



## Assessing new technology (4/9/1998)



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Every day seems to bring a new technology for farmers. Global positioning, infrared analysis, herbicide resistant seeds, new hybrids, and variable rate applications are a few of the relatively recent agricultural technologies.

Agriculture is not alone in being overwhelmed with new technologies and innovations. J.M. Silliman observed, "[t]he pace of social, political and economic change has been so rapid the latter part of this century that people have had little time to come to grips with it."

Indeed the changes are coming so fast that it is hard to evaluate them. Economic theory shows that the early adopters of a clearly superior technology are the ones who benefit most. This is because by the time the late adopters have changed to the new technologies, the profits generated through the improvement have been factored into the market price. Those who did not adopt the new technology are at a competitive disadvantage.

The problem is knowing which of the technologies are clearly superior and which offer only marginal changes. Additionally, some technologies are not the most efficient initially, but are refined over time so that they become the most effective choices. Knowing which technologies to adopt and when to adopt them are critical questions facing farmers.

This paper discusses two kinds of analysis that can be used. There are no magic solutions and it is important that farmers realize what may be the right decision for one farm may not be the right decision for another farm. Farmers need to seek the most appropriate technology for their operation, not necessarily the newest technology.

### Steps Prior to Evaluation

Before discussing the analysis techniques, there are two steps that must be completed to evaluate any technology. First, farmers must know their goals. This has been said so often that to some it may seem like a cliché, but it is critical in evaluating the appropriateness of a new technology. Economists often assume profit maximization is the only goal. However, there are additional considerations. Most choices hinge on making money but there are other goals that may enter into the decision.

Different technologies use different resource mixes and this mix of resources can determine whether or not a technology is appropriate. For example, some farmers adopt different technologies because they save labor. If the labor that is freed up has a higher use, then such technologies will usually be appropriate. The labor that is freed up can be used either for more work,

  

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more leisure, or family time or whatever. The key question is what value is placed on the labor saved. If adopting a labor saving technology frees up labor that has a low alternative value, then the technology may not be appropriate.

The second step in evaluating alternative technologies is accurately assessing your resources. Economists typically talk about four categories of resources: land, labor, capital, and management. For farms, however, it is more descriptive to think of the resource categories in a slightly modified way. This modification acknowledges that most of the labor and management is provided by the same person or people. In this context there are three categories of resources available: land, which includes all the plants and animals inhabiting it; capital which includes flow (money or liquid assets) and stock (buildings and equipment and the technology they encompass) dimensions; and labor, which includes physical labor, hand labor, and head labor. Physical labor simply means the hard work, heavy lifting, and so forth involved with any farm, hand labor can be thought of as the machinery and equipment operations, and the head work is really the management. One reason for separating the labor components is that the ability to perform the various labor functions changes over time. A 25 year-old farmer will have a greater capacity for physical labor than a 45 year-old.

Assessing your resources is important in determining the appropriateness of new technologies because the resource mix changes over time and new technologies require a different mix of resources. An appropriate technology for a starting farmer may not be appropriate for one reaching retirement age. An appropriate technology for someone who enjoys working with computers and high-technology equipment may not be appropriate for someone who enjoys working with animals.

## Evaluating a New Technology

When evaluating a new technology the farmer must ask a basic question: Does adoption of this technology involve relatively minor changes in my operations or will adoption of this technology significantly alter the way I farm? The first type of technology changes, those that involve relatively minor modifications in the way things are done, are referred to as incremental or embodied technologies. A partial budget is the best evaluation technique to use when evaluating an incremental technological change. Those changes that will have a significant impact are referred to as alternative technologies and whole farm analysis is needed for an effective evaluation.

Not all technologies fall clearly into one category or another. The classification of the technology change is not as important as using the right tool to evaluate the change. The partial budget approach is easiest, but in many instances the change requires a more substantial analysis.

## Partial budgeting

The concept of a partial budget is relatively simple, but as usual, the implementation of the procedure can be complex. A partial budget looks at the change in profitability of adopting a new technology or way of doing something on the farm. When using the partial budget you are comparing the existing situation with the new or alternative method.

There are four categories of changes to estimate when conducting a partial budget. First, you must estimate the added or new cost of adopting the technology. Second, estimate the revenue added with using the new technology. The third parameter to estimate is the decreased cost of not using the technology that is being replaced. And, finally, you need to estimate the lost revenue. A simple technique for preparing the partial budget is to divide a piece of paper into four quadrants. In the upper left enter the decreased costs, and in the upper right quadrant enter the costs that increase. In the lower left enter the revenues added, and in the lower right quadrant enter the decreased revenues. Adding the two columns on the left (the decreased costs and increased revenues) gives the benefits of the new technology. The two columns on the right (the increased costs and decreased revenues) equal the costs of adopting the new technology. If the benefits exceed the costs, then the new technology will be profitable. See Table 1 for an example.

Simply because a new technology is profitable does not mean that it is necessarily appropriate for a particular farm. As will be discussed, there are other factors that need to be considered when determining whether or not to adopt a new technology.

## Whole Farm Analysis

If a new technology requires major changes in the farming operation, then it will be necessary to evaluate the new technology using a whole farm analysis. Under a whole farm analysis, all of the enterprises on the farm are evaluated. The first step is to determine the profitability and resource use under the current system and the second step is to estimate the changes under the new system.

A whole farm analysis approach is necessary because certain factors of production may limit the ability to fully implement the new technology. If you only use a partial budget, these weak areas will not be identified. For example, if a new technology requires more labor at peak labor demand periods, then labor availability becomes a constraint that must be effectively dealt with if the new plan is to be successful. Similarly, the new technology could require a large capital investment. If the capital is not available either internally or through borrowing potential, then the new technology cannot be implemented.

In preparing the whole farm analysis, all the enterprises have to be identified and counted. The technical coefficients such as input requirements and outputs have to be estimated, and the financial characteristics must be identified.

Conducting a whole farm analysis is time-consuming, but there are several computer programs and spreadsheets available to help with the analysis. In addition there are private companies that will provide such analysis for a fee. The ISU Extension Service also offers a Farm Financial Planning Program that can be utilized for whole farm analysis.

## Example

The following two examples illustrate evaluating a new technology. The first is a cropping example, shifting from 30-inch row soybeans to drilled soybeans. The second is a livestock example comparing hoop structures and a total confinement building.

Drilling soybeans has become more popular in recent years. The following example compares drilled soybeans to 30-inch row soybeans. The data used in this example come from the 1996 cropping practices survey. This was a state wide, random sample, survey with 250 drilled soybean fields and 320 30-inch row soybean fields.

The comparison of drilled and 30-inch row soybeans uses the partial budget approach. In this case assume the person uses a custom planter or drill. The assumption simply makes the comparison easier since it would not involve machinery purchases.

The first step is to estimate the costs that will decrease or be eliminated by a shift from 30-inch rows to drilled soybeans. These cost decreases are entered in the upper left-hand column in Table 1.

The second step is to estimate the cost that will increase as a result of using the drill. These costs are entered in the upper right column of Table 1.

The revenue changes in this case are only the yield changes. The average yield for drilled soybeans in 1996 was 44.8 bushels per acre. This is entered in the lower left hand column of Table 1. The average 30-inch row yield, 47.7, is entered as a revenue decrease, shown in the lower right hand column of Table 1.

Remember what we are trying to estimate is the positive impacts (cost decreases and revenue increases) and the negative impacts (cost increases and revenue decreases) from a change from 30-inch rows to drilled soybeans. The per acre profitability is the difference between the positive and negative impacts as shown in Table 1.

The data shown in Table 1 are from a cross-sectional study, not from a research project. The variations in yields for either planting system were substantial. In 1996 the yield was 2.9 bushels per acre higher for 30-inch rows. This yield difference will vary by year and individual field. The data show in 1996, on the average, the 30-inch rows had a per acre profit

advantage over the drilled soybeans.

These results show that simply comparing the profitability of different technologies is not enough to explain technology adoption. The simple per acre comparison shows that a move to drilled soybeans would not be profitable. However, people have adopted this technology. A question would be why.

One of the factors included in Table 1 is labor. The value of the labor saved is assumed to be \$7.00 per hour. If the opportunity cost of a producer's time were greater than \$7.00 per hour then the results shown in Table 1 would be different.

**Table 1. Comparing Drilled Soybeans versus 30-inch Row Soybeans\***

<b>COST DECREASES (+)</b>		<b>COST INCREASES (-)</b>	
Planter	\$ 9.80	Drill	\$10.50
Seed	16.02	Seed	20.26
Herbicide	29.61	Herbicide	32.62
Pre-plant tillage trip**	2.55	<b>Total</b>	<b>\$63.38</b>
Row cultivation	1.31		
Labor @ \$7.00/hr	3.50		
<b>Total</b>	<b>\$62.79</b>		
<b>REVENUE INCREASES (+)</b>		<b>REVENUE DECREASES (-)</b>	
Yield	44.8	Yield	47.7
@\$6.80	\$304.64		\$324.36
Positives (\$62.79 + \$304.64) = \$367.43			
Negatives (\$63.38 + \$324.36) = 387.74			
<b>Total \$ (20.31)</b>			

\*Data from 1996 Cost of Production Survey

\*\*30-inch rows averaged 1.5 pre-plant tillage trips more than the drilled soybeans. Machinery cost estimates are from ISU Extension Publication FM1712.

A factor not considered in Table 1 is risk. Some producers may feel that the risk of not being able to perform timely cultivation offsets the lower returns to drilled soybeans. There are others who feel that the risk of diseases, especially white mold, increases with narrower rows.

The opportunity cost of a farmers labor, their attitude towards risk, the

relative weight placed on the different risks and so forth are all important factors in determining whether or not a technology is appropriate. Again, remember that the key is to determine the most appropriate technology for a given set of circumstances.

Another new technology that is being considered by some swine producers is hoop houses. The hoop house is a relatively simple structure consisting of a tarp stretched over a tubular frame. The hoops are used primarily as a facility for finishing pigs.

To compare the hoop and confinement systems we need to do more than a partial budget. Space does not permit an entire whole farm budget. Comparing resource use and returns to just the swine finishing aspects of a farm will illustrate some important points to remember when evaluating a new technology. The Midwest Plan Service has recently published a pamphlet discussing hoop houses. This publication, MWPS AED-41, February 1997, also presents a budget comparing the costs and expected returns using a hoop facility or a confinement building. Table 2 summarizes the data presented in the publication.

**Table 2. Selected Costs Comparisons for Hoops and Confinement Swine Production\***

Item	Confinement	Hoop
Facility		
Building	\$64.29	\$19.64
Feed and manure handling equipment	12.86	12.86
Total Investment (per pig sold)	\$77.14	\$32.50
Fixed Costs (per pig sold)	\$10.18	\$5.36
Operating Costs (per pig sold)	\$94.70	\$98.96
Total Cost (per pig sold)	\$104.88	\$104.32
Total Cost (per CWT live)	\$41.95	\$41.73
Net Cost per CWT	\$41.35	\$41.73

\*Source: Hoop Structures for Grow-Finish Swine, MWPS, AED 41, Feb. 1997. Note that the operating cost estimate assume .21 hours of labor for confinement and .4 hours of labor for hoops. The net cost assumes a \$.60 per CWT premium for confinements.

The comparison presented in Table 2 shows that the confinement system would have a \$.38 per CWT advantage over the hoop finishing system. Table 2 clearly illustrates the importance of considering different resource constraints when evaluating technologies.

If capital is the limiting factor then the most profitable strategy might shift to

the hoops. For example, if a farmer had \$200,000 to invest in swine facilities they would have enough to build a confinement facility holding 1111 pigs or 3636 pigs with hoop facilities. For any prices over \$41.73 the added volume would be enough to offset the \$.38 per CWT difference in expected returns. However, if labor were the limiting factor then the advantage would shift to the confinement because of the different labor requirements used.

A comparison of hoops and confinements should include much more than the information contained in Table 2. Other issues include differences in odor, differences in air quality, differences in pork quality, disease problems, manure handling, straw for the hoops, and so forth.

It is possible to estimate and quantify many of these factors. However, in the end, the decision on which is the most appropriate technology must be made at the individual farm level.

## Discussion

Whether a partial budget or whole farm analysis is used, there are several key factors to successfully evaluating new technologies. There are also several sources of information available and all of them should be used as appropriate.

It is critical to identify all of the areas that will be impacted by a new technology. Often the analysis just focuses on a single aspect of the technology when in reality the level of the change and its impact are much broader.

With new technologies, it is often hard to get good estimates of how the technology will perform in your circumstances. The costs and benefit estimates are not readily available. In these cases, it is important to gather as much information as possible to help form the best estimate and to analyze the change with several different assumptions regarding the performance of the technology. When possible, test the new technology on a small scale first.

Placing value on the costs and revenues is also difficult in some circumstances. Labor savings are perhaps the best example. As noted, the labor change should be entered at its value. In some cases extra time can be quite valuable and in other cases not as valuable. Similarly, labor savings at different times of the year or season will have different values depending on the individual circumstances. Machinery changes can also be difficult to value.

Remember to distinguish between per unit analysis and the whole farm. It is possible for the per unit profit to be lower but because of the scale changes, the profitability of the whole farm can increase.

Another major difficulty is estimating and valuing changes in risk. Some new technologies may have higher expected returns but the variance of the returns has also increased. What happens to risk and how that impact is valued can

have a big impact on the appropriateness of alternative technologies for different farms.

There is a distinction between risk and uncertainty. Risk has known variability so the expected variation in returns can be calculated. Uncertainty occurs when a technology is not well proven and the variability is unknown. Both risk and uncertainty can impact the choice of appropriate technology.

Risk and uncertainty also includes factors that are extremely difficult to quantify. Many new and alternative technologies will have different impacts on worker health, food safety and environmental impacts.

Finally, the affects of technologies on the mix of the resources used can have a major impact on desirability of the technology. It may be that with a certain technology farmers rely almost entirely on hired labor and have most of their labor contributed as management labor. This points out the importance of knowing your goals when assessing new technologies.

## Conclusion

When evaluating a new technology, collect as much background information as possible. Trade publications, company literature, university research, Extension, neighbors, and other farmers are all potential knowledge sources. It is important to factor all the information, considering the source, and adjust it for the individual circumstances.

New technologies can represent a totally new way of doing things, a modification in current practices, or simply a refinement of current technology. Some technologies can be implemented relatively easily while others will involve considerable changes and risk. These factors must all be considered when evaluating a new technology.

Remember, just because something is new or a different way does not mean that it is better. In some circumstances, the old way will remain the most efficient choice for a given set of resources. Using appropriate technology is the key to a successful farming operation.

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