0.06).	(1.48).	(0.16).			

Table 2

Full OLS and 2SLS First and Second Stage Estimates without Farm Size, Tenure, and Plantation Variables

Table 2

			Two Stage Least Squares							
	OLS		Second Stage		First Stage					
	Tractor Growth Rate		Tractor Growth Rate		Farm Loans per rural farm person		AAA Grants per Rural Farm Person		Relief and Public Works Grants Per Capita	
VARIABLES	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Constant	1.404	2.47	-0.080	-0.08	-261.784	-1.46	-520.379	-3.5	-102.479	-0.38
NEW DEAL GRANTS AND LOANS										
FSA AND FCA loans per rural farm population	-0.032	-0.17	0.005	2.73						
AAA spending per rural farm population	-0.014	-0.13	0.001	1.41						
Per Capita Public Works and Relief Grants	-0.052	-0.45	0.002	1.89						
IDENTIFYING INSTRUMENTS										
Number of Harbors					-2.568	-3.05	-2.534	-2.15	10.246	3.08
Latitude					2.696	1.44	5.137	3	0.235	0.07
Longitude					3.520	4.48	3.854	6.52	1.487	0.9
St. Dev. of %. Democrat for President, 1896-1928					-0.125	-0.18	0.358	1.08	1.497	2.02
House Agricultural Committee, Jan. 1933					-4.307	-1.28	25.815	6	-0.725	-0.13
House Labor Committee, Jan. 1933					-3.224	-0.9	29.817	3.41	12.312	1.89
Rivers Running Through 51 or More Counties					4.209	1.32	-2.476	-0.85	13.715	2.86
CORRELATES FOR TRACTOR GROWTH										
Log of Tractors Per Farm, 1929	-0.222	-14.22	-0.233	-12.17	1.787	0.92	-1.323	-0.69	-4.331	-1.24
GEOGRAPHY AND SOIL QUALITY										
Elevation Range	0.000	-0.58	0.000	0.58	-0.004	-1.54	-0.010	-4.05	0.007	0.78

Maximimum Elevation	0.000	1.96	0.000	-0.34	0.006	1.83	0.011	4.04	-0.004	-0.45
Slope of the map unit	-0.014	-6.12	-0.011	-3.68	-0.727	-3.04	0.151	0.67	-0.273	-0.56
Average water content	2.600	3.92	2.945	3.4	-35.531	-0.47	342.721	4.02	-306.114	-2.33
% of soil consisting of clay	0.009	2.29	0.005	0.68	1.504	1.36	-0.296	-0.59	-0.810	-0.79
k factor measuring soil loss by water	0.230	0.78	0.673	1.54	-79.394	-1.51	-2.271	-0.06	32.196	0.57
Organic material in soil	-0.005	-1.1	-0.010	-0.84	1.053	0.59	-2.359	-2.12	1.912	1.96
Permeability of soil in inches per hour	0.034	3.55	0.043	3.22	0.938	0.53	-1.394	-1.18	-1.838	-1.03
Depth of soil layer in inches	-0.001	-0.54	-0.001	-0.71	-0.104	-0.43	0.357	1.57	-0.039	-0.09
A code identifying hydrologic characteristics	0.037	0.92	0.037	0.68	-2.689	-0.32	-6.109	-1.13	14.403	2.12
A code identifying the quality of soil drainage	-0.060	-1.71	-0.011	-0.22	0.315	0.04	-1.129	-0.25	-14.246	-2.19
Liquid limit of soil layer	-0.005	-1.34	-0.003	-0.48	-0.626	-0.94	0.588	1.08	-0.362	-0.35
Share of map unit with hydric soils	0.553	3.91	0.523	2.45	-23.120	-0.82	44.345	2.76	15.183	0.7
Annual flood frequency code	-0.014	-0.32	0.110	0.82	-16.344	-0.8	7.354	1.35	-15.265	-2.18
WEATHER VARIABLES IN 1930S										
Temperature Standard Deviation 1930-1939	-0.007	-0.69	-0.016	-1.05	1.104	0.65	-2.629	-1.5	6.914	1.73
Precipitation Average 1930-1930	-0.126	-4.79	-0.100	-2.89	-3.459	-0.73	-6.692	-1.79	4.456	0.75
Temperature Average 1930-1939	-0.008	-1.78	0.001	0.13	0.353	0.36	-0.092	-0.1	0.463	0.21
Months of Extreme or Severe Wetness 1930s	-0.001	-0.4	-0.015	-2.5	1.698	3.4	0.001	0.01	3.165	1.31
Months of Extreme or Severe Drought 1930s	-0.003	-4.03	-0.002	-2.25	0.026	0.24	-0.457	-3.25	-0.105	-0.52
Dust Bowl County Dummy	-0.212	-3.32	-0.856	-3.63	45.900	3.76	216.528	6.82	68.203	4.42
SOCIO-ECONOMIC VARIABLES 1930 AND 1929										
Number of Layoffs as % of population, 1930	-0.002	-0.19	0.003	0.16	-2.799	-1.11	2.118	1.61	3.301	0.94
Number Unemployed as % of population 1930	0.018	1.68	-0.016	-0.59	0.417	0.13	-1.962	-1.25	14.906	2.81
% Illiterate 1930	-0.003	-0.99	-0.001	-0.3	-0.067	-0.14	0.640	2.11	-0.957	-0.77
% Black 1930	0.000	-0.37	0.000	-0.24	-0.092	-0.65	0.019	0.23	0.201	0.95
% Urban 1930	0.000	-1.02	0.003	2.28	-0.392	-3.03	-0.543	-6.06	-0.166	-1.13
Population in Thousands 1930	0.000	0.44	0.000	1.92	-0.020	-2.09	-0.003	-0.29	-0.049	-2.02
Retail Sales Per Capita 1929	0.000	1.55	0.000	-1.71	0.085	3.15	0.103	4.55	-0.013	-0.46

Average Family Size 1930	-0.075	-1.78	-0.066	-1.02	0.407	0.09	-2.630	-0.44	1.890	0.3
CROP MIX AND FARM SUCCESS 1929										
Corn % of Crop Value 1929	0.008	0.1	0.153	1.37	-28.797	-2.1	8.932	0.69	-1.206	-0.06
Wheat % of Crop Value 1929	-0.436	-5.91	-1.012	-2.94	11.206	0.78	380.087	22.12	8.623	0.45
Cotton % of Crop Value 1929	0.398	5.16	0.810	4.6	-82.204	-4.87	22.468	2.14	-49.726	-2.63
Tobacco % of Crop Value 1929	0.042	0.41	0.220	1.54	-35.694	-3.44	48.279	5.94	-44.640	-3.08
Crop Value Per Rural Farm Population, 1929	0.000	1.2	0.000	-2.34	0.074	6.62	0.164	8.04	-0.058	-3.02
% of Acres on Farms with Crop Failures 1929	-0.005	-1.94	-0.008	-1.94	0.288	0.54	1.719	3.73	-0.223	-0.19
State Fixed Effects	Included				Included		Included		Included	
R^2	0.480				0.743		0.898		0.625	
N	3019		3019		3018.000		3018.000		3018.000	

Table 3

Full OLS and 2SLS First and Second Stage Estimates Including Farm Size, Tenure, and Plantation Variables

			Two Stage Least Squares							
	OLS		Second Stage		First Stage					
	Tractor Growth Rate		Tractor Growth Rate		Farm Loans per rural farm person		AAA Grants per Rural Farm Person		Relief and Public Works Grants Per Capita	
Variables	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Constant	0.566	0.79	-0.810	-0.45	-320.706	-2.03	-478.836	-3.28	501.050	1.41
NEW DEAL GRANTS AND LOANS										
FSA AND FCA loans per rural farm population	0.00001	0.06	0.00798	2.23						
AAA spending per rural farm population	0.00017	1.48	0.00042	0.42						
Per Capita Public Works and Relief Grants	0.00002	0.16	0.00226	1.63						
IDENTIFYING INSTRUMENTS										
Number of Harbors					-1.108	-1.39	-1.515	-1.4	8.579	2.65
Latitude					3.798	2.25	4.752	2.88	0.623	0.17
Longitude					1.144	1.89	3.001	4.98	0.717	0.49
St. Dev. of %. Democrat for President, 1896-1928					-0.273	-0.42	0.394	1.2	1.617	2.15
House Agricultural Committee, Jan. 1933					2.125	0.73	28.221	6.65	-0.605	-0.1
House Labor Committee, Jan. 1933					-2.084	-0.63	30.086	3.68	13.338	2.08
Rivers Running Through 51 or More Counties					4.639	1.39	-3.217	-1.14	12.394	2.29

CORRELATES FOR TRACTOR GROWTH										
Log of Tractors Per Farm, 1929	-0.26254	-16.22	-0.28656	-11.66	2.625	1.57	0.118	0.06	-2.658	-0.8
GEOGRAPHY AND SOIL QUALITY										
Elevation Range	-0.00001	-0.90	-0.00001	-0.31	-0.002	-0.86	-0.008	-3.57	0.006	0.77
Maximimum Elevation	0.00003	2.32	0.00001	0.15	0.004	1.78	0.010	3.8	-0.003	-0.36
Slope of the map unit	-0.01489	-6.67	-0.01012	-2.48	-0.694	-3.14	0.357	1.5	-0.217	-0.38
Average water content	-2.59595	-3.98	-2.51224	-2.51	85.020	1.29	353.888	4.35	-351.013	-2.66
% of soil consisting of clay	-0.00726	-1.98	-0.00018	-0.02	1.292	1.21	-0.656	-1.32	-0.911	-0.85
k factor measuring soil loss by water	-0.16263	-0.58	-0.84356	-1.49	-78.926	-1.55	-10.003	-0.26	24.283	0.41
Organic material in soil	-0.00360	-0.79	-0.01974	-1.05	1.334	0.73	-2.542	-2.35	2.632	2.81
Permeability of soil in inches per hour	0.03716	4.01	0.04453	2.79	0.500	0.33	-3.132	-2.55	-3.197	-1.6
Depth of soil layer in inches	-0.00055	-0.36	-0.00430	-1.53	0.351	1.51	0.425	1.96	0.103	0.25
A code identifying hydrologic characteristics	-0.08603	-2.12	-0.08576	-1.21	-2.221	-0.29	-14.374	-2.92	9.923	1.21
A code identifying the quality of soil drainage	-0.08103	-2.29	-0.08659	-1.37	5.500	0.77	8.615	2.01	-10.030	-1.22
Liquid limit of soil layer	-0.00501	-1.38	-0.00198	-0.29	-0.418	-0.72	0.902	1.69	-0.018	-0.02
Share of map unit with hydric soils	-0.53622	-3.76	-0.87595	-2.82	-47.331	-1.66	28.907	1.92	-7.279	-0.32
Annual flood frequency code	-0.04430	-0.97	-0.16057	-0.8	-17.919	-0.91	2.770	0.52	-19.190	-2.75
WEATHER VARIABLES IN 1930S										
Temperature Standard Deviation 1930-1939	-	-1.95	-	-2.26	0.949	0.63	-1.722	-1.03	7.301	1.79

	-0.02020		-0.04810							
Precipitation Average 1930-1930	-0.10306	-4.00	-0.17115	-3.59	8.249	2.35	-1.928	-0.52	0.789	0.11
Temperature Average 1930-1939	-0.00763	-1.75	-0.00604	-0.65	0.914	1.12	-0.186	-0.21	1.676	0.79
Months of Extreme or Severe Wetness 1930s	-0.00146	-0.76	-0.01190	-1.61	0.382	1.27	-0.267	-1.06	3.299	1.31
Months of Extreme or Severe Drought 1930s	-0.00253	-4.05	-0.00303	-2.71	0.054	0.55	-0.369	-2.86	-0.048	-0.24
Dust Bowl County Dummy	-0.14280	-2.37	-0.56094	-2.39	29.400	2.7	192.717	6.27	49.725	3.38
SOCIO-ECONOMIC VARIABLES 1930 AND 1929										
Number of Layoffs as % of population, 1930	-0.00005	0.00	-0.01333	0.56	-3.001	-1.27	1.645	1.29	4.555	1.34
Number Unemployed as % of population 1930	0.01594	1.60	-0.03280	-0.81	1.493	0.5	-0.658	-0.43	14.787	2.75
% Illiterate 1930	0.00001	0.00	0.00712	1.08	-0.265	-0.67	0.867	2.81	-1.830	-1.05
% Black 1930	-0.00014	-0.12	0.00208	0.91	-0.255	-1.35	-0.099	-1.07	-0.103	-0.45
% Urban 1930	0.00024	0.52	0.00296	1.9	-0.252	-1.95	-0.498	-5.56	-0.198	-1.28
Population in Thousands 1930	0.00017	1.80	0.00045	2.66	-0.019	-2.06	-0.008	-0.7	-0.074	-2.22
Retail Sales Per Capita 1929	0.00012	1.19	-0.00030	-1.2	0.051	2.51	0.109	4.88	-0.007	-0.25
Average Family Size 1930	-0.07512	-1.73	-0.07689	-1.04	0.487	0.11	-3.597	-0.69	3.563	0.56
CROP MIX AND FARM SUCCESS 1929										
Corn % of Crop Value 1929	-0.31467	-4.14	-0.35578	-2.5	7.464	0.69	22.870	1.69	-1.885	-0.06
Wheat % of Crop Value 1929	-0.42214	-5.42	-0.47239	-1.25	4.300	0.28	341.170	18.52	-45.562	-1.64

Cotton % of Crop Value 1929	0.27512	3.20	0.62215	3.11	-27.392	-2.61	35.826	3.22	-71.073	-1.91
Tobacco % of Crop Value 1929	-0.11908	-1.14	0.02842	0.19	-9.292	-1.22	60.057	7.38	-48.859	-2.49
Crop Value Per Rural Farm Population, 1929	0.00005	0.82	-0.00047	-1.78	0.081	7.96	0.164	8.41	-0.070	-3.14
% of Acres on Farms with Crop Failures 1929	-0.00260	-1.01	0.00444	0.8	-0.674	-1.79	1.113	2.61	-0.788	-0.74
FARM SIZE AND INSTITUTIONS, 1929 (unless otherwise noted)										
% of Farms 3-9 Acres	0.79765	1.17	1.68898	0.99	114.323	1.35	45.680	0.82	-772.058	-1.33
% of Farms 10-19 Acres	1.13558	2.17	1.73166	1.2	70.942	1.57	-90.230	-1.89	-537.470	-1.19
% of Farms 20-49 Acres	0.13233	0.25	0.72111	0.55	68.793	1.4	27.478	0.61	-494.553	-1.14
% of Farms 50-99 Acres	1.17224	2.27	1.98197	1.36	91.581	1.94	33.550	0.72	-683.395	-1.43
% of Farms 100-174 Acres	0.94216	1.78	2.33924	1.66	7.548	0.16	-12.485	-0.27	-647.332	-1.44
% of Farms 175-259 Acres	1.97055	3.52	2.03766	1.48	139.682	2.38	41.954	0.69	-526.172	-1.28
% of Farms 260-499 Acres	1.22128	2.33	1.51809	0.91	162.501	2.55	-55.655	-0.97	-670.530	-1.2
% of Farms 500-999 Acres	0.53024	0.87	-0.07170	-0.06	123.275	1.67	244.424	2.73	-243.177	-0.79
% of Farms 1000-4999 Acres	0.59950	1.09	1.09090	0.59	164.888	1.8	128.551	1.3	-782.723	-1.34
% of Farms over 5000 Acres	1.33678	2.09	-4.78937	-1.2	974.944	7.86	-37.152	-0.41	-746.343	-1.56
% of Harvested Acres on Share Tenant and Cropper Farms	0.23620	1.52	-0.08377	-0.24	26.898	0.79	37.774	2.15	11.201	0.3
% of Harvested Acres on Cash Tenant Farms	0.28358	3.02	0.35865	2.33	-17.007	-1.78	6.822	0.54	14.918	0.49

Index of % of Acres on Plantations 1910	0.04822	3.17	0.05094	3.05	0.553	0.8	-1.856	-2.48	-3.097	-1.97
State Fixed Effects	Included		Included		Included		Included		Included	
R^2	0.519				0.807		0.86		0.637	
N	3017		3017		3017		3017		3017	

TABLE 4

ONE-STANDARD DEVIATION EFFECTS OF CORRELATES ON TRACTOR GROWTH RATES, IN STANDARD DEVIATIONS

			One Standard Deviation Effects			
	Mean	Std. Dev	Excluding size and tenure		Including Size and Tenure	
Variables	0.57	0.50				
Constant						
NEW DEAL GRANTS AND LOANS						
FSA AND FCA loans per rural farm population	65.75	75.93	0.717	*	1.209	*
AAA spending per rural farm population	83.26	128.58	0.313		0.107	
Per Capita Public Works and Relief Grants	107.50	119.20	0.448	*	0.538	
CORRELATES FOR TRACTOR GROWTH			0.000			
Log of Tractors Per Farm, 1929	4.87	1.49	-0.692	*	-0.853	*
GEOGRAPHY AND SOIL QUALITY			0.000			
Elevation Range	1513.44	2357.77	0.076		-0.045	
Maximimum Elevation	2383.97	2940.01	-0.060		0.030	
Slope of the map unit	9.87	8.96	-0.189	*	-0.181	*
Average water content	0.13	0.03	0.185	*	0.158	*
% of soil consisting of clay	25.84	9.12	0.090		-0.003	
k factor measuring soil loss by water	0.28	0.07	0.090		0.112	
Organic material in soil	1.39	2.53	-0.052		-0.100	
Permeability of soil in inches per hour	2.56	2.11	0.180	*	0.187	*
Depth of soil layer in inches	61.31	8.68	-0.026		-0.075	
A code identifying hydrologic characteristics	2.75	0.46	0.034		0.078	
A code identifying the quality of soil drainage	3.68	0.81	-0.018		-0.140	
Liquid limit of soil layer	35.54	7.81	-0.041		-0.031	
Share of map unit with hydric soils	0.14	0.18	0.188	*	0.315	*

Annual flood frequency code	3.75	0.29	0.064		0.094	
WEATHER VARIABLES IN 1930S			0.000			
Temperature Standard Deviation 1930-1939	16.52	3.40	-0.108		-0.326	*
Precipitation Average 1930-1930	2.92	1.12	-0.223	*	-0.383	*
Temperature Average 1930-1939	55.07	8.19	0.016		-0.099	
Months of Extreme or Severe Wetness 1930s	3.42	5.21	-0.160	*	-0.124	
Months of Extreme or Severe Drought 1930s	22.84	16.97	-0.075	*	-0.102	*
Dust Bowl County Dummy	0.02	0.13	-0.216	*	-0.141	*
SOCIO-ECONOMIC VARIABLES 1930 AND 1929			0.000			
Number of Layoffs as % of population, 1930	0.52	0.63	0.004		0.017	
Number Unemployed as % of population 1930	1.30	1.06	-0.034		-0.069	
% Illiterate 1930	5.40	5.84	-0.015		0.083	
% Black 1930	11.20	18.44	-0.012		0.077	
% Urban 1930	20.73	24.39	0.129	*	0.144	*
Population in Thousands 1930	35.84	111.43	0.048	*	0.100	*
Retail Sales Per Capita 1929	277.41	136.69	-0.100	*	-0.081	
Average Family Size 1930	4.23	0.58	-0.076		-0.088	
CROP MIX AND FARM SUCCESS 1929			0.000			
Corn % of Crop Value 1929	0.20	0.18	0.056		-0.129	*
Wheat % of Crop Value 1929	0.10	0.17	-0.349	*	-0.163	
Cotton % of Crop Value 1929	0.16	0.27	0.439	*	0.337	*
Tobacco % of Crop Value 1929	0.03	0.12	0.051		0.007	
Crop Value Per Rural Farm Population, 1929	295.07	240.71	-0.168	*	-0.224	*
% of Acres on Farms with Crop Failures 1929	3.15	3.74	-0.060	*	0.033	
FARM SIZE AND INSTITUTIONS, 1929 (unless otherwise noted)						
% of Farms 3-9 Acres	0.05	0.05			0.171	
% of Farms 10-19 Acres	0.07	0.07			0.248	
% of Farms 20-49 Acres	0.19	0.14			0.204	
% of Farms 50-99 Acres	0.20	0.10			0.413	
% of Farms 100-174 Acres	0.22	0.11			0.519	*
% of Farms 175-259 Acres	0.09	0.06			0.256	
% of Farms 260-499 Acres	0.10	0.11			0.320	
% of Farms 500-999 Acres	0.05	0.09			-0.012	
% of Farms 1000-4999 Acres	0.03	0.07			0.149	

% of Farms over 5000 Acres	0.01	0.03	-0.288	
% of Harvested Acres on Share Tenant and Cropper Farms	0.07	0.07	-0.012	
% of Harvested Acres on Cash Tenant Farms	0.30	0.19	0.137	*
Index of % of Acres on Plantations 1910	0.19	0.74	0.075	*
IDENTIFYING INSTRUMENTS				
Number of Harbors	0.15	1.08		
Latitude	38.11	4.87		
Longitude	91.65	11.41		
St. Dev. of %. Democrat for President, 1896-1928	10.23	4.91		
House Agricultural Committee, Jan. 1933	0.21	0.47		
House Labor Committee, Jan. 1933	0.16	0.38		
Rivers Running Through 51 or More Counties	0.09	0.29		

Figure 1

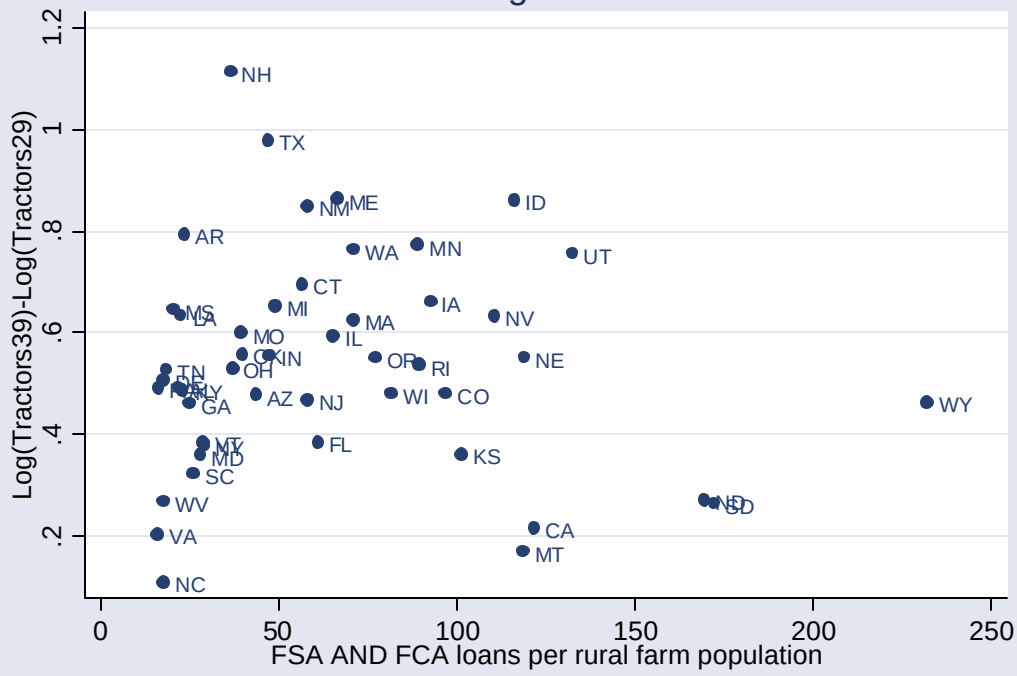


Figure 2

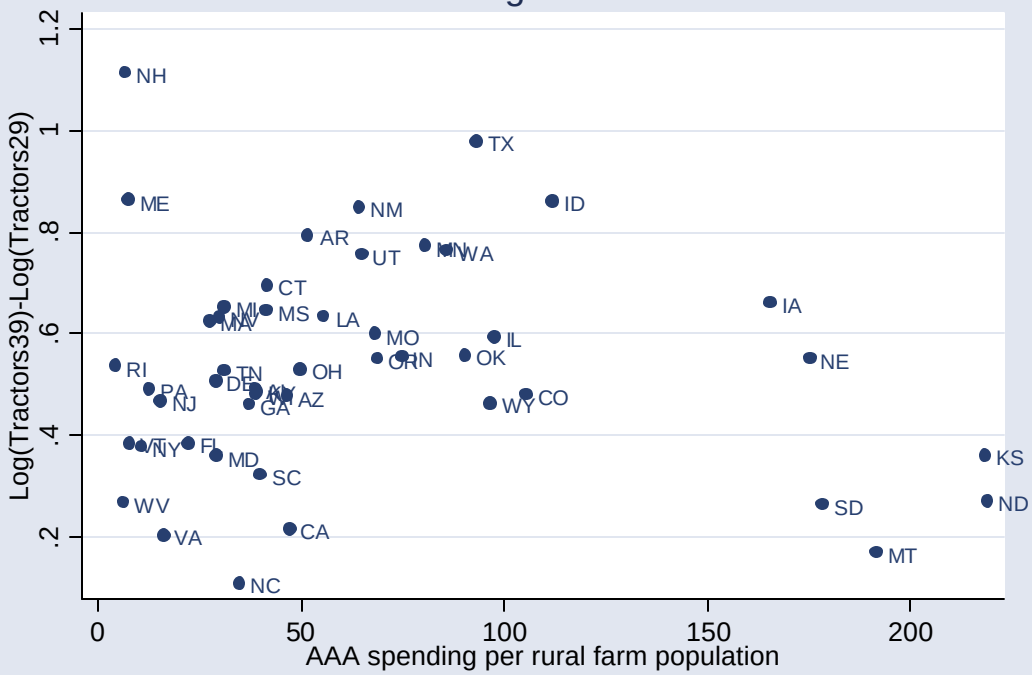
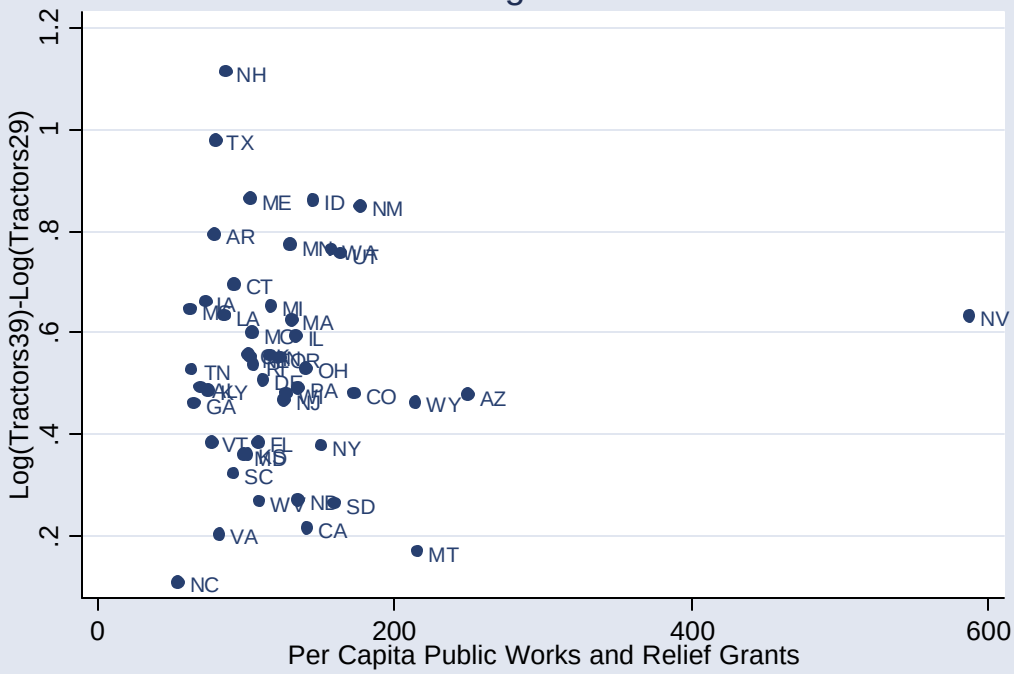


Figure 3


Log(Tractors39)-Log(Tractors29)
.2
.4
.6
.8
1
1.2
0
200
400
600
Per Capita Public Works and Relief Grants
NH
TX
ME
ID
NM
AR
MN
WA
UT
CT
MS
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REFERENCES

Agricultural Adjustment Administration. Agricultural Adjustment, 1933-1935: A Report of the Administration of the Agricultural Adjustment Act May 12, 1933 to December 31, 1935. A76.401:33-40. Washington, D.C.: Government Printing Office, 1936.

Agricultural Adjustment Administration. Agricultural Conservation, 1936 Washington, D.C.: Government Printing Office, 1937.

Alston (1981) "Tenure Choice in Southern Agriculture." Explorations in Economic History 18 (1981): 211-232.

Alston, Lee J. and Joseph P. Ferrie (1999) Paternalism and the American Welfare State: Economics, Politics, and Institutions in the U.S. South, 1865-1965**.** Cambridge: Cambridge University Press, 1999.

Alston, Lee J. and Joseph P. Ferrie. "Time on the Ladder: Career Mobility in Agriculture, 1890-1938." Journal of Economic History. (forthcoming).

Alston Lee J. and Robert Higgs (1982) "Contractual Mix in Southern Agriculture Since the Civil War: Facts, Hypotheses and Tests," Journal of Economic History, XLII (June 1982): 327-353.Arnold, C.R. (1958). 1933-1958: Farmers Build Their Own Production Credit System…Organization and first 25 years. Washington, DC: Farm Credit Administration, August 1958.

Anderson, Gary M., and Robert D. Tollison, "Congressional Influence and Patterns of New Deal Spending, 1933-1939," Journal of Law and Economics, 34 (April 1991), 161-75.

Arrington, Leonard, "Western Agriculture and the New Deal," Agricultural History, 49 (Oct. 1970), 337-53.

Biles, Roger, The South and the New Deal (Lexington, KY: University of Kentucky Press, 1994).

Bound, John, David Jaeger and Regina M. Baker. "Problems with Instrumental Variables Estimation When the Correlation Between the Instruments and the Endogenous Explanatory Variables is Weak." Journal of the American Statistical Association 90 (June 1995): 443-450.

Clarke, Sally. "New Deal Regulation and the Revolution in American Farm Productivity: A Case Study of the Diffusion of the Tractor in the Corn Belt, 1920-1940." The Journal of Economic History: 51(1), March, 1991, 1201-1213.

Clarke, Sally. Regulation and the Revolution in United States Farm Productivity. Cambridge University Press, New York, 1994.

Couch, Jim, Atkinson, Keith E.; Wells, William H., "New Deal Agricultural Appropriations: A Political Influence. Eastern Economic Journal 24 (Spring 1998): 137-48.

Couch, Jim, and William Shughart II, The Political Economy of the New Deal (New York: Edward Elgar, 1998).

Couch Jim and Peter M. Williams. "New Deal or Same Old Shuffle? The Distribution of New Deal Dollars Across Alabama," Economics and Politics 11 (July 1999): 213-223.

David, Paul. Technical Choice Innovation and Economic Growth: Essays on American and British Experience in the Nineteenth Century. New York: Cambridge University Press, 1975.

Day, Richard. "The Economics of Technological Change and the Demise of the Sharecropper." American Economic Review, 57(2), June 1967, 427-449.

Farm Credit Administration, Financing Agriculture in 1934 (Washington, D.C: GPO, 1935).

_____, Farm Credit Quarterly, June 1936 (Washington, D.C.: GPO, 1936).

Federal Trade Commission. Report on the Agricultural Implement and Machinery Industry, 2 parts. House Document No. 702, 75th Congress, 3d session. Washington, D.C.: U.S. Government Printing Office, 1938.

Fishback, Price V., Michael R. Haines, and Shawn Kantor, "The Impact of New Deal Programs on Black and White Infant Mortality in the South," Explorations in Economic History 38 (Jan. 2001), 93-122.

Fishback, Price; Kantor, Shawn; and Horrace, William "Do Federal Programs Affect Internal Migration? The Impact of New Deal Expenditures on Mobility During the Great Depression." Explorations in Economic History (forthcoming). NBER Working Paper 8283, Revised 2005, available also at http://econ.arizona.edu/faculty/Fishback.aspx

Fishback, Price; Horrace, William; and Kantor, Shawn. "Did New Deal Grant Programs Stimulate Local Economies? A Study of Federal Grants and Retail Sales During the Great Depression?" Journal of Economic History: 65(1), March 2005: 36-71.

Fishback, Price; Horrace, William; and Kantor, Shawn. "Did New Deal Grant Programs Stimulate Local Economies?" Unpublished working paper. National Bureau of Economic Research Working Paper W8108, revised 2004, available also at http://econ.arizona.edu/faculty/Fishback.aspx.

Fishback, Price V., Shawn Kantor, and John Joseph Wallis, "Can the New Deal's Three Rs Be Rehabilitated? A Program-by-Program, County-by-County Analysis," Explorations in Economic History, 40 (July 2003), 278-307

Fleck, Robert Kenneth, "Essays on the Political Economy of the New Deal," unpublished Ph.D. dissertation, Stanford University, 1994.

_____, "Inter-party competition, intra-party competition, and distributive Policy: A Model and Test Using New Deal Data." Public Choice 108 (2001a): 77-100.

_____, "The Marginal Effect of New Deal Relief Work on County-Level Unemployment Statistics." Journal of Economic History 59 (September 1999a), 659-87.

_____, "Population, Land, Economic Conditions, and the Allocation of New Deal Spending." Explorations in Economic History 38 (2001b): 296-304.

_____, "The Value of the Vote: A Model and Test of the Effects of Turnout on Distributive Policy," Economic Inquiry 37 (October 1999b): 609-23.

Halcrow, Harold G. Agricultural Policy of the United States. New York: Prentice-Hall, 1953.

Hansen, Zeynep and Gary Libecap. "Small Farms, Externalities, and the Dust Bowl of the 1930s." Journal of Political Economy 112 (June 2004): 665-694.

Hayashi, Fumio. Econometrics. Princeton, NJ: Princeton University Press, 2000.

Hoffsomer, Harold, editor. The Social and Economic Significance of Land Tenure in the Southwestern States: A Report of the Regional Land Tenure Project. Chapel Hill, NC: University of North Carolina Press, 1950.

Holley, William C., Ellen Winston, and Thomas Jackson Woofter. The Plantation South, 1934-1937. Freeport, NY, Books for Library Press, 1971 (reprint of 1940 edition).

Howard, Donald S., The WPA and Federal Relief Policy (New York: Russell Sage Foundation, 1943).

Hoxby, Caroline M., "Does Competition Among Public Schools Benefit Students and Taxpayers?," American Economic Review, 90 (De. 2000), 1209-38.

Inter-University Consortium for Political and Social Research, Historical, Demographic, Economic, and Social Data: The United States, 1790-1970, ICPSR Number 0003. Computerized data tapes from ICPSR. The version has corrections by Michael Haines, Department of Economics, Colgate University, Hamilton, NY.

Inter-University Consortium for Political and Social Research, United States Historical Election Returns, 1824-1968, ICPSR Number 0001. Computerized data tapes from ICPSR.

Jones, Jesse H, Reconstruction Finance Corporation Seven-Year Report to the President and the Congress of the United States, February 2, 1932 to February 2, 1939, Reconstruction Finance Corporation pamphlet, 1939.

Manuelli, Rodolfo and Ananth Seshadri. "Frictionless Technology Diffusion: The Case of Tractors." Unpublished working paper. University of Wisconsin-Madison Department of Econmics, September 2004.

Mertz, Paul E. New Deal Policy and Southern Rural Poverty. Baton Rouge, LA, Louisiana State University Press, 1978.

National Climate Data Center, Time Bias Corrected Statewide-Regional-National Temperature-Precipitation, 1895-2000, http://www.noaa.ncdc.gov.

Nourse, Edwin G., Joseph S. Davis, and John D. Black, Three Years of the Agricultural Adjustment Administration. Washington, D.C.: The Brookings Institution, 1937.

Olmstead, Alan L. & Rhode, Paul W. "Reshaping the landscape: The Impact and Diffusion of the Tractor in American Agriculture, 1910-1960." The Journal of Economic History: 61(3), Sep 2001: 663-698.

Olmstead, Alan. "The Mechanization of Reaping and Mowing in American Agriculture, 1833-1870." Journal of Economic History 35 (June 1975): 327-52.

Olson, James S., Saving Capitalism: The Reconstruction Finance Corporation and the New Deal, 1933-1940 (Princeton, NJ: Princeton University Press, 1988).

Peterson, Willis & Kislev, Yoav. "The Cotton Harvester in Retrospect: Labor Displacement or Replacement?" The Journal of Economic History: 46(1), March 1986, 199-216.

Reading, Don C., "New Deal Activity and the States, 1933 to 1939," Journal of Economic History, 33 (Dec. 1973), 792-810.

Rucker, Randal & Alston, Lee. "Farm Failures and Government Intervention: A Case Study of the 1930s." The American Economic Review: 77(4), September 1987, 724-730.

Saloutos, Theodore. "New Deal Agricultural Policy: An Evaluation." The Journal of American History: 61(2), September, 1974, 394-416.

Schuler, E.A. Social Status and Farm Tenure—Attitudes and Social Conditions of Corn Belt and Cotton Belt Farmers. Social Research Report No. 1, V., U.S. Department of Agriculture, Bureau of Agricultural Economics, Washington, April 1938.

Sechrist, Robert P. Basic Geographic and Historic Data for Interfacing ICPSR Data Sets, 1620-1983 (United States). Inter-university Consortium for Political and Social Research, Spring 1984.

Spatial Data Set "ussoils", USGS: http://water.usgs.gov/lookup/getspatial?ussoils

U.S. Bureau of the Census. Fifteenth Census of the United States, 1930, Population, Volume VI: Families. Washington, D.C.: Government Printing Office, 1933.

U.S. Bureau of the Census, Fifteenth Census of the United States: Population, Volume VI, Families. Vol. 6 (Washington DC: GPO, 1933).

U.S. Bureau of the Census, Historical Statistics of the United States: Colonial Times to 1970 (Washington, DC: GPO, 1975).

U.S. Bureau of the Census. Sixteenth Census of the United States: 1940 Agriculture, First and Second Series State Reports: Statistics for Counties. Washington, DC: Government Printing Office, 1942.

U.S. Congress, Official Congressional Directory, for the 73rd Congress 1st session through 76th Congress (Washington, D.C.: GPO, 1933).

U.S. Office of Government Reports, Statistical Section, Report No. 9, Volume 1, "Direct and Cooperative Loans and Expenditures of the Federal Government for Fiscal Years 1933 through 1939." Mimeo, 1940.

U.S. Office of Government Reports, Statistical Section, Report No. 10, Volume 1, "County Reports of Estimated Federal Expenditures March 4 1933-June 30, 1939," Mimeo, 1940.

U.S. Department of Agriculture. Report of the Secretary of Agriculture. Washington, D.C.: Government Printing Office, various years.
U.S. Resettlement Administration. First Annual Report of the Resettlement Administration. Washington, D.C.: Government Printing Office, 1936.
Virts, Nancy. "Change in the Plantation System: American South, 1910-1945." Explorations in Economic History. Forthcoming.
Wallis, John Joseph. "The Political Economy of New Deal Spending Revisited, Again: With and Without Nevada," Explorations in Economic History 35 (April 1998), 140-70.
_____. "The Political Economy of New Deal Spending, Yet Again: A Reply," Explorations in Economic History 38 (April 2001): 305-14.
Whatley, Warren C. "Labor for the Picking: The New Deal in the South." The Journal of Economic History: 45(4), Dec 1983: 905-929.
Whatley, Warren C. "A History of Mechanization in the Cotton South: The Institutional Hypothesis." The Quarterly Journal of Economics: 100(4), Nov 1985, 1191-1215.
Whatley, Warren C. "Southern Agrarian Labor Contracts as Impediments to Cotton Mechanization." The Journal of Economic History: 47(1), March 1987, 45-70.
White, William. "An Unsung Hero: The Farm Tractor's Contribution to Twentieth-Century United States Economic Growth." The Journal of Economic History 61 (June 2001): 493-496.
White, William. "An Unsung Hero: The Farm Tractor's Contribution to Twentieth-Century United States Economic Growth." Unpublished Ph.D. dissertation, The Ohio State University, 2000.
Williams, Edward Ainsworth, Federal Aid for Relief (New York: AMS Press, reprint, 1968).
Wright, Gavin, "The Political Economy of New Deal Spending: An Econometric Analysis," Review of Economics and Statistics, 56 (Feb. 1974), 30-38.

ENDNOTES

[1]For discussions of the importance of the tractor, see Day 1967, Olmstead and Rhode (2001), White (2001, 2000), and Peterson and Kislev (1986). White (2001, 495) suggests that more than 24 million work animals were replaced by the adoption of the tractor. Before 1920, nearly a quarter of all crop land in the United States was needed to produce feed to support draft animals on farms. In addition, land was needed to pasture these animals. Olmstead and Rhode (2001) suggest that this could have led to a 20 percent increase in the land devoted to crop production for markets and human consumption. In addition, they estimate that the tractor was responsible for replacing 1.7 million farm jobs by 1960. Similarly, Day (1967) suggests that tractors might have cut farm hours worked by more than half between 1940 and 1960, although Peterson and Kislev (1986) find that higher wages off the farm account for 79% of this decline, leaving only 21% to be explained by mechanization.

[2] See Olmstead and Rhode (2001), Clarke (1991, 1994), Alston (1981), Whatley (1985, 1987), Day (1967), Peterson and Kislev (1986), and Manuelli and Seshadri (2004), among others.

[4]A number of scholars agree that farms faced problems in finding enough wage laborers during harvest. See Olmstead and Rhode (2001), Alston (1981), Higgs and Alston (1982), and Clarke (1991) among economic historians. Generally studies show that farms are better able to overcome labor constraints as they are closer to urban areas.

[5] Hoffsomer (1950, p. 116, 541) reports that white croppers earned about 17 percent and black croppers 10 percent of their income off tract and often for wage work on the plantation in an Arkansas coastal plain county. In a Mississippi coastal plain county the percentages were 24 for white croppers and 11 for black croppers. Total gross incomes for the croppers were $1028 for whites and $645 for blacks in Arkansas, $901 and $705, respectively in Mississippi.

[6] Jefferson County received $59.8 in public works and relief spending per capita, less than Arkansas' average of $77.6 and $13.54 per rural farm person, also less than Arkansas' average of $25.3. Jefferson also started with more tractors and experienced a higher growth rate of tractors (138 percent to 65 percent) than the typical Arkanasas county.

[7] Rucker and Alston (1987) find that a rise in the share of loans in federal government programs reduced the likelihood of farm failures during the 1930s. To the extent that the AAA raised farm earnings, the AAA also reduced farm failures.

[9] Olmstead and Rhode (2001) are critical of threshold studies; they argue that these are very sensitive to changes in variables and measurement errors. Additionally, they find that the cost differentials between tractors and animal power are quite small, suggesting that this capital market was working quite efficiently. Manuelli and Seshadri (2004) develop a dynamic neoclassical model of tractor adoption with heterogeneous farmers. After calibrating their model using data from Olmstead and Rhode, they find that tractor adoption appears to follow the path we might expect taking into account tractor quality and the changes in relative prices.

[10] This discussion is reminiscent of Alan Olmstead's (1975) criticism of Paul David's original use of the threshold model in discussing the adoption of the mechanical reaper in the 1840s and 1850s.

[11]We believe that CCC loans were included in the values reported for the Reconstruction Finance Corporation, which was the agency that administered the loans. The RFC loans included loans to banks and local governments in 1932 and 1933, to industry and railroads, and to a variety of other groups. We are considering using regressions of state level information of the CCC loans on RFC loan totals (and possibly some other correlates) and then using predicted CCC loans, but as yet have not tried this. We also have information on Rural Rehabilitation Grants RRHG) and the Rural Electrification Administration (REA) loans. We do not focus on these because the rural rehabilitation grants went to small farms that were unlikely to use tractors. The

CCC operated in conjunction with the AAA but the loans were made through the RFC administration. The only crops receiving CCC loans in fiscal years 1933 through 1935 were cotton (roughly $139 million), corn (approximately $405 million), and gum turpentine and rosin (nearly $7 million. See Agricultural Adjustment Administration (1936, pp. 71-78).

[12] The original list of crops eligible for AAA adjustment in 1933 included wheat, cotton, corn and hogs, milk and its products, tobacco, rice, and cattle. In 1934 sugarbeets and sugarcane, peanuts, rye flax barley, grain, and sorghums were added. Potatoes were added in 1935. See Agricultural Adjustment Administration 1936, p. 19.

[13] In *United States v. Butler, et. al* on January 6, 1935 the U.S. Supreme Court declared that the original Agricultural Adjustment Act "regulates agricultural production in violation of the tenth amendment to the Federal Constitution; that the (processing) tax is a mere incident of such regulation; that the benefit-payment plan…amounts to coercion by economic pressure; and that the act is accordingly invalid. The case came about when the U.S. government sued the receivers for the Hoosac Mills Corporation to collect certain processing and floor-stock taxes imposed by the AAA (Agricultural Adjustment Administration 1936, 99).

[14] In the corn belt states (Ohio, Illinois, Indiana, Iowa, Nebraska and Missouri) the acres rented under the AAA program in 1934 were transferred to other uses in the following ways: "About one-third for new seedings of meadow and pasture crops, chiefly alfalfa, sweetclover, and clover and timothy. About one-fourth in old meadow crops left unplowed (clover, timothy, sweet clover, bluegrass pasture). About one-third planted to emergency forage crops (soybeans, millet, Sudan grass, forage sorghums, fodder corn). About one-twelfth, used for controlling weeds, was fallowed or left idle. In the South contracted acreage could not be used for cash crops. In five cotton states (Arkansas, Oklahoma, Texas, Georgia, and South Carolina) about three-fourths of the cotton acreage was planted to home food and feed crops, chiefly corn, wheat, and oats, soybeans, cowpeas, sorghums, Sudan grass, lespedeza and Mung beans. About one-tenth was planted to new seedings of permanent pasture and meadow crops. About one-eighth went to soil improvement crops to be turned over. About 2 percent was left idle. In Arkansas and Tennessee considerable acreage was moved to planting trees, primarily black locust (Agricultural Adjustment Administration 1936, 48).

[15] The description of the original AAA relies heavily on Nourse, Edwin G., Joseph S. Davis, and John D. Black (1937) and Agricultural Adjustment Administration (1936). Descriptions of the post 1935 AAA are based on Agricultural Adjustment Administration (1937). After 1935 under the Domestic Soil and Allotment Act, the AAA administrators claimed much greater flexibility. "In 1936 committees of representative farmers in 2400 counties worked out tentative over-all goals for agriculture in their counties." The AAA annual report suggested that the AAA expanded so that it could be applied to all farms and not just the specific crops under the pre-1935 AAA rules. The new goal shifted from reestablishing the pre-World War I parity between farm prices and the prices of goods farmers bought to reestablishing income parity for farmers and non-farmers to the pre-war levels (Agricultural Adjustment Administration, 1937, pp. 10-13.)

Under the original AAA, the state and county extension services played important roles in distributing information and gathering data on the program. There were 4000 county agricultural adjustment associations on the 1933-35 program. In 1936 there were 2711 county agricultural conservation associations, organized everywhere but in the Northeast, where they were appointed in 1936 but are being formed as the others were in 1937 (Agricultural Adjustment Administration, 1937, pp. 56-57) After 1935 the AAA state committees were appointed by Secretary of Agriculture, the local county agricultural conservation association officers were elected by the producers. These officers recommended bases, productivity indexes, and normal yields for the farms in the community and assisted with paperwork and monitoring of the grants.

[16]The taxes were added under the Bankhead Cotton Control Act for cotton and the Kerr-Smith Tobacco Control Act. See Nourse et. al., (1937, pp. 39-40, 96-102).

[17] For descriptions of the operations of the individual programs under the original AAA, see Nourse, et. al., (1937, pp. 92-114, 123-146, 287-323) and Agricultural Adjustment Administration (1936, pp. 119-278).

[18] See Farm Credit Administration, June 30, 1936, pp. 6-10; U.S. Department of Agriculture 1934, p. 18, 26; Arnold 1958, 23-35; Halcrow 1953, pp. 340-350. The FCA also provided for funding of cooperative marketing associations but we have no information on the size of that funding.

[19] See U.S. Resettlement Administration 1936, 10-26; Fishback, Wallis and Kantor 2003. U.S. Department of Agriculture, 1938, 63-67. For discussions of the political economy of the Farm Security Administration, see Alston and Ferrie 1999.

[20]There are two other loan programs that we are working to include in the analysis at some point. The Rural Electrification Administration was established in 1935 to provide loans to rural electrical cooperatives to be formed in rural areas where electrical lines had not yet reached. The nature of the program is different enough that we believe it should be treated separately; however, we have had problems in developing a good set of instruments and are still working on its inclusion. Electrification might have had conflicting effects on tractor adoption. Prior to electricity farmers without electricity were purchasing tractors as a source of motor power on the farm, so electrification might have reduced this incentive. On the other hand electrification might have complemented the use of tractors.

The other program is the Commodity Credit Corporation (CCC) crop loans. This was operated through the Reconstruction Finance Corporation (RFC) and the data source only offers data on the loans under the RFC, which included loans to banks and industry as well as the CCC loans. We do have state level data on the CCC and the RFC loans by year and are still working out ways to impute CCC loans at the county level using information.

[21]Manuelli and Seshadri (2004) have developed a neoclassical dynamic model of the farmer's decision but do not incorporate the risk factors emphasized by Clarke.

[22] One way to model Clarke's emphasize on downside cash price risk is to use a prospect model in this context so that the farmer puts stronger weight on anticipated losses than on anticipated gains. We have not explored this modeling strategy as yet, but don't believe it will change the basic results much.

[23] We focus on price fluctuations here to capture some features of Sally Clarke's (1991, 1994) analyses. We could also recast this in a similar way for yield fluctuations.

[24]Since we do not have CCC loan data we have not explicitly modeled the features of that program. However, we believe it can easily be done by showing the impact of raising the low price, P_A^L.

[25] We are in the process of loading data on croppers in 1929 from the Supplement to the Agriculture Census for southern states. We also plan to load information on indebtedness in 1929, and the growth rate in tractors between 1925 and 1929 that has not been previously loaded.

[26] For discussions of the determinants of New Deal spending, see Reading (1973); Wright (1974); Wallis (1987, 1998, and 2001); Anderson and Tollison (1991); Couch and Shughart (1998); Couch, Atkinson, and Wells (1998); Fleck (1999a, 1999b, 2001a, 2001b); Couch and Williams (1999); and Fishback, Kantor, and Wallis (2003). The last paper summarizes the results of all of the studies and provides new estimates at the county level.

[27]Fleck's (2001a, 2001b, 2001c) county-level research finds that swing voters were important determinants of the number of relief jobs allocated to a county and the standard deviation could be used as an instrument for relief in a 2SLS county unemployment rate analysis. He has also explored more complicated interactions of swing voting with voter loyalty. In response to suggestions that we explore differential effects for the standard deviation on the New Deal distribution related to urbanization, region, and Democratic loyalty, we have also tried

adding interactions between a southern region dummy, percent urban, and a Democratic loyalty variable to the list of identifying instruments. Their inclusion as instruments leads to the same qualitative conclusions about the effects of the New Deal, but sharply reduces the F-statistic for the hypothesis test that the coefficients of the identifying instruments are all zero. Another suggestion was to use state capitals as an instrument, but it had little effect on the New Deal variables. When included it in the final net migration equation, its positive effect varied from specification in terms of its statistical significance.

[28]In considering political measures for instruments, we have also explored the use of the mean democratic vote for president from 1896 to 1928, the percent voting in the 1928 election, and a series of other committee assignments in the House. These variables tended to have weak or unusual effects on the New Deal programs in first-stage regressions that include all exogenous variables in the system. By eliminating them from the instrument lists the F-statistics on the group of instruments increased and thus the weak-instrument bias was reduced.

[29]A number of scholars have used natural resource endowments or physical characteristics as instruments in cross-sectional analyses in part because these factors were established long before the economic decisions under consideration in the research were made (see, e.g., Frankel and Romer, 1999; Hoxby, 2000).

[30]We also explored use of a two other river size groupings, the number of rivers in the county that passes through 11 to 20 counties and the number passing through 21 to 50 counties that Fishback, Horrace, and Kantor (2005) used in a study of retail sales. However, the smaller rivers did not have statistically significant effects on public works and relief spending, and thus weakened the instruments. For more detail on the construction of the river variables, see Fishback, Horrace, and Kantor (2004) or the data appendix for the retail sales study in the data from published studies section at Price Fishback's website at the Department of Economics, University of Arizona (currently http://econ.arizona.edu/faculty/Fishback.aspx).

[31]We test for the validity of our instruments using the Hansen's J statistic, which is equivalent to the Sargan test statistic under assumptions of homoskedasticity. The test statistic is distributed chi-squared with the degrees of freedom equal to the number of identifying instruments minus the number of New Deal variables for which we are instrumenting. A significant chi-squared statistic implies a rejection of the For each of our IV estimations, we report the p-value on the test at which the chi-squared statistic could reject the joint null hypothesis that the instruments are valid and the model is correctly specified. See Hayashi (2000, pp. 217-218.) for more detail.

[32]Missing data on the number of tractors led to the loss of 35 county observations. Another 11 observations were lost because they were major urban areas with no rural farm population, and 4 more observations were lost due to missing information on farm size, retail sales, and/or presidential voting.

[33] In several other studies we found land area to be an important determinant. Here the coefficient was positive but not statistically significant and thus weakened the identification strength of the first state equation. We therefore left it out of the analysis.

[34] See U. S. Bureau of Census, Historical Statistics, pp. 211-12, series E-135.

[35] We made several corrections to the Sechrist data set, which are reported in Fishback, Horrace, and Kantor (2004, Appendix 1).

[36] See Fishback, Horrace, and Kantor (2004, Appendix 1) for a more complete discussion of the creation of the geography variables and of our handling of county boundary changes since the New Deal.