Diffusion During Depression: The Adoption of the Tractor by Illinois Farmers

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Between 1920 and 1939 a nearly six-fold increase occurred in the number of tractors on American farms, from 246,000 tractors in 1920 to 1,445,000 tractors in 1939 [5]. This substantial growth in tractor usage occurred during a period where the role of the tractor in agricultural production was changing. In 1920, the tractor was primarily viewed as the supplier of the peak power needs in spring planting. However, by 1939, the tractor was regarded as superior to horses and mules in meeting the power requirements for a large number of farmers. This change in the role of the tractor resulted from the numerous secondary and complementary innovations that occurred during that period. The introduction of the general-purpose Farmall in 1924, the power-

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lift in 1929, and rubber tires in 1932 all helped to make the tractor a viable substitute for horses in supplying farm power needs.

This evolution in the role of the tractor in agricultural production partially explains the tractor's diffusion between 1920 and 1939. However, the actual path of that diffusion was also substantially influenced by the economic conditions of that time. Farm prices were to reach a peak in 1920, and the sharp decline in prices that began in the summer of that year initiated a twenty-year period where the highest price level farmers would obtain was 26 percent below the 1920 level. The parity ratio (a measure of the purchasing power for a farmer in a given year relative to the purchasing power in 1910-1914) showed a similar pattern. Although its high for the period 1921 to 1939 was only 4 percent below the 1920 level, there were six years during the period when the ratio was over 20 percent below the 1920 level, and an additional seven years where the ratio was between 10 and 20 percent below the 1920 level [6]. This substantial fluctuation in farm prices, and thus farm income, during the period 1920 to 1939 generated instability in the environment in which tractor diffusion was taking place. Therefore, the farmer's decision to purchase a tractor was one part of the adjustment to the new agricultural equilibrium of the time.

There can be little doubt that the underlying factor influencing the individual's decision to purchase a tractor as part of this adjustment was the economic viability of the two competing power sources, tractors and horses. However, other economic considerations would also influence that decision. For instance, during this period of price fluctuation and, at least for some years, severe depression, one of the farmer's primary concerns would be the prevention of foreclosure. In order to prevent foreclosure, a farmer would have to maintain a sufficient level of cash balances to make the necessary fixed payments on such items as farm debt and taxes, as well as, living expenses for the family. The purchase of a tractor would only be made out of an excess of this cash balance, or what I term the net cash balance. Therefore, the actual rate of diffusion would reflect an interaction between the

economic condition of the individual farmer and the economic viability of the competing power sources.

There are several studies that have previously examined tractor diffusion for various regions of the United States.[1] These studies, however, have been universally hampered by a lack of data sufficiently detailed for an in-depth analysis of that diffusion process. In most cases, this lack of data has forced the researchers to rely upon various government and agricultural experiment station reports, which has led them to generalize results from a small number of years for which data could be obtained. My disseration overcomes this handicap with the introduction of a new data source that will permit a detailed analysis on an annual basis of the factors that influenced the diffusion of the tractor among Illinois farmers during this period of instability.

Data reports, entitled Annual Farm Business Reports, were collected by the Department of Farm Organization and Management at the University of Illinois beginning in 1917. The purpose of the collection of these data was to guide the individual farmer to more profitable operation of his farm. By 1924, 606 farmers representing thirty-five of Illinois' 102 counties participated in the program.

In order to fulfill its stated purpose, the farm business report program collected data on annual farm revenue and expenses, as well as beginning and ending inventories, for each participating farmer. Additional information was collected on ownership and use of farm land, yields per acre of various crops, and the use of horses and/or tractors in providing farm power. Finally the forms contain some analysis of farm costs and returns to aid the farmer in improving his operation. Additional data on household consumption of farm products were collected less consistently, and no data were collected on payments for servicing farm debt.

Due to the voluntary nature of participation in the farm business report program, a possibility exists that participating

[1]For example, see [1; 2; and 3]

farmers do not represent a cross-section of Illinois farmers. Indeed, an examination of the participants shows them to be a more homogeneous group than Illinois farmers as a whole. Most of the participants tend to be innovators or early adopters of new technology, as well as opinion leaders. The degree to which this is a concern in an analysis based upon the available data is debatable, but as Everett Rogers notes with regard to this type of individual: "Opinion leaders have often been found to be just like their followers, only more so. Opinion leaders conform more closely to social system norms than the average member" [4]. Therefore, although this data source does not enable an analysis of the historial pattern of tractor diffusion among Illinois farmers, the much greater detail available from these data enable a clearer analysis of the factors that influenced that diffusion.

In order to assess the impact various economic variables had on the diffusion of the tractor among Illinois farmers, I began with a modified form of the logistic model that Griliches utilized in his study of hybrid corn. The modification resulted from the specification of additional independent variables, representing real net cash balances for farmers not owning tractors and the real tractor price, to be used with time in explaining variation in the dependent variable. I hypothesized that the inclusion of variables representing nontractor farmers' economic conditions and the cost of purchasing a tractor would be significantly related to tractor diffusion during this period of substantial income fluctuation.

The estimation of the model on both a regional and state-wide level had mixed results. The independent variables representing time and the real tractor price had the hypothesized relationship and tended to be significantly related to the dependent variable, while no significant relationship was estimated between the variables representing real net cash balances and the dependent variable.

These results raised two concerns in addition to the insignificance of the real net cash balance variables. First, the high degree of correlation between time and the dependent variable

leads to concern over whether or not the noneconomic variable, time, is driving the model. Indeed, there is no logical reason that the passage of time itself leads to the diffusion of an innovation, but rather that time is capturing indirectly the influence of factors such as information dissemination and secondary and complementary innovations. If this is the case, it would be desirable to specify and include variables in the model that more directly capture these factors. The second concern is that the modified form of the logistic model that was estimated failed to include a variable that compared the economic viability of the two competing power sources. As a consequence, there may be a specification bias in the estimated model.

In order to address these concerns, I undertook a cross-sectional analysis of the relationship between structural variables and tractor usage. The model that was specified had as a dependent variable whether or not an individual farmer used a tractor. The independent variables included the number of tillable acres, the percent of tillable acres planted in grain, and the percent of total acres which were owned by the individual farming the land. A logit estimation of that model on an annual basis for the years 1924 to 1939 showed that a significant positive relationship, at a 1 percent level, existed between tractor usage and the size of the farm in every year. From this, I concluded that the concept of a threshold level would be appropriate in analyzing the diffusion of the tractor.

Within the context of this research, the threshold level is that acreage at which a farmer should switch from using horses and mules to tractors based upon minimizing the cost of production. The estimation of cost functions for production based upon the alternative power sources, and the subsequent calculation of the threshold levels was made possible by the detail of the available data set. The calculated threshold levels for the period from 1924 to 1939 ranged from a low of 243 acres in 1930 to a high of 380 acres in 1933. In general, these estimates are higher than the estimates obtained by other researchers, perhaps due to the difference between actual behavior and the ideal behavior generally reflected in government bulletins. Specifically, government bul-

letins typically compared the costs of farmers using a tractor and no horses, with farmers using just horses. In actuality, a farmer, upon purchasing a tractor, rarely got rid of all of his horses. As a consequence, the power cost associated with tractor farming tended to be inflated above its ideal level. Nevertheless, year-to-year changes in the threshold levels do appear to reflect improvements in tractor design or changing relative costs associated with the use of a tractor or horses and mules.

The replacement of time in the logistic model with the threshold level overcomes the two concerns raised earlier. First, the threshold level more directly captures the impact of the secondary and complementary innovations, as well as changing factor prices. Secondly, the threshold level, since it is calculated based upon a comparison of the costs of the alternative power sources, represents a variable that compares the economic viability of the competing power sources.

The final form of the logistic model that was estimated includes the threshold level, real net cash balances, real tractor price, and a dummy variable representing structural change in farming associated with the Great Depression as independent variables. All of the independent variables have the hypothesized sign and are significantly related to the dependent variable except for the real tractor price.[2] In addition, for the period 1925 to 1939, the independent variables explained more than 84 percent of the variation in the dependent variable. From this, I conclude that the diffusion of the tractor in Illinois between 1925 and 1939 can be primarily explained by changes in the economic attributes of the tractor and the changing economic conditions that the farmers of that time were experiencing.

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[2]The insignificance of the variable representing the real tractor price is perhaps due to the fact that it reflects the changes that were occurring in supply and demand during this period. Therefore, it is not possible to ascertain what is happening to the quantity demanded of tractors as the price of the tractor changes.

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