The Impact of Government Policies on Agricultural Productivity and Structure:

Preliminary Results

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Abstract: *Our paper begins with a consideration of the causal relationships among productivity, farm structure, government farm payments and public investments in research and extension. We then empirically test key relationships for a relatively recent period (1960-96) in the history of agricultural structural adjustment using a simultaneous equations econometric model. Future work will expand and refine the measurement of variables thought to explain the relationship between productivity and structure.*

Introduction

The industrialization and consolidation of the food system is proceeding at a rapid rate. This is especially evident, and of greatest social interest, in the agricultural production component of the food system. For example, agricultural production has become concentrated on a smaller share of farms. Between 1987 and 1997, the number of farms in the U.S. declined by 8 percent (from 2.1 to 1.9 million), and even more telling, the number of farms accounting for 50 percent of U.S. production declined by 39 percent (from 75,682 to 46,068) (USDC, 1989; USDA, 1999). At the same time, society benefits greatly from having a highly productive farm system because of the resulting low food prices. U.S. consumers currently spend only 11 percent of their disposable personal income on food, compared to 25 percent in 1930 (Putnam and Allshouse, table 99, 1999). This is the smallest share of income spent on food for any country (Putnam and Allshouse, table 101, 1999). Of course, U.S. taxpayers also pay for a myriad of single-purpose programs that are intended to impact the agricultural system.

The links between productivity and structure are many, both direct and subtle. In fact, the definition of the "farm problem" is closely tied to both productivity issues and structural change issues. The "farm problem" has traditionally been viewed as the social problems associated with agricultural productivity growth and the ability of farm households to earn an "adequate" return on their resources. Penn (1979, p. 3) describes the farm problem as:

> "…fundamentally derived from an excess of resources in the agricultural sector—more resources (land, labor, and capital) were engaged in agricultural production than could earn an adequate return for their services. The low prices from abundant production meant these resources received a lower return than they might have commanded elsewhere in the economy."

Gardner (1992) states:

> "For half a century U.S. agriculture has been seen as a paradigm of technical efficiency and productivity growth, and at the same time an economically depressed sector. The economic difficulties have been identified as 'the farm problem'."

While the definition of the "farm problem" may evolve over time and vary in the eyes of economists--and under some old definitions, the problem may even be solved[1]--new definitions will likely continue to draw on the links between productivity and structure. The purpose of this paper is to contribute towards the emerging understanding of: (1) the relationship between how efficiently agricultural commodities are produced on U.S. farms and the organization and management of this production process, that is, the structure of agricultural production activities and (2) the role of public policies in affecting productivity and structure.

Background on Agricultural Productivity

Changes in productivity measures, or indexes, whether for the general economy or any sector of the economy such as agriculture, are a key indicator of its health. Productivity indexes

[1] The farm problem defined strictly as low household income of farm compared to nonfarm households, is known to be obsolete, i.e. solved (Ahearn, 1986).

commonly measure the growth in outputs not accounted for by the growth in production inputs.[2] Although agriculture is a relatively small component of the U.S. economy, employing about 2% of the labor force, it makes a disproportionately large contribution to the total factor productivity (TFP) of the general economy. Jorgensen, Ho, and Stiroh (2002) provide productivity estimates for 35 industries (plus households and government) and report agricultural productivity for the 1958-99 period. The contribution (share-weighted growth rate) to the economy-wide TFP from agriculture alone was 0.09 out of the total 0.569 over the period. Moreover, the TFP growth experienced by agriculture is among the most stable over time of all industries. Productivity growth arises largely from enhanced efficiency associated with variation in scale and/or technological change. Since growth in productivity leads to higher standards of living, understanding the specific sources of that growth, and fostering it, is of great public policy interest.

Over the past century, productivity is the major force behind the changes in U.S. agricultural output. Between 1948 and 1994, the rate of growth in total factor productivity in agriculture was 1.94 on an annual average basis (Ahearn, Yee, Ball, and Nehring, 1998). Using 1948 as the base year (i.e., 1948 =100), the 1994 index of agricultural output was 237, compared to the index of all farm inputs of 97 (Figure 1). That is, measured aggregate inputs actually declined during that period while output more than doubled. Of course, during the period, there was a great deal of variation by output categories and input categories that is masked by the aggregate measures.

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[2] USDA first published total factor productivity (TFP) indicators for agriculture in the 1940s (Barton and Cooper (1948); Cooper, Barton, and Brodell (1947). Since productivity is such an important indicator and because it is calculated as a residual, a great deal of attention is focused on its accurate calculation and refinements are continuously being made (e.g., AAEA Taskforce (1980); Capalbo and Antle (1988); Ball and Norton (2002)). Jorgensen also maintains an industry-level measure of productivity which includes agriculture. We only consider conventional inputs and outputs, e.g., nonmarket environmental impacts are not considered.

There is also a great deal of variation in measures of state-level TFP over the time period. We employ USDA's current measure of state-level TFP for the 48 continental states from 1960-96 (www.ers.usda.gov). These measures are described in Ball, Bureau, and Nehring (2002). Using a measure of the variation in TFP across states (the coefficient of variation) they found some narrowing of the range from 1960-87 followed by an increase in the 1987-96 period. They hypothesize that one reason for this post-1987 increase in state-level TFP was the industrialization of agriculture.

Changing Structure of Agriculture

Structural change in agriculture is of continual interest to policy makers, producers, and society in general. This is evident from the history of public discussions on agricultural structure, and the most recent farm bill debate is no exception. USDA has a compilation of comprehensive reports on agricultural structure, including USDA, 1979; Lin, Coffman, and Penn, 1980; USDA, 1981; USDA, 1998; USDA, 2001b; and annual Family Farm Reports focused on structure issues, such as the recent Hoppe, 2001. Other significant volumes include reports by the U.S. Senate (1980), Office of Technology Assessment (1986) and the more technical treatment of structure issues in Hallam (1993). The motivation for this enduring interest includes issues associated with social sentiments regarding family farms and more recently recognition of the amenities of farm landscapes usually associated with family farms (OECD). Unlike for the case of productivity, there is no one single conceptual indicator of structure. Whereas for productivity the challenge is to accurately empirically measure a generally accepted concept of productivity, the measurement challenge in structure comes more from the lack of a single conceptual indicator as a starting base for measurement than it does from the challenge of empirical measurement. The most basic of all indicators of farm structural change is the change in the number of farms. (There are now approximately 2 million farms, which is down from the peak number of 6.8 million, in 1935.) Other indicators of structure are associated with: the distribution of the size of farms, such as concentration; production issues, such as specialization; a variety of organizational issues, such as contracting; and the dependence of the farm household on off-farm sources of income.

In spite of the lengthy history and volume of this literature, there is little agreement on a conceptual model for the structural change process in agriculture. Several useful review articles address the diversity and conflict among competing conceptual models (e.g., Harrington and Reinsel, 1995). Cochrane's technology treadmill is perhaps the most widely recognized hypothesis on structural change forces (Cochrane, 1958). Cochrane's hypothesis focuses on the impact of technological innovation reducing per unit cost of output, encouraging adoption of new technologies. As adoption becomes widespread, prices of farm commodities fall, triggering structural adjustments. Technology adoption certainly plays a prominent role in the structural change process, but many factors are believed to play important roles in this process. Other schools of thought that make contributions to understanding the structural change process in U.S. agriculture include: those most closely associated with production issues (e.g., asset fixity, economies of size), those which recognize joint business-household goals (e.g., life-cycle hypothesis, nonpecuniary returns from a farm lifestyle, household production theory, tax management), and those which focus on government intervention and political economy. In this study, we draw on many of these ideas in our specification and explanation of relationships. That is, we find it most useful to *not* identify any single conceptual model as the dominant one.

We identify what we believe are two basic indicators of structure as the endogenous structure variables in our model: (1) size of farm measured as the average land rental value per farm[3] and (2) the odds of an operator working 200 or more days off the farm. Because the amount of land in agricultural uses has been relatively fixed, the change in the number of farms is closely correlated with the change in the size of farms. Figure 2 shows the change in the number of farms and acres operated per farm over time. The rising average acres operated per farm overtime masks the growth in the share of small farms. Most of today's farms are small farms by some definitions (USDA, 1998), and many are classified as retirement and lifestyle farms (Hoppe, 2001).

The majority of workers on U.S. farms are the operators and their families, contributing at least two-thirds of the labor hours worked. In addition, most farm families have at least one family member working in a non-farm occupation and receive more income from off farm sources than from farm sources. Off-farm income has played a major role in closing the income gap between farm and non-farm households and in reducing income inequality among farm operator households (Ahearn, Strickland, and Johnson, 1985). The most recent Census of Agriculture reports that off-farm income of farm households increased 300 percent between 1988 and 1998. It also reports that off-farm income was 6 times that of cash farm income in 1998 (USDA, 2001a). Many studies have focused on the off-farm labor supply of farmers or farm families and addressed a variety of issues. Most of these studies have been for small areas. Huffman (1980) conducted a national study using county level data and El-Osta and Ahearn (1996) conducted a national study using farm household level data. The national level studies generally support the small area studies in identifying the most important factors explaining off-

[3] We tried a variety of measures of average farm size, based on land values, acres, and cash receipts.

farm labor supply. In particular, human capital variables, size of farm, government payments, and local area labor market characteristics are important factors.

Previous Studies

Huffman and Evenson (2001) have made a recent empirical contribution to the literature that is highly relevant to our study. They used state level data from 1950 to 1982 to consider the relationship between farm structure (farm size, specialization, and off-farm work), government policies, and productivity changes over the period. They found that farm structural change does impact productivity. They also found that public R&D impacts farm structure, while agricultural policies had little impact on structure. Huffman and Evenson (2001) assumed that farm productivity did not affect farm structure. While this specification is consistent with the empirical findings of Weersink and Tauer (1991), it is not consistent with a theme of many conceptual models of structural change.

Prior efforts to explain the sources of state TFP growth, excluding structural considerations, have been undertaken by Huffman and Evenson (1993); Alston, Craig, and Pardey (1998); and Yee, et al. (2002). The Huffman and Evenson data set covered the period 1950-1982 for 42 U.S. states. They used public and private research stocks and agricultural extension stocks to explain TFP. Although the impacts of public agricultural research were generally positive on agricultural productivity, applied livestock research had a negative impact on livestock sector productivity.

Alston, Craig, and Pardey (1998) constructed another state level productivity data set for 48 states, 1949-1991, and they have examined the impacts of a single combined public agricultural research and extension variable on TFP. They used essentially all of the public agricultural research expenditures of state agricultural experiment stations to construct the research and extension stock variable, irrespective of whether the research was focused on production agriculture. Interstate spillovers have generally been excluded. They have found positive effects of the combined public agricultural research and extension variable on agricultural productivity.

Using data for 1960-1993, Yee, et al. (2002) explained agricultural productivity growth at the state level with R&D, R&D spillovers, extension, transportation infrastructure, and weather variables. Where their results overlapped with prior studies, the results were largely as expected. Public agricultural research and highways had positive impacts on agricultural productivity, and the marginal real social rate of return to public agricultural research was large. The results for public agricultural extension were mixed, but this was consistent with Huffman and Evenson (1993). Spill-in research stocks were found to impact agricultural productivity positively in all regions, and the computed real rate of return to investments in public agricultural research to any one state was less than the social rate of return to all states in its region.

Sources of Change for Productivity and Structure

The sources of change that we examine can be categorized into: government investments and interventions, organizational and structural dimensions, and other exogenous market price and weather related variables.

Government Investments and Interventions in Agriculture

Government involvement in the agricultural sector is pervasive and significant. Some government policies are designed to impact agriculture, and other government policies that impact agriculture, are likely not designed to do so, e.g., macroeconomic policies. In that case, the impact is a secondary impact. Of course, it is extremely difficult and, perhaps, foolish to identify the intended impacts of many government policies on agriculture, given the nature of our system of government. Rausser (1992) classifies agricultural policies into two groups: those that correct for market failures, lower transaction costs, or enhance productivity, and other policies that result from manipulation by special interest groups. Generally, the intended impacts of government agricultural policies are not to alter the structure of agriculture, likely because a consensus on the ideal structure does not exist and because of our recognition of the efficiency of the marketplace for allocating resources.[4] Exceptions to this would be programs such as the Limited Resource Farmer program, Farm Service Agency's "lender of last resort" programs, and certain aspects of the tax code. In addition, payment limitations on receipt of direct payments could also be considered an explicit policy designed to minimize the impacts of policies on agricultural structure. In contrast, there are government policies clearly designed to impact the productivity growth of agriculture in recognition of the value of enhancing the social benefits of a more productive sector. Regardless of the primary intent of government intervention, there are significant impacts from government actions on both structure and productivity. The major government policies affecting productivity and/or structure include: public research and extension, investments in highway infrastructure, and commodity and conservation programs.

Research and Extension. The justification for public investment in agricultural research and extension is to realize the social benefits resulting from an increase in productivity. The output of agricultural research includes higher yielding crop varieties, better livestock breeding

[4] All modern farm bills make reference to the importance of preserving the family farm, but an operational definition of that group is not communicated and a transparent plan for accomplishing that goal is not contained in the Act.

practices, more effective fertilizers and pesticides, and better farm management practices. Plus, a significant share of agricultural research expenditures is devoted to so-called maintenance research (Huffman and Evenson 1993, pp. 114). Public agricultural research is performed in state agricultural experiment stations, land grant and other universities, and the USDA's Agricultural Research Service, Forest Service, and Economic Research Service. Various aspects of the system have been thoroughly studied by several authors (e.g., Huffman and Evenson (1993), Alston, Norton, and Pardey (1995); National Research Council (1995); Fuglie et al. (1996)). Agricultural research is also performed by the private sector, mainly in the areas of farm machinery, agri-chemicals and pharmaceuticals, plant breeding and food processing. Private research expenditures have increased dramatically during the past three decades and now surpass that of the public sector (Fuglie et al. 1996; Fuglie 2000.)[5] For U.S. agriculture, the real rate of return is high--somewhere between 20 percent and 60 percent. The high rates of return to public agricultural research emerge regardless of the level of aggregation (individual commodities or more aggregate measures) or geographical area considered.

There is a limited research on how public research and extension have affected the structure of agriculture. A classical article is the one by Schmitz and Seckler (1970) on the adoption of the tomato harvester. In the past, the implications of an agricultural research agenda were not explicitly considered among planning priorities, likely because of the dearth of information on the relationships. There is a significant interest in recognizing structural implications in research priority setting currently. For example, ARS conducted a program evaluation to determine that two-thirds of its programs at the time of the review had potential to contribute to the competitiveness of small farms (USDA, 2000). The USDA has asked the

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[5] Unfortunately, we do not consider the role of private R&D in our empirical model in this paper.

National Research Council to review the relationship between publicly funded research and the evolving structure of agriculture (National Research Council, 2001).

The role of agricultural extension is to extend useful information to farmers and other constituents at a level that can be useful in application and problem-solving. Extension agents disseminate information on crops, livestock, and management practices to farmers and demonstrate new techniques as well as consult directly with farmers on specific production and management problems. In particular, giving farmers good information on new technologies can speed the adoption process, which generally increases the rate of return on research expenditures. Unlike research, agricultural extension input can be expected to have an almost immediate impact on agricultural productivity. The bulk of public extension funding now comes from state and county governments rather than the federal government (Ahearn, Yee, and Bottum, 2002). There is increasing involvement by the private sector in extension activities, as well. For example, private crop consultants offer advice on pest and nutrient management. The empirical evidence on the social rate of return to public agricultural extension shows a greater variation and, in general, lower levels than for research (Fuglie, et al, 1996).

Infrastructure. The transportation of agricultural inputs and outputs in modern agriculture requires good infrastructure, especially roads and communications. Aschauer (1989) argued declining public capital stocks were a drag on productivity in the nonfarm sector during the 1970s. Since that time, several studies have investigated the impact of public infrastructure (highways and streets, water and sewer systems, schools, hospitals, conservation structures, mass transit, etc.) on productivity outside of agriculture. For the nonfarm sector, the empirical evidence is that public infrastructure has a positive and statistically significant impact on output and productivity. This finding is even more impressive given that much public infrastructure spending goes for improving the environment and other objectives that are not captured in output or productivity measures (as conventionally measured). This finding also implies that the rate of return to public infrastructure investment may be under-estimated because of the neglect of environmental and other benefits.

Little research, however, has examined the effects of public infrastructure on agricultural productivity in the United States. Antle (1983) did find a positive contribution of transportation and communication infrastructure on agricultural productivity for a cross-section of 66 countries. More recently, Gopinath and Roe (1997) at the national level and Yee, et al. (2002) at the state level found a significant positive relationship between infrastructure and U.S. agricultural productivity. Transportation infrastructure, as a provider of access to the local labor market, is also important in explaining off-farm labor supply of farm households.

Commodity Programs. Two basic commodity programs were in effect throughout our study period (Rasmussen, 1980). A flexible agricultural price support plan based on supply and projected demand, in contrast to earlier plans based on parity, went into effect in 1954. Stockpiles of surplus commodities grew significantly by 1960, the beginning of our study period. These surpluses were much reduced in the beginning of the 1970s as policies (e.g., P.L. 480) were expanded to use the surplus stocks to feed hungry people domestically and internationally. In fact by 1973, the stocks were at a very low level for a variety of reasons, such as poor crop yields in other countries (e.g., the Soviet Union), major shifts in the policies of other countries, and allowing the value of the dollar to float rather than be pegged to the value of gold (Penn, 1979). Legislation in the 1970s established a two-tier price system with target prices and commodity loan rates.

The literature is mixed on how government commodity programs have affected farm structure. This is in spite of the fact that it has been widely studied. Tweeten (1993) provides a literature review, describes the conflicting results in the literature, and an analysis of how payments have affected farm numbers from 1950-1987. He concludes that government payments modestly increase farm numbers in the short run and slightly decrease farm numbers in the long run.

Conservation Programs. A variety of conservation programs have been established during our study period. The largest program during the period is the Conservation Reserve Program, established in 1985. Small farms, those with less than $250,000 in sales, currently receive more than 80 percent of government conservation payments. Other programs provide technical assistance for conservation, such as those delivered by the Natural Resource and Conservation Service, formerly the Soil Conservation Service, but measures of those activities are not included in the model.

Organizational and Structural Dimensions

There are many indicators of structural change that are related to the most basic indicators of farm size and off-farm labor supply. These include the level of specialization, or the lack of diversification, on the farm. Also, there is reason to believe that there is an important distinction to be made for crop and livestock production in terms of productivity (Huffman and Evenson, 1993). The same could be argued for studies of structural change. For example, dairy is a specialization that requires a high intensity of labor, which has significant impacts on how a farm family organizes its resources, including supply labor to off-farm employment activities.

It is difficult, if not impossible, to adequately capture the trends in industrialization of agriculture with our data systems. Vertical integration for the whole of the sector is especially difficult to quantify at any point in time, let alone over multiple decades, since it involves links among multiple industries, upstream and downstream. An exception to this is for contracting. Historical Censuses of Agriculture do document the still small in aggregate, but increasing trend towards contract production.

Other Dimensions

A variety of other dimensions affect productivity levels and/or structure. These include regional variables, weather variables, and prices. Early explanations of structural change have featured changing relative input prices. Most notable is the work by Kislev and Peterson (1981). In observing the drastic reductions in farm labor in the postwar period, they explain these by the importance of the capital and labor price ratios. In addition, the impacts of much research investments are labor saving.

The Model

The model we employ is a simultaneous equations model with equations for productivity, farm size measured as land rent per farm, and the odds that an operator works off-farm at least 200 days per year. We estimate the model using three stage least squares in recognition of the endogeneity of regressors and the correlation of the disturbance terms. For example, it is reasonable to imagine that farm size and off-farm work are jointly determined. The basic conceptual model for the productivity equation is identical to that found in Yee, et al. (2002), with the addition of structural variables. The farm size equation is not based on a single formal model of structural change because we would argue that there is not a sufficiently comprehensive model that dominates the literature. Hence, our farm size equation is a seemingly ad hoc specification of variables believed to be linked to the farm size determination. The conceptual model for the off-farm labor force participation is rooted in the standard labor-leisure household utility maximization model extended to address the farm household choice set (e.g., see Hallberg, Findeis, and Lass, 1991). This study will empirically test key relationships between productivity and structure for a relatively recent period in the history of agricultural structural adjustment, the period 1960-96. We estimate a simultaneous equations econometric model to determine the relationships among productivity, farm structure, and the variables hypothesized to impact those. We are especially interested in the policy-relevant variables, such as government farm payments and public investments in R&D and extension. Table 1 lists the variables used in our productivity-structure model, along with a description of each variable.

Results

The regression results for our productivity-structure model are presented in Tables 2. Public investments in R&D, extension, and highways all have positive and significant impacts on total factor productivity. Spill-in R&D has a bigger impact than a state's own R&D. Some might consider this surprising given that a state's R&D would be directly targeted to the state's agriculture. On the other hand, there are R&D investments from several states with similar agriculture that are being captured by the spill-in measure. Past studies have found mixed results about the role of extension in explaining productivity growth. In contrast, we find very strong and positive results for the role of extension in explaining productivity. Two of our structure variables, the use of production contracting and our Herfindahl indicator of specialization, have a positive effect on productivity. The result on contracting lends support for the argument that contracting increases the efficiency of production, but it makes no contribution to the controversy regarding the allocation of rents between farmers and contractors. Commodity payments have a positive effect on productivity. One simplistic reason is because our output measure used to compute TFP is valued at the subsidized price, i.e., market price weighted by government payments. Another explanation may be that farmers use part of the commodity payments to purchase newer and more efficient farm machinery, which increases productivity. We find a negative relationship between the ratio of farm machinery price to hired farm labor wage and productivity. Over the study period, this ratio has not been linear in time; there was a spike in the relationship in the mid-1980s. However, the simple relationship specified here indicates that the overriding impact was for the price of capital to be increasing at a slower rate than the price of hired farm labor. Farmers substituted relatively cheaper farm machinery for farm labor. Hence, the finding is consistent with the most basic story about agricultural production in the postwar period. Drought has an expected negative effect on productivity. Flood has an insignificant effect on productivity.

The two structural variables were both significant in explaining productivity. Increased probability of off-farm work by the operator is associated with a lower level of productivity. This is to be expected because an off-farm job that is 200 or more days per year is likely to the primary occupation of the operator; productivity in farm enterprises may be secondary. But there are several explanations for this finding, as well. We find a negative effect of farm size (measured by land rent per farm) on productivity, possibly indicating diseconomies of size. However, this may not be that unexpected given the productivity data. For example, several small farm states, like Connecticut, were among the highest 10 states in terms of TFP in 1996, while Texas, Oklahoma, Montana, and Wyoming were among the lowest 6 states in terms of productivity levels in 1996.[6] Alternatively, this could be the result of the commodity mix, by state. A large share of cow-calf producers in a state may contribute to lower TFP indexes and larger farm sizes in those states.

In the farm size model, public R&D and extension both have positive and significant impacts on farm size. This provides some evidence for the concern that public investments encourage the growth in farm size. Huffman and Evenson (2001) also found some evidence of this result for crop R&D investments. Specialization has a positive and significant impact on farm size. We find that government transfer payments under commodity payments are positively related to farm size, indicating that farmers may invest part of the commodity payments to expand their farm size. This finding is consistent with Cochrane's "cannibalism" tendency of payment recipients to out-bid farmers not receiving payments for farm land (Cochrane, 1958). Contracting has a positive, but insignificant, effect on farm size. Increased off-farm work is associated with a smaller farm size, as more time spent working off-farm means less time available for working on the farm. A decrease in the farm machinery price - hired farm labor wage ratio leads to an increase in farm size. A decrease in this ratio makes farm machinery cheaper relative to farm labor. Purchase of farm machinery generally entails a high fixed cost, which the farmer wants to spread over a higher level of output. Again, surprisingly, we find a negative relationship between productivity and farm size.

In Table 2 the estimate of the structural off-farm equation shows that the real manufacturing wage has a positive and significant effect on the odds of farmers working off-farm more than 200 days per year. We find an insignificant effect of the manufacturing wage -

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[6] We are also concerned that there is some nonagricultural upward bias in the agricultural rents of states dominated by small farms, in particular, that there are some urbanizing influences in their rent measures.

hired farm labor wage ratio on the decision to work off-farm. In lieu of a variable measuring the schooling of farm operators, we have included a time trend variable.[7] It has a positive and significant effect. A higher level of education expands the opportunities for off-farm work. The highway stock has a positive effect on off-farm work by making it easier for farmers to get to their off-farm jobs. Specialization has a negative effect on off-farm work, in contrast to the result for farm size. Commodity and conservation payments both have negative effects on off-farm work. Commodity payments increase the value of the farmer's time working on the farm, relative to the off-farm wage rate. An increase in the share of dairy in total cash receipts is associated with a lower level of off-farm work. This is the usual finding in studies of off-farm labor supply because of the high labor requirements of a dairy farm. Finally, an increase in farm size is associated with lower off-farm work as the farmer has more work to do on the farm, as the size of the operation increases.

Concluding Remarks

We found positive and significant impacts of government policies (investments in public research, extension, and highways and commodity programs) on productivity growth. We also found evidence that government intervention, including direct payments for commodity programs, affect dimensions of structure. And, we found evidence of a simultaneous relationship between productivity and measures of farm structure. Knowledge of the significance and direction of these relationships is timely as there are new indications that agricultural research institutions are concerning themselves with the implications of research outcomes on agricultural structure (NRC, 2001; USDA, 2000). The negative relationship between off-farm labor supply and government payments that has been found in previous studies was confirmed by this

[7] Unfortunately, the time trend also accounts for other excluded variables that may vary with time.

simultaneous modeling effort between productivity and structure. In light of the continuing large agricultural subsidies, this study indicates that off-farm employment is likely less than it would be in the absence of programs. The majority of farm operators already work off the farm, and most of those work at least 200 days each year.

We want to emphasize that the estimates presented in this paper are preliminary and we have several improvements underway: (1) We plan to estimate our productivity-structure model at the regional level with state dummy variables for each of our 7 regions. While we have used the regional groupings of states employed in our earlier work (Yee, et al., 2002), we also plan to estimate our model using alternative regional groupings (e.g., the 9 NRC (NRC, 1995) and 10 traditional farm production regions (USDA, 1999)). (2) We examined the role of commodity program payments, but we did not examine the impact of the required land set asides that vary widely over time. The land that was required to be set aside under the commodity programs, is not accounted for by the land input measure implicit in our TFP measure. We plan to include a measure of the set aside acres in a future model. (3) We used national input prices in the present paper. We plan to develop a data set of state-specific input prices. (4) We plan to develop several more farm structural variables (e.g., measures of entry, exit, and farm growth and output concentration) to supplement the ones we used in this paper. (5) We plan to include measures of private investments in research and development from extensions of the data base employed in Huffman and Evenson (1993). (6) Finally, we plan to more closely examine the role of education in agricultural productivity. The TFP measure we use in this study includes a labor input measure which adjusts for changing labor quality over time. We hope to employ a total factor productivity measure which does not quality adjust labor and to examine the role of education separately in TFP, farm size, and off-farm labor supply decisions.

Finally, there are a group of factors that have taken hold since the end of our study period. The U.S. economy has experienced a very large growth since the end of this study period, and there is still a divergence of views about the sources of that growth, but information technology is viewed as one of the keys. Information technology advancements have been adopted by some farm operators. The adoption of GM seeds has proceeded more rapidly than most agricultural technologies, although it has been slowed by consumer acceptance concerns. In addition, the post 1995 period has seen a major change in the mechanisms for transferring income to the farm sector. It will be interesting to extend this analysis to determine how these changes have affected agricultural TFP and structure during this very recent period.

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Figure 1. Index of Farm Input Use

U.S. 1948-1996

1948 = 100

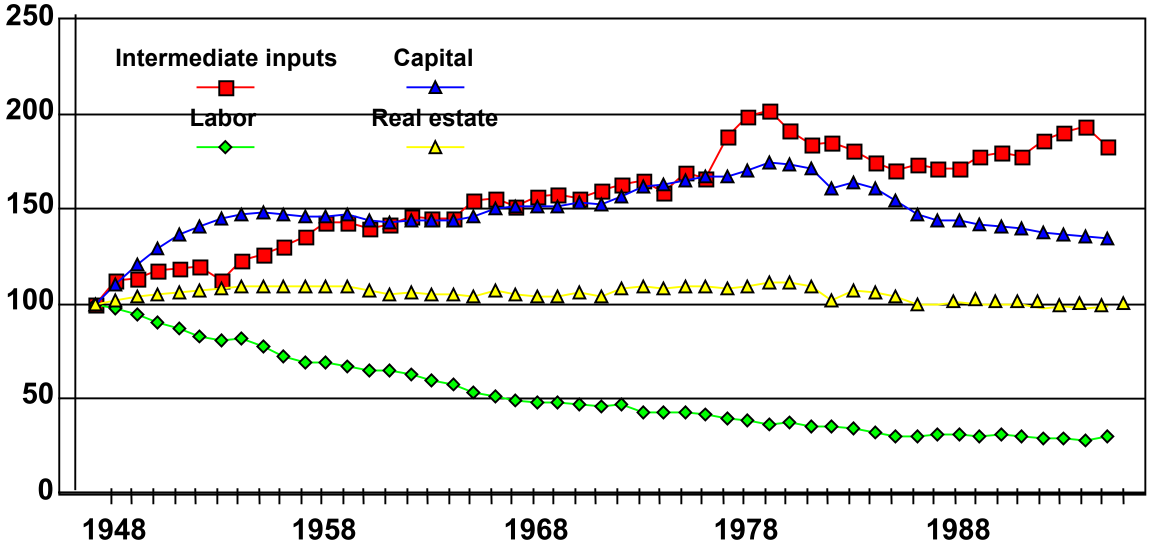
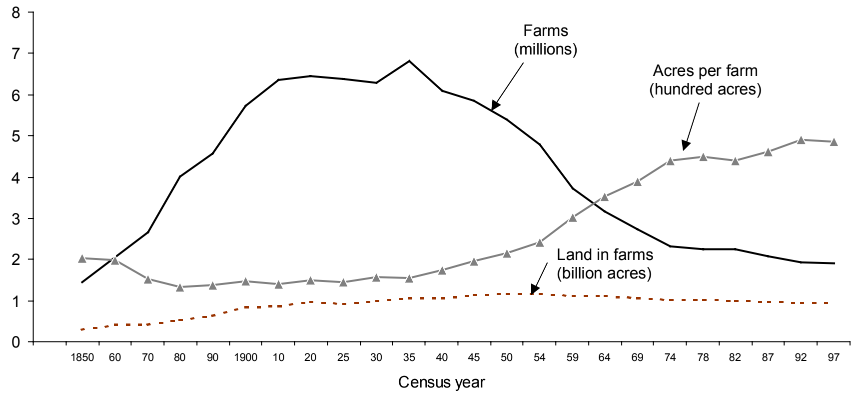


Figure 2

Farms, land in farms, and average acres per farm, 1850-1997

Most of the decline in farms occurred between 1935 and 1974



Source: Compiled by ERS from Census of Agriculture data, Hoppe, 2001.

Table 1. Variable definitions

Variable	Definition
tfp	Level of total factor productivity (relative to Alabama in 1987)
size	Real land rental per farm
off	Proportion of farm operators who worked 200 or more days off farm
ownrd	Own research stock
spillin	Spillin research stock
ext	Extension stock per farm
hiway	Highway stock
hiwaya	Highway stock adjusted for the share of agriculture in a state's GDP
spec	Specialization computed as a herfindahl index, based on 10 commodity categories
contract	Proportion of farms with production contracts
compay	Real commodity payments per farm
conpay	Real conservation payments per farm
time	time trend
m	Real manufacturing wage (lagged one year)
kw	Farm machinery price - hired farm labor wage ratio (lagged one year)
mw	Manufacturing wage - hired farm labor wage ratio (lagged one year)
drought	Drought dummy
flood	Flood dummy
dairy	Dummy variable equal to 1 if dairy is greater than 20% of total cash receipts

Notes:

"l" in front of a variable denotes taking the log (e.g., ltfp).

Regional dummy variables are included in each equation. The regions considered in this paper are:

1 – Northeast (NE): CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT
2 – Southeast (SE): AL, FL, GA, KY, NC, SC, TN, VA, WV
3 – Central (CENT): IN, IL, IA, MI, MO, MN, OH, WI
4 – Northern Plains (NP): KS, NE, ND, SD
5 – Southern Plains (SP): AR, LA, MS, OK, TX
6 – Mountain (MOUNT): AZ, CO, ID, MT, NV, NM, UT, WY
7 – Pacific (PAC): CA, OR, WA

Table 2
Three stage least squares estimates of productivity and structure model, 1960-96 (n = 1776)

Variables	**ltfp**		**lsize**		**l[off/(1-off)]**	
	coeff.	**t-stat.**	**coeff.**	**t-stat.**	**coeff.**	**t-stat.**
Endogenous variables						
ltfp			-1.032	-9.948		
lsize	-0.238	-14.469			-0.117	-4.410
l[off/(1-off)]	-0.138	-5.181	-0.341	-4.985		
Exogenous variables						
lownrd	0.122	10.823	0.459	18.633		
lspillin	0.206	15.103	0.607	19.161		
lext	0.355	28.311	0.671	17.943		
lhiwaya	0.117	9.721				
lhiway					0.118	8.081
lspec	0.187	10.050	0.493	10.542	-0.265	-9.008
lcontract	0.011	2.961	0.011	1.105		
lcompay	0.027	7.635	0.050	5.086	-0.018	-2.903
lconpay					-0.009	-0.737
time					0.011	8.926
lm					1.822	9.939
lmw					0.054	0.714
lkw	-0.166	-6.723	-0.411	-6.100		
drought	-0.056	-5.070				
flood	0.003	0.271				
dairy					-0.142	-4.705
Regions						
SE	-0.082	-3.887	0.158	2.735	0.153	4.444
CENT	0.223	6.948	1.254	18.620	-0.076	-1.543
NP	0.370	7.585	2.210	28.133	-0.556	-8.013
SP	0.033	1.118	0.966	14.830	0.036	0.715
MOUNT	0.348	8.386	2.099	41.031	0.214	3.038
PAC	0.295	8.639	1.595	24.033	0.160	2.568
Intercept	-6.482	-24.527	-15.053	-21.095	-6.418	-14.718
R^2	0.502		0.827		0.559	