Introduction and Overview

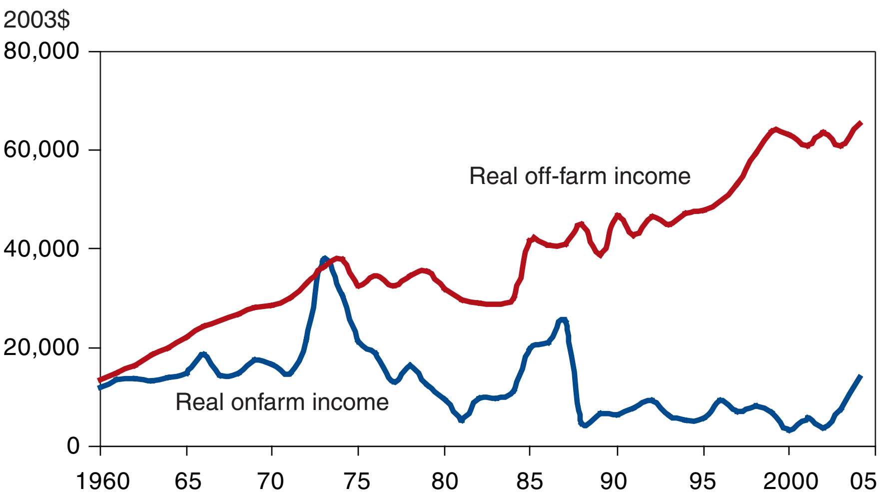
Decisionmakers (mainly farm operators and their spouses) are a major determinant of farms' economic performance. The effort and ability to manage land, water, machinery, and other inputs— as well as adoption of technologies and production practices—can help secure farm business success and the economic well-being of a farm household. However, many farm operators (and other household members) use a large share of their time in off-farm income-generating activities. Consequently, for many farm households, economic decisions (including technology adoption and other production decisions) are likely to shape and be shaped by the allocation of managerial time to such activities. While time allocation decisions are usually not measured directly, we observe the outcomes of such decisions, such as onfarm and off-farm income.

Off-farm income (largely earned income from employment and off-farm business income) received by U.S. farm operators and their spouses has risen steadily over recent decades and now constitutes the largest component of farm household income (fig. 1a, b). The impact of off-farm income is felt particularly by households operating small farms, allowing many of them to survive and even flourish to an extent not thought possible 20 or 30 years ago (Gardner, 2005). In addition, the growth in off-farm income over the last 40 years reduced income inequality among farm households and helped U.S. farmers' average incomes overtake those of the nonfarm population (Gardner, 2002).

This report examines the empirical relationships between off-farm income, farm household characteristics, production decisions (particularly technology adoption), and various measures of economic performance for U.S. farm households. This research provides insights into farmers' choices in the context of farm/household integration and helps improve our under-

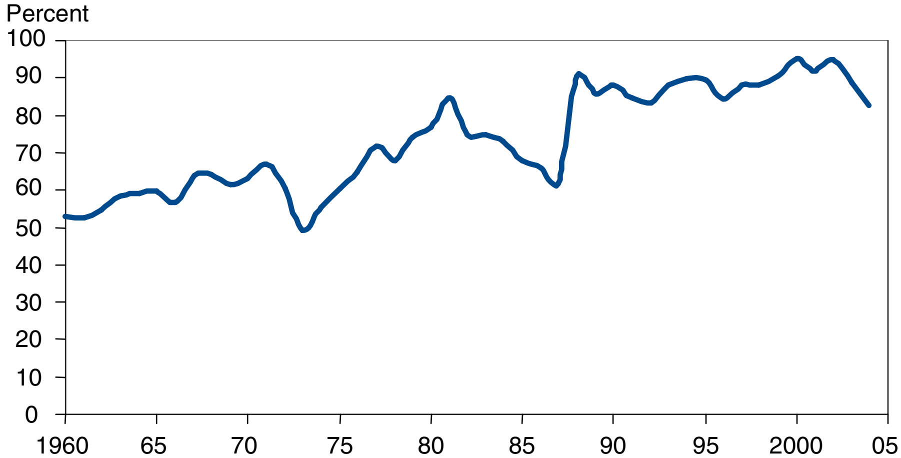
Figure1a

Farm household income, U.S. average 1960-2004



Sources: USDA, ERS. Deflator used to calculate real income is the consumer price index (CPI-U) from the Bureau of Labor Statistics.

Figure 1b
Off-farm income share of total farm household income, U.S. average, 1960-2004



Sources: 1960-2003: USDA farm household income estimates over time, ERS farm structure briefing room, http://www.ers.usda.gov/Briefing/FarmStructure/Data/historic.htm; 2004: Covey et al., 2005.

standing of the pace of technological innovation and its relation to the structure of agriculture.

The report also suggests the need to analyze the economics of the farm business and farm household in an integrated framework and describes two approaches for doing so. We summarize statistics of off-farm work and income in U.S. farm households and examine the relationship between off-farm income and farm size, location, and household characteristics.

Our main research focus is to examine how off-farm work influences the economic performance of the integrated farm business and household. To do this, we expand traditional concepts of economic performance, such as economies of scale and efficiency, to incorporate onfarm and off-farm income-generating activities of household members. In addition, we examine the relationship between off-farm income and the adoption of agricultural technologies of varying managerial intensity, namely herbicide-tolerant crops, precision agriculture, conservation tillage, and Bt (*Bacillus thuringiensis*) corn.

An Integrated Approach

While increasing household income, off-farm activities also compete for managerial time (mainly of farm operators and their spouses), which may affect the economic performance of the farm business. Consequently, economic decisions (including technology adoption and other production decisions) are likely to shape and be shaped by the underlying allocation of time within the farm operator household. So, rather than examining the farm business or farm household in isolation, an integrated approach captures the interplay of farm and nonfarm considerations and contributions.

Despite its importance, the role of off-farm income has been largely neglected in empirical analyses of farm economic performance and technology adoption.[1] Some exceptions include Gardner (2001), Boisvert (2002), Goodwin and Mishra (2004), Fernandez-Cornejo et al. (2005), Nehring et al. (2005), Paul and Nehring (2005), and Chavas et al. (2005).[2] One reason for this lack of studies may be the modeling and data challenges in moving from the traditional unit of analysis (the farm business) to the farm household.

While agricultural economists have made major contributions in understanding farm production functions, they may not have exploited as fully the concept of the household production function (Offutt, 2002). In this context, the allocation of time (and money) of household members to production, consumption, and other activities is particularly important. An integrated firm-household perspective was suggested back in 1952 by E.O. Heady, who observed that "the firm-household complex is important not only to defining the organization of resources and family activities which will maximize utility at a given point in time but also in helping to explain uncertainty precautions, capital accumulation, soil conservation, and other production-consumption decisions, which relate to time."[3]

Approaches To Integrate Off-Farm Work and Farm Production

Two approaches are used in this report to model the interaction of off-farm income-generating activities with traditional farm production activities. The unifying notion underlying the two approaches is that managerial time is a key resource in both onfarm and off-farm activities.

In one approach, we expand the agricultural household model to include the technology adoption decision together with the off-farm work decisions by the operator and spouse. The agricultural household model describes how a farm household allocates its time (and other resources) among producing commodities, earning off-farm income, leisure, and home production.[4] The model assumes that the farm household maximizes its utility subject to constraints on its time (including work and leisure), income, and production technology (production function). Household members derive utility from goods purchased for consumption, leisure, and factors exogenous to current household decisions, such as human capital, household characteristics, and weather. Using this model, we examine the interaction of off-farm work and the adoption of agricultural innovations (both management saving like herbicide-tolerant crops, and management using like precision agriculture or integrated pest management—IPM), then obtain empirical estimates of the relationship between adoption of these technologies and farm household income.

Though the agricultural household model has intuitive appeal in modeling farm household behavior, it requires much in the way of assumptions and data (Offutt, 2002). Parameter estimation for the models spawned by the household production function often requires hard-to-get data, including consumption expenditures, farm and off-farm labor supply, farm and nonfarm outputs and inputs, assets, and prices for all goods, inputs, and labor. Also needed is information on technologies and participation in

[1]Economic researchers have been examining farm economic performance focusing on the farm business for several decades (Heady; Griliches; Dawson and Hubbard; Hallam). Another line of research has focused on the farm household and the labor allocation decisions by the operator and their spouses (Huffman, 1980, 1991; Lass, Findeis, and Hallberg, 1989; Lass and Gempesaw, 1992; Kimhi, 1994, 2004).

[2]Boisvert (2002) stressed not only the growing links between farming activities and off-farm labor markets but also the links between farm household activities, conservation payments, and agricultural pollution.

[3]Loosely, utility is a measure of satisfaction. Economists assume that people act if doing so gives them utility.

[4]The household model initially received a great deal of attention in studies of developing countries' agriculture because of the relative importance of consumption activities in such households. Agricultural economists have also applied these models in developed countries to examine how household members make decisions about the allocation of labor both on and off the farm (Huffman, 1980, 1991; Sumner, 1982; Lopez, 1985; Singh et al., 1986; Lass et al., 1989; Lass and Gempesaw, 1992; Kimhi, 1994, 2004; Mishra and Goodwin, 1997; Goodwin and Holt, 2002). Other analysts have examined income and wealth distributions and links between income instability and consumption/investment (El-Osta and Morehart; Mishra and Morehart). Lopez is one of the few to have considered labor supply and farm production decisions simultaneously. In a very recent application, Chavas et al. used a farm household model to investigate the economic efficiency of farm households in Gambia (Chavas et al., 2005).

government programs, as well as demographic data. For these reasons, it is sometimes necessary to use alternative methods. In this approach, we expand the concept of scope economies to include as output all income-generating activities, on or off the farm, in addition to the traditional farm outputs such as corn, soybeans, and livestock (Nehring et al., 2005). In addition, we estimate scale economies and technical efficiency, and compare results at the farm and household levels.

Scale and Efficiency

Scale Economies

A farm is said to have economies of scale (or increasing returns to scale) if the average cost declines as output (scale of production) increases. If a farm is subject to economies of scale, it is cost effective for that farm to increase all outputs simultaneously while holding the mix of outputs constant (costs would rise less than proportionally). Thus, the existence of scale economies suggests that farms can achieve lower average costs by becoming larger. Economists have established (under reasonable conditions) the equivalence between the information provided by the costs and the production technology (Carlton and Perloff, 2000). Based on the production technology, economies of scale may be viewed from an output or input perspective.

From an output perspective, the term elasticity of scale is used to measure the percent increase in output generated by a 1-percent increase in all inputs (Varian, 1992). There are increasing returns to scale if the elasticity is greater than 1; that is, an increase in overall inputs generates a more than proportionate increase in output. For example, a scale elasticity of 1.15 means that a 1-percent increase in inputs leads to a 1.15-percent increase in output. Conversely, if the elasticity is lower than one there are decreasing returns to scale; that is, an increase in overall inputs generates a less than proportionate increase in output. For example, a scale elasticity of 0.8 means that a 1-percent increase in inputs leads to a 0.8-percent increase in output. Constant returns to scale means that a 1-percent increase in overall inputs generates a 1-percent increase in output; in this case the elasticity of scale is equal to 1.

From an input perspective, a similarly defined scale elasticity measures the percent increase in inputs required to support a 1-percent increase in all outputs. In this case, returns to scale are increasing when the input-oriented scale elasticity is less than one. For example, if the scale elasticity of a farm is 0.75, it means that a 0.75-percent increase in inputs will be needed to support an output increase of 1 percent. This suggests that there is an incentive for the farm to grow larger. If the elasticity is equal to one (constant returns to scale), there are no scale economies available. In this report, we use an input perspective (input distance function, appendix 1).

Technical Efficiency

Economic efficiency can be decomposed into technical efficiency and allocative efficiency. A farm is technically efficient if it uses the minimum possible levels of inputs to produce a given level of output, given the technology. An allocative efficient farm produces a given output using the best (minimum cost) input proportions given prevailing input prices. Unless specified otherwise, the efficiency results discussed in this report involve technical efficiency.

Technical efficiency is the ratio of current to maximum possible or "best practice" production and it is calculated in this study using an input distance function (see appendix 1). Technical efficiency is defined relative to an "efficient frontier" and all farms operating on the efficient frontier are classified as 100 percent efficient with an efficiency score equal to 1. Farms using more inputs to produce a given output level than those on the efficient frontier are inefficient and their efficiency score is less than 1. Technical efficiency is often associated with managerial ability and experience.