USE OF A PROFIT MODEL TO MEASURE EFFICIENCY

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Develop a model which quantitatively measures three efficiency components: technical, price and economic efficiency.

INTRODUCTION

Food distribution industry and public researcher's are united in their efforts to isolate important criteria in the food distribution system where productivity can be accurately measured, evaluated, and improved. Recent articles in the Journal (1,2) have outlined the problems, challenges, and opportunity for research dealing with productivity. This article attacks this illusive issue at the firm level, and, in particular, measures efficiency with respect to technological change.

Productivity or efficiency seem, at a glance, to be a fairly simple term. Traditionally, research has concentrated on the physical engineering input/output productivity index. A partial productivity index considers a single factor of production, for example, labor, and ignores all other inputs. In an attempt to overcome this obvious shortcoming, index numbers have been constructed to include all inputs. However, this method of measuring production efficiency suffers from the problem of choosing representative weights. In addition to measurement problems, by simply using a productivity index, the important role that factor prices (i.e., wage rates) play in determining efficiency are ignored. For example, if labor and capital are substitute inputs in a particular production process of a firm, the optimal quantity of labor and capital for profit maximization will depend on the relative wage rate and cost of capital.

The following sections briefly outline some basic definitions of efficiency and suggest a model which quantitatively measures each efficiency component. The data for the model can be obtained from a firm's accounting records. In addition, a comparison of the relative efficiency of two retail meat systems, fabricated and carcass, is presented as an example of the applicability of the model.

THE MEASUREMENT OF EFFICIENCY

Measurement of relative efficiency should consider three minimum requirements (3). First, the efficiency measure should account for firms that produce different quantities of output from a given set of measured inputs of production. This is comparable to the production index discussed above. The differences in attaining this input/output ratio of productivity is called technical efficiency. Two possible sources leading to differences in technical efficiency between firms, which are explored in this paper, are the existence of economies of scale, and the existence of different technologies within the industry.

Second, the efficiency measure should take into account that different firms succeed to varying degrees in maximizing profits. That is, not all firms are equally successful in combining each variable factor of production (i.e., labor and capital) in the most optimal combination, given the relative price of the inputs. This measure is the component of price efficiency. Differences in pricing efficiency can occur for several reasons, including inadequate decision making information, institutional constraints, or simply differences in the relative entrepreneurial ability of management.

The third minimum requirement is that the model should take into account that firms operate at different sets of market prices. The prices of inputs and outputs can and do vary within and between market areas. It is clear that two firms with equal technical and pricing efficiency will have different maximized profits as long as they face different prices. This is important in obtaining a third measure of efficiency. Economic efficiency is a function of both technical and pricing efficiency, and for firms of different technical and price efficiency, but identical prices, the firm with the greatest profits is the most relative economically efficient firm.

In summary, efficiency is composed of three measurable aspects: technical efficiency, which is an input/output productivity measurement; pricing efficiency, which measures the success which a firm maximizes profits; and economic efficiency, which is simply the composite result of the technical and pricing efficiency of the firm, given that each firm faces identical prices.

THE PROFIT MODEL

The "unit-output-price" profit, or UOP profit model (3,6) used in this study to measure technical, pricing, and economic efficiency is based on neoclassical production theory of the firm. But, of more importance and interest for research in food distribution, the theory is applicable for all firms in the same industry. Therefore, differences between firms, due to different technology employed and/or a different scale of production are isolated in this study for analysis. However, stratification of firms can be made in any number of ways, depending upon the researcher's specific area of interest. For example, the effect of geographic location, demographic characteristics of market areas, types of managerial personnel, chain or independent organizations, and other identifiable criteria could be used.

The UOP profit model for this study is of the general form:

$$\pi^j = f(c_i^j, \ldots, c_m^j; Z_1^j, \ldots, Z_n^j)$$

where: π^j = "Unit-Output-Profit": Profit of the firm divided by the price of the output of the same specific firm, p^j;

c_i^j = price of the variable input divided by the price of the output, p^j;

Z_1^j = fixed inputs of production;

and i represents the specific input, j the specific firm. The formal UOP profit model and the hypothesis tests for differences in pricing and economic efficiency will not be presented here. The relative merits of the model, as well as the initial results of this study, are reported by O'Connor and Hammonds (5).

AN APPLICATION

The packer-retail segment of the beef distribution system in the United States is undergoing one of its first major technological changes since the 1920's. Some beef, which traditionally has moved through the system in carcass form, is now being centrally fabricated at the packer or wholesale level, eliminating these functions at the retail store. The fabricated system has several advantages, which indicate that retail firms utilizing this new system should be relatively more efficient than retail stores which use the carcass beef handling system. The first advantage is the elimination of the bulky carcass at each distribution point. Second, savings as a result of the reduction in weight loss due to trim and waste favors the fabricated system at the retail level. Transportation and refrigeration costs should also be reduced. Third, when the retailer handles carcass beef, instead of fabricated meat, he is committed to market all of the resulting cuts. This prevents regional distribution of retail cuts for better conformity with local or ethnic purchasing preferences.

While a central fabrication system probably would improve beef marketing efficiency in the aggregate, there is wide variation in the profitability of individual retail meat departments. One might suspect that not all retailers would benefit uniformly from such a change, and that some might fail to benefit at all. The purpose of this study was to examine the relative technical, pricing, and economic efficiency between sample retail stores which are using the two beef handling systems in the Pacific Northwest.

The sample for this study is composed of 32 retail stores in the major metropolitan areas of Oregon and Washington; 17 medium-volume stores, (average weekly meat sales of $4,000-$10,000) and 15 large-volume (average weekly meat sales in excess of $10,000) departments.[1] Variables of interest are the meat department inputs: wholesale meat, labor, and service flow of capital. The output is retail meat composed of beef, pork, lamb and poultry. Information for these variables were obtained from operational records of the sample stores. More specifically, invoices of all meat purchases, sales records, meat department labor requirements, and a description of all equipment in the meat department provided the empirical basis for estimating the efficiency indices.

ESTIMATES OF RELATIVE EFFICIENCY

This section reports the results of tests using the UOP profit model of relative <u>technical</u>, <u>pricing</u>, and <u>economic</u> efficiency among four groups of stores. The four groups are: medium and large size stores using the carcass meat system, and medium and large stores utilizing the fabricated meat system. Table 1 shows the relative ranking of economic efficiency for the four groups of stores. The medium-size stores using the carcass system are significantly less economically efficient than either the large carcass or large fabricated stores. It is important to note that large-volume meat departments, as a group, are equally as profitable regardless of meat handling systems. Furthermore, the economic efficiency of medium-volume meat departments using the fabricated handling system is equal to that of their larger counterparts, while the opposite is true of efficiency of medium-volume departments using the traditional carcass system.

Table 1. Relative Ranking of Economic Efficiency for Medium and Large Stores Using Carcass and Fabricated Meat Handling Systems

Relative Ranking	Economic Efficiency
1. Most efficient	Large carcass
2.	Large fabricated
3.	Medium fabricated
4. Least efficient	Medium carcass*

*Significantly different from the large carcass and fabricated stores, based upon computed t-values.

The significant difference in the economic efficiency of medium-volume carcass stores could arise from a difference in the pricing efficiency of the variable inputs, wholesale meat or labor, a difference in technical efficiency, or both. If a difference in the relative efficiencies exists, it will be necessary to identify which group of stores is most pricing efficient with respect to each variable input, wholesale meat and labor.

The pricing efficiencies or success of the firms to combine the optimal amount of each variable input, given the relative price of the input, are ranked in Table 2. Some very interesting results emerge. First, it's not surprising that the medium-volume stores using the carcass meat system are in the only group which is significantly different from each of the other groups. This would be expected, given the economic efficiency results discussed above.

However, the surprising result is that the medium carcass group is most pricing efficient with respect to labor, but least pricing efficient with respect to purchasing wholesale meat. That is, labor employment was closest to optimal in medium carcass stores, given their wage rates. On the other hand, the medium carcass stores are significantly less successful in purchasing an optimal quantity of wholesale meat, given its wholesale price. These results seem to be contradictory at first, but are resolvable.

Labor is an indivisable input. Meat departments with weekly sales below $4,000 generally employ one meat cutter, departments with sales between $4,000 and $8,000 generally employ two meat cutters, and departments with sales in excess of $8,000 generally employ three or more. Medium-volume departments switching from a carcass to a fabricated handling system generally find that they cannot reduce their number of meat cutters below two in the short run. That is, meat cutters normally are full-time unionized employees, and are guaranteed a minimum number of hours per week. As a result, the medium-volume store using the fabricated system is penalized in labor pricing efficiency for a relative excess of labor.

However, for wholesale meat, the variable input that can be easily controlled on a weekly purchasing schedule, stores using the carcass system are less efficient in purchasing an optimal quantity. In fact, medium-sized stores using the carcass system are significantly less pricing efficient with respect to wholesale meat than each of the other groups of stores.

Therefore, with respect to both variable inputs, taken together, the degree of relative pricing efficiency in explaining the variation in economic efficiency is inconclusive. It appears, however, that the indivisability of labor as an input may cause the conversion from carcass to fabricated handling systems to be less attractive.[2]

Table 2. Relative Ranking of Labor and Wholesale Meat Pricing Efficiency for Medium and Large Stores Using Carcass and Fabricated Meat Handling Systems

Relative Ranking	Labor Pricing Efficiency	Wholesale Meat Pricing Efficiency
1. Most efficient	Medium carcass*	Large fabricated
2.	Large carcass	Medium fabricated
3.	Medium fabricated	Large carcass
4. Least efficient	Large fabricated	Medium carcass*

*Significantly different from the other groups, based upon computed t-values.

Table 3. Relative Ranking of Technical Efficiency for Medium and Large Stores Using Carcass and Fabricated Meat Handling Systems

Relative Ranking	Group	Relative Percent Efficiency
1. Most efficient	Large carcass	100%
2.	Large fabricated	99%
3.	Medium fabricated	87%
4. Least efficient	Medium carcass	82%

As explained earlier, economic efficiency can also be affected by a second component, a difference in technical efficiency. The UOP profit model generates relative technical efficiency indices which are presented in Table 3. However, one of the shortcomings of the model is that no statistical test exists to indicate if differences are significant.[3] However, as expected, medium-size stores are less technically efficient than large stores which employ production line techniques. Furthermore, medium-size stores using the carcass system are the least technically efficient.

SUMMARY

The profit model for this sample indicates that medium-volume carcass departments comprised the only group with significantly different efficiency parameters than the other three groups. This group was significantly less pricing efficient with respect to the meat input and ranked the least technically efficient although no significance test for this characteristic was available.

Although a fabricated system appears to produce a gain in technical and meat-pricing efficiency for medium-volume departments, the labor requirement is not reduced proportionally, at least in the short run. This is due in part to existing union agreements and in part to the inherent lumpiness of the input itself. The inability to scale down labor may cause the conversion to fabricated-handling systems to be less desirable than would be the case if labor could be employed in continuous hourly units. It remains to be seen what long-run pattern of labor utilization in the store will develop.

The unit of study for this research effort was the meat department in individual retail supermarkets. Benefits for a chain or group of independent retail stores converting to a vertically integrated wholesale fabrication system may be realized. In fact, based on the results of this analysis, there is substantial incentive for groups of stores to integrate backward into their own fabrication to help solve the short-run labor utilization problem. Under such a system, meat cutters could be moved from the store to the central fabrication unit without having to terminate present employees. The technical, pricing, and economic efficiency of a vertically integrated system is certainly a relevant problem for further research.

At the individual store level, it appears likely that both the traditional carcass system and the newer fabricated-handling system will continue to exist side by side in the industry for some time. No clear advantage for the fabricated system existed for the large-volume departments in this sample. Some fabricated departments in this group were more efficient than large-volume carcass departments; some were less efficient.

SOME CONCLUSIONS

Measurement of efficiency is an important research issue. However, studies which only measure an input/output productivity index, technical efficiency, may be ignoring some important aspects of the economic problem. For example, if one were to simply look at technical efficiency in the illustrative case presented above, fabrication would seem advantageous for medium sized stores. However, the inability of fabricated firms to utilize their labor in a profit maximizing manner cannot be identified from the technical efficiency data. Pricing efficiency as well as technical efficiency affect the profit or economic efficiency of the firm. A decision or policy maker should attempt to examine the whole, rather than any one part of an issue. The UOP profit model is a step in the right direction, and is a tool which should be considered for measuring relative efficiency in food distribution.

FOOTNOTES

[1] Ten small retail stores (average weekly meat sales of less than $4,000) were included in the initial sample. However, due to the statistical problem of heteroskedasticity, this group was omitted from the study. It is clear that small stores in the original sample, as a group, had a lower economic efficiency than medium or large stores, however, nothing can be said concerning technical or pricing efficiency. Unfortunately, this group of stores may have a greater need for research concerning meat handling systems than the remaining firms which are analyzed in this study.

[2] There is, of course, the possibility that meat cutters under a fabricated system may be diverted to other productive activity not measured in this study. The assumption for this research effort was that the retail meat output appeared identical to consumers under either system. With a fabricated system, meat cutters may devote more time to maintaining the display case, merchandising the meat, and providing customer service.

[3]The technical efficiency parameters are calculated from several variables in the regression model. Therefore, the variance associated with the technical efficiency index can not be specified.

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