Alternative Uses for Crop and Livestock Enterprise Budgets in Research and Extension

by

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Abstract

Diewert's quadratic approximation lemma is suggested as a means of measuring changes in scale economies, regional competitive advantage, and productivity between stratified sets of enterprise budgets. As an example, Diewert's lemma and USDA/FEDS data are used to determined that there was no increase in cost efficiency among very-large, Washington-Palouse, soft-white-wheat-following-fallow producers between 1974 and 1983.

Key Words

cost functions, cost efficiency, technological change, price indexes

I. The Nature of Enterprise Budgets

How can enterprise budgets be used to do economic analysis? Budgets contain prices, input, expenditures, and yields for a farms sub-production function called an enterprise. Farmers use enterprise budgets to compare their own expenditures to produce a commodity to those of a "typical" enterprise with similar cultural practices, about the same size, and within the same region, using the technology available at a the time. This approach implies that extension agents have the representative enterprise budgets available by commodity, cultural practice, region, size, and technology. This goal of having a complete set of budgets is not always possible to achieve but it remains an ideal for a farm management extension program.

Departments of Agricultural Economics support various types of farm record keeping systems like Telefarm and Teleplan as a means of collecting data to develop representative enterprise budgets to help farmers and to use in research and teaching. Some of the ways enterprise budget data can be used in research are (1) to measure changes in productivity through time, (2) to determine the existence of scale economies, (3) to assess regional competitive advantage within and between states. Representative enterprise budgets can also be used as the basis of comparison with experimental data to evaluate the profitability of alternative cultural practices like LISA, IPM, and no-till.

This all sounds very promising but the approach of using representative enterprise data has a number of problems that include 1) tractor, machinery and farm size assumptions, 2) depreciation rates and useful life, 3) acquisition and salvage value 4) opportunity cost of capital, 5) management charges, 6) overhead costs, 7) labor costs, 8) irrigation costs, 9) land charges. The list could go on. In fact, many of these item come directly from your agenda for later this afternoon. These problems in generating accurate enterprise budgets are real, important and time consuming. The substantial investment in man-hours to derive a set of crop and livestock enterprise budgets underscores the case that these budgets should be milked for all the analytical insight possible.

After the enterprise budgets are built, there is still one practical problem that remains. How can two enterprise budgets be compared if they are based on different input prices and quantities? Such enterprise budgets are not on the same expansion path. The budgets lack a common denominator. Therefore, the substitution effects resulting for a change in input prices can not be distinguished from the output effects resulting for scale economies, differences in regional resource endowments, or changes in technology adopted over time. There are just too many things going on at once to be able to say what is being caused by what.

I would not have raised this messy problem if I did not think there was a possible solution that is within our grasp. The solution to the decomposition problem of enterprise budgets exists in the theory of "index numbers." Index number theory helps separate the effect of changes in input prices from the changes in scale, regional resource endowments, and differences in technology. That may not seem like much of an advantage given what is left as a residual but it represents an major step in the right direction. The remaining problem of separating the effects of scale and regional endowments and technological change can be handle by segmenting the enterprise budgets themselves by size, region, and time. Diewert's "quadratic approximation lemma" is presented as a simple and accurate way of estimating the input price index.

II. A General Model of Cost Efficiency

Consider now a unit average cost function, the surface of which is continuous, twice differentiable, concave, non-decreasing, non-homothetic in input prices and is subject to discrete shifts by time, region, and enterprise size.

(1) $C_{jtru} = f(P_{itru}, T, R, U)$.

Where:

C_{jtru} is unit average cost of commodity j in time t, region r, and enterprise size u; T is time; R is region, and U is enterprise size; P_{itru} is price per unit of input i to produce commodity j in time t, region r, and size u; i is the input category for capital (k), labor (l), energy (e), fertilizer (f), materials (m), and land (a); all inputs within input categories are complements; input categories may be either complements or substitutes; all input categories are variable.

Equation (1) can be expressed in translog form and approximated using Diewert's quadratic lemma as the geometric mean of C_1 and C_0 expanded around points 0 and 1 respectively. Diewert's quadratic approximation lemma for a quadratic function f is

(2) $f(z^1)-f(z^0) = \frac{1}{2}[Vf(z^1)+Vf(z^0)]T(z^1-z^0)$

$Vf(z^r)$ is the first derivative of f evaluated at r and where 0 is the initial period and 1 is the subsequent period (Diewert, p 118). This lemma claims that using only the geometric mean of the first derivatives, a second-order or quadratic approximation of a function can still be obtained.

(3) $\ln C_{jtru1}-\ln C_{jtru0} =$

$$\Sigma_i \tfrac{1}{2}(S_{itru1}+S_{itru0})(\ln P_{itru1}-\ln P_{itru0})$$

$$+ \tfrac{1}{2}(\alpha_{t1}+\alpha_{t0})(T1-T_0) + \tfrac{1}{2}(\alpha_{r1}+\alpha_{r0})(R_1-R_0)$$

$$+ \tfrac{1}{2}(\alpha_{u1}+\alpha_{u0})(U_1-U_0),$$ (Cooke and Sundquist, p. 1005).

Where:

S_{i0} is the change in unit cost for a change in initial input prices and equals the factor share of total expenditures on input i in the initial time period (Shephard, p. 11).

S_{i1} is the change in unit cost for a change in subsequent input prices and equals the factor share of total expenditures on input i in the subsequent time period.

α_0 is the change in unit cost from a change in initial technology., e.g., $\alpha_{t0} = \delta \ln C_1/\delta T_0$; and similarly for regions (α_r) and enterprise size (α_u).

α_1 is the change in unit cost from a change in subsequent technology.

Solving equation (3) for the measures of cost efficiency by time, region, and size

$$(4)\quad \tfrac{1}{2}(\alpha_{t1}+\alpha_{t0})(T_1-T_0) + \tfrac{1}{2}(\alpha_{r1}+\alpha_{r0})(R_1-R_0) + \tfrac{1}{2}(\alpha_{u1}+\alpha_{u0})(U_1-U_0) = \ln(C_{jtru1}/C_{jtru0}) - \tfrac{1}{2}\Sigma_i(S_{itru1}+S_{itru0})\ln(P_{itru1}/P_{itru0}).$$

Equation (4) can be interpreted as meaning that any difference between unit costs and input prices is credited to differences in cost efficiency across time, region and size of enterprise.

By holding the region and size variables constant equation (4) can be rewritten in antilogs as,

$$(5)\quad e^{\frac{1}{2}(\alpha t1+\alpha t0)(T1-T0)} = C_{t1}/C_{t0} \div \pi_i(P_{it1}/P_{it0})^{\frac{1}{2}(Sit1+Sit0)}$$

Equation (5) measures changes in cost efficiency from differences in technology across time.

III. An Empirical Measure of Intertemporal Cost Efficiency

To determine cost efficiency using Diewert's lemma, data are needed on total expenditures per acre, yield per acre, individual input expenditures per acre, and the input prices per unit of input. The original survey data for wheat from the USDA/Farm Enterprise Data System (FEDS) survey of 1983 were used. Enterprise data were selected from Washington Palouse (area 400) for soft white winter wheat, following fallow produced in 1974 and 1983. The data were sorted by total planted acres and, using a budget generator, generated two representative enterprise budgets from a composite of data for the 91-100 percentiles, the enterprises which we designated as "very large" for this region. These two representative budgets for the "initial" 1974 and the "subsequent" 1983, very large wheat enterprises in Washington are used to illustrate Diewert's method of measuring changes in intertemporal cost efficiency.

See table 1. Rows (1) and (2) give the expenditures on inputs per acre. The sum of these rows equals total cost for the respective enterprises. Rows (3) and (4) present factor shares as the percent of an input's cost to total cost. Row (5) is the average of the factor shares.

The 6th and 7th rows give the input prices as \$/hour for capital and labor, \$/gallon for energy, \$/pound for fertilizer, \$/wt ave unit for materials, and \$/acre for land. The 8th row is the input price ratio in logs for the two enterprises. The 9th row is the product of rows (5) and (8). The last element in row (9) is the sum of the elements in that row and equals a Fisher input price index in logs.

Rows (10) and (11) present the five-year average yields per acre for wheat in the Palouse from 1972 to 1976 and 1981 to 1985. The 12th row is the log of the yield ratio. Row (13) is the log of the total expenditure ratio. Row (14) is the log of the unit cost ratio and is equal to row (13) minus row (12). Row (15) is intertemporal cost efficiency in logs and equals row (14) minus the Fisher price index in row (9). Row (16) is the index of intertemporal cost efficiency in the Palouse for winter wheat following fallow between 1974 and 1983 and equals the antilog of row (15) multiplied by 100.

The Washington Palouse intertemporal cost efficiency index between 1974 and 1983 is 100. This means that "the change in unit costs is proportioned correctly between changes in input prices and the change in efficiency." In this case, total costs increased 217%, yields increased 14.5%, average cost per unit increased 177%, and input prices increased by 177%. Thus, all of the change in unit costs are explained by changes in input prices. Consequently, Palouse wheat producers have increased inputs use at the same rate as yield increased resulting in no increase in cost efficiency.

IV. Warranted Assertions

Stratified crop and livestock enterprise budgets can be used to determine scale economies, regional competitive advantage, and productivity or its inverse, cost efficiency by applying Diewert's quadratic approximation lemma to estimate the cost function.

Diewert's lemma was used in conjunction with USDA/FEDS enterprise data to determine that very large Palouse wheat enterprises did not increase their the cost efficiency between 1974 and 1983.

Table 1. Intertemporal Cost Efficiency for Very Large Washington Wheat Enterprises: 1974 to 1983

	Capital	Labor	Energy	Fert.	Mat'ls	Land	Total
---Cost							
1 WA VL 1983 ($/acre)	60.93	9.85	8.31	16.31	22.01	189.48	306.89
2 WA VL 1974 ($/acre)	16.70	14.11	1.94	9.03	24.09	40.91	96.78
---Cost Share							
3 WA VL 1983 (%)	.20	.03	.03	.05	.07	.62	1.00
4 WA VL 1974 (%)	.17	.04	.02	.09	.25	.42	1.00
5 $\frac{1}{2}(S_{83}+S_{74})$ (%)	.19	.04	.02	.07	.16	.52	1.00
---Price & Price Index							
6 WA VL 1983 ($/Unit)	36.41	5.13	1.11	.28	5.19	88.54	
7 WA VL 1974 ($/Unit)	12.26	2.51	.33	.20	8.68	19.06	
8 $Ln(P_{83}/P_{74})$ ($/Unit)	1.09	.71	1.21	.31	-.51	1.54	
9 $\frac{1}{2}(S_{83}+S_{74})Ln(P_{83}/P_{74})$	.22	.03	.03	.02	-.08	.80	1.02
---Yield, Cost & Results							
10 WA VL 1981-85 (Ave Bu/Acre)							39.98
11 WA VL 1972-76 (Ave Bu/Acre)							34.92
12 $Ln(Q_{83}/Q_{74})$ (Bu/Acre)							.13
13 $Ln(TC_{83}/TC_{74})$ (Cost/Acre)							1.15
14 $Ln(C_{83}/C_{74})$ (Cost/Bu)							1.02
15 $\frac{1}{2}(\alpha_{83}+\alpha_{74})(T_{83}-T_{74})$							.00
16 $100e^{1/2(\alpha 83+\alpha 74)(T83-T74)}$ Index of Cost Efficiency (1974 = 100)							100

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