Research Review

The Elasticity of Substitution and Land Use in Agricultural Production: A Cause for Optimism?

By Thomas Lutton*

Introduction

Neo-Malthusian futurists contend that world population growth is outstripping the growth of world food production and distribution Such pessimism is reinforced by others who contend that rising resource prices, such as land, energy, and water, and resource availability constraints compounded by technological stagnation will exacerbate food scarcity in the middle to long term Still others, while admitting to technological advances in input development and food supply, argue that the political situation in *both* developing and developed countries will occasionally result in policies precluding food distribution in times of need Examples include output-restrictive agricultural policies in developed countries and military purchases by developing countries in times of food shortages "Plentyists," more optimistic counterparts by contrast, contend that a series of technological advances in plant and livestock genetics, agricultural chemical breakthroughs, information dissemination through computers, and other unforeseen technological advances will mitigate the degree of the food scarcity problem Some also contend that resource prices will decline relative to output prices, lowering the cost of producing food

The opinions of both groups, optimists and pessimists, are well reflected in the 1981 Yearbook of Agriculture, *Will There Be Enough Food?* Both groups cite historical evidence to support their arguments, and it is difficult to reconcile their differences

In this article, I examine a narrow portion of what appears to be one source of disagreement, that is, precisely what is meant by technology and how do we measure it? If we can agree on a definition and on the feasibility of measuring the concept, we can then ask "Given existing technology, can domestic agriculture increase output sufficiently to provide a target output level by the year 2000?" I use a hypothetical example for heuristic purposes to illustrate the importance of input substitution when one answers this question To the extent that input substitution is possible within existing technology, farmers' ability to cope with the price changes in selected inputs is enhanced After an input price change, farmers' costs of production, average and marginal, are higher when their technology reflects the potential for limited input substitution Indeed, input substitution potential is critical to understanding the problem of agricultural capacity

I do not attempt to measure substitution potential in this article Measurement problems are difficult given existing analytical techniques and data I do, however, provide a general definition for technology which is identical with a production function and the underlying optimization process Furthermore, I illustrate the importance of factor substitution in agricultural crop production by permutating an elasticity of substitution in a hypothetical constant elasticity of substitution (CES) production (cost) function (see appendix) I hope this article will sharpen the debate on agricultural capacity by calling attention to input substitution potential

Technological Characterization

In this article, I define technology in agricultur as follows

> Technology is a knowledge of production possibilities which individual farmers use in the purposeful application of any or all sciences (agronomy, soil science, and botany) as well as "technics" (engineering, economics, and industrial management) in the production of food and fiber

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Economic theory suggests that a competitive producer employs this knowledge in the optimization of an objective function with a given set of relative input and output prices and technological constraints The knowledge base may differ from farmer to farmer Similarly, the objective function and technological constraints including environmental factors such as soil organic content, soil moisture, temperature, and pest infestation may also differ

The parameterization of this knowledge base and constraints is contained in the functional form of the production or transformation function, which is defined as a schedule of maximum output(s) for all input combinations Blending a simple objective function such as cost minimization with this production or transformation function, one can embody both the objective and production function into a cost function parameterization of the knowledge base For simplicity, let total crop output be represented by Q, nonland input prices by P_N, and rental land prices by P_L Assume that output is obtained as a function of land and nonland inputs The minimum cost associated with producing a fixed level of Q denoted $\overline{Q}$ given a fixed set of factor prices, $\overline{P}_N$ and $\overline{P}_L$, is a scalar given by

$$\text{MIN } C = \overline{P}_N N + \overline{P}_L L + \lambda(\overline{Q} - f(N,L)) \qquad (1)$$

where f(N,L) is the production function N and L are input quantities of nonland and land inputs and the variables of choice used in producing any given level of output λ is a Lagrangian multiplier Solving equation (1) for the closed form solutions associated with N and L, we obtain a cost function, equation (2), (*8*)[1] which represents the minimum cost of producing at all output levels Q for all input prices P_N and P_L

$$C = P_N N(P_N, P_L, Q) + P_L L(P_N, P_L, Q)$$

$$= C(P_N, P_L, Q) \qquad (2)$$

Substitution

I contend that the processes for future food production in North America and the resources they utilize are not immutably fixed Minimum tillage, crop rotations, irrigation, and general input juggling within production processes can all alter input requirements for a fixed level of output Such substitution, although often difficult to measure, minimizes adverse economic impacts of resource constraints and input price changes[2] Although the flexibility of a single farmer after planting is limited, the set of production possibilities and alternatives before planting may be quite large The substitution between inputs in neoclassical production theory may be viewed in numerous ways In this analysis, I link substitution to the concept of derived demand for inputs given an output level Inputs may be substituted for each other while the costs of producing a given output level are minimized If the substitution potential between two inputs is zero, the average product of each in equilibrium is a constant, a result well known to input-output analysts A casual look at the input-output measures from 1965 to 1980 demonstrates how the factor intensities have changed (see table) Note that the average products of land and labor increased 5 4 and 110 6 percent, respectively, between 1965 and 1980 The average products of agricultural chemicals and machinery decreased 46 4 and 8 6 percent, respectively, between 1965 and 1980

Unless these variations in input-output indexes overtime are attributed solely to weather or technological change, one has difficulty explaining such changes without considering factor substitution Factor substitution is prompted by changing relative input prices Substitution effects must be separated from technological change, however, when such data are examined Technological change is most evident in agricultural equipment, hybrid seed varieties, and an overall increase in the knowledge base To separate the effects of substitution from technical change, Ray (*8*), Lopez (*6*), Huffman and Evenson (*4*), and Binswanger (*2*) find econometric

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[1] Italicized numbers in parentheses refer to items in the References at the end of this article

[2] The difficulty in measurement is attributed primarily to lack of homogenous input quantity data such as land and agriculture chemicals There are also the inherent difficulties in econometrically estimating substitution potential and technology change from time series, aggregate data For a discussion of these problems, see (*3*)

evidence of factor substitution in North American agriculture by using both time series and cross-sectional data These studies and others (see (*10*)) find evidence of input price sensitivity conditional upon output levels, another indication of substitution potential The greater the substitution potential the more flexibility farmers have in switching inputs and the more sensitive they are likely to be to input price changes Simply put, there is statistical evidence that North American farmers employ different input mixes when relative prices dictate economic adjustments In short, farmers have indeed demonstrated flexibility in their production methods

Input/Output Indexes Agricultural Production, 1965-80

Time	Acres harvested/ output	Labor hours/ output	Agriculture chemical/ output	Machinery/ output
			1965 = 1 0	
1965	1 00	1 00	1 00	1 00
1970	95	79	1 49	1 03
1975	97	59	1 46	1 03
1980	95	47	1 86	1 09

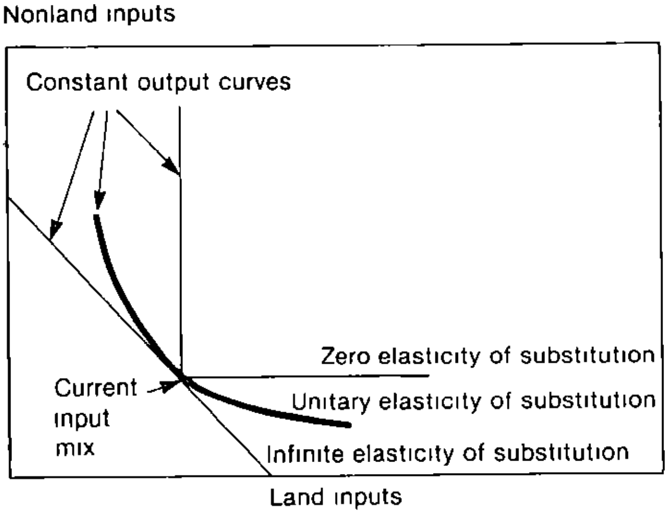
Source (*11*)

In the language of production economics, different assessments of farmer flexibility can be phrased as disagreement about the numerical value of the elasticity of substitution, *ceteris paribus* The elasticity of substitution between two inputs is a measure of the ease or difficulty of substituting one input for another while maintaining output, given the existing technology When inputs number more than two, the definition becomes a bit murkier Here I confine the discussion to the measure of two inputs However, other measures are available (see (*1,7*))

Figure 1 illustrates the elasticity of substitution concept for two inputs For simplicity, let there be two inputs in production of agricultural crops land and other outputs The other output category, hereafter referred to as nonland inputs, may be composed of labor, capital, fertilizer, seed, and so forth For a particular moment in time identify the point, "current input mix," as one possible combination of inputs used to produce output

Figure 1

The Elasticity of Substitution Concept[1]



[1] The elasticity is formally defined for the single output two input case as

$$\sigma = -\frac{\partial \ln (L/N)}{\partial \ln (MP_L/MP_N)}$$

where L is the land quantity N is nonland quantity and MP_L and MP_N refer to the marginal products of land and nonland inputs used to produce output

The elasticity of substitution is a measure of the curvature of the constant output curves that intersect the current input mix In our simple two-factor model, this elasticity summarizes the potential for substitution between land and other inputs The shape of the constant product curves is affected by the number of alternative agricultural processes used to produce output The more processes that are available, the larger the elasticity of substitution becomes, that is, the more opportunities for adjustments in input use as relative input prices change

A Leontief production function characterized by fixed input/output equilibrium values implies a zero elasticity of substitution between land and other nonland inputs Agricultural economists concerned with yield growth and decline would generally dispute this assumption At the opposite extreme, where the elasticity is equal to infinity, other inputs may completely substitute for land to produce output, an implausible assumption

Still another hypothesis is that the elasticity of substitution is unity This hypothesis would imply that as the rental price of land rose, the value share of land (cost share) would remain at a constant share of production costs This assumption is often embodied in Cobb-Douglas production functions The elasticity of substitution need not equal 1, zero, or infinity It may take on many values For the agricultural sector the elasticity is probably nonconstant, fluctuating between 0 3 and 0 7, however, other values higher and lower may be found specific to individual crops or regions

Assumptions Regarding Simulation

To illustrate, I choose a production function of constant elasticity of substitution, CES and its dual cost function to illustrate how the elasticity of substitution affects costs of production, crop yield, levels of prices received by farmers necessary to achieve target output and land use, given a trajectory of land prices, nonland input prices, and output levels Let output grow at 1 32 percent per year from 1980 to 2000 so that output increases 30 percent over 1980 levels by the year 2000 Hold nonland input prices constant To allow for land scarcity, assume the rental price for land increases at the rate of 3 5 percent per year, that is, effectively doubling between 1980 and 2000

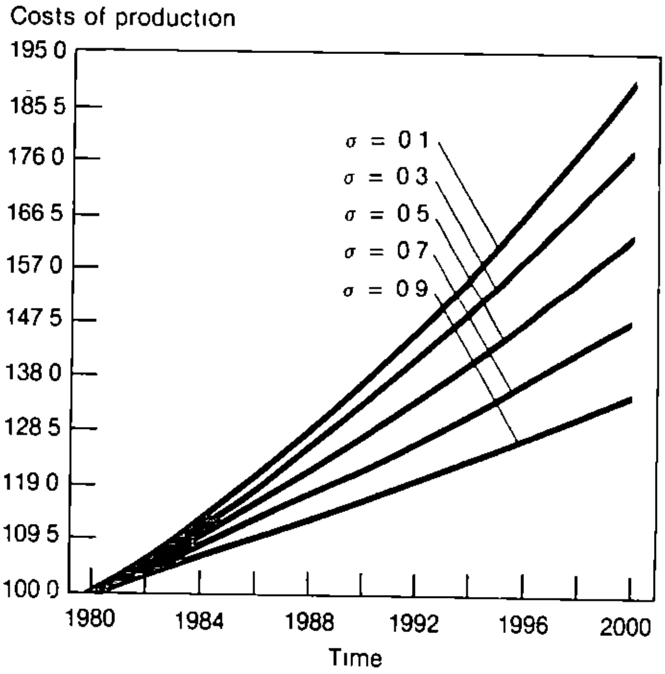
Normalizing costs, output, input quantities, yields, and average costs of production (equal to prices received by farmers in longrun competitive equilibrium) at the 1980 values equal to 100, we can simulate our simple model to illustrate the dramatic differences in magnitude of selected economic variables for the cost-minimizing farmer (see figs 2-5) Note that figures 2-5 are internally consistent by model design Each point on the figures corresponds to a comparative statics optimal solution The appendix provides a more detailed discussion of the model

Costs of Production

In figure 2, the cost of producing 30 percent more output by the year 2000 is 90 8 percent higher than 1980 levels when the elasticity of substitution (σ) is 0 1 When the σ = 0 9, costs are only 35 percent higher by the year 2000 As the elasticity grows, production costs are correspondingly lower

Figure 2

Costs of Production with Alternative Elasticities of Substitution



For σ = 0 3, 0 5, and 0 7, the costs of production are, respectively, 78 4, 63 3, and 48 1 percent higher than 1980 levels The lower costs are indicative of more opportunities for factor substitution between land and nonland input for the higher elasticity functions

Prices Received by Farmers

If we assume average cost equals marginal cost and marginal cost equals price, a familiar longrun equilibrium condition, prices must rise 46 8, 37 2, 25 6, 13 9, and 3 9 percent as σ = 0 1, 0 3, 0 5, 0 7, 0 9 to entice farmers to produce 30 percent more output (fig 3) These are substantial differences To increase production 30 percent over 1980 levels, prices received must increase much more if the technology exhibits minimal input substitution, given the land price increase Recall that land prices are assumed to increase by 3 5 percent per year during the 1980-2000 period, whereas nonland input prices remain at the 1980 level The higher the elasticity of substitution, the smaller the impact of land price increases on output price For different elasticities of substitution, this result is

Figure 3

Prices Received with Alternative Elasticities of Substitution

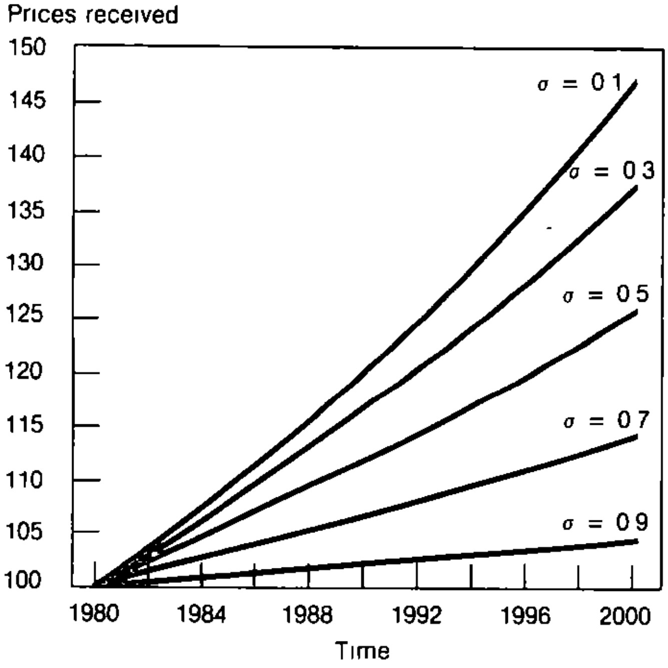


Figure 4

Yield with Alternative Elasticities of Substitution

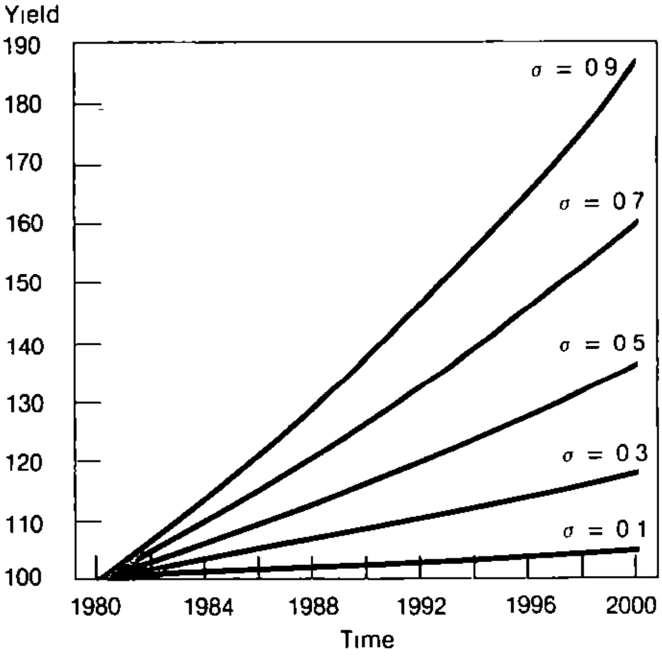
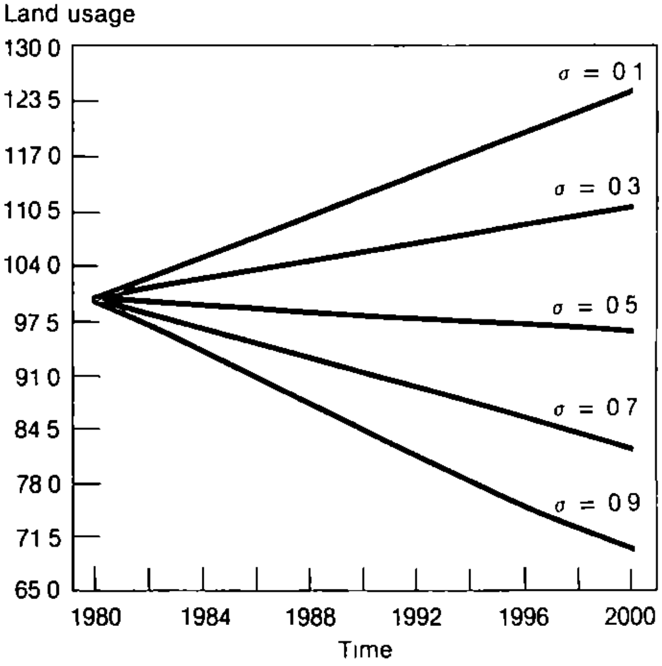


Figure 5

Land Usage with Alternative Elasticities of Substitution



reasonable, given the differences in costs of producing identical output levels in any given period

Yield

The average product of land (typically measured as yield) also exhibits marked differences for alternative values of the elasticity of substitution When $\sigma = 0\ 1$, the yield for the year 2000 is only 4 7 percent higher than in 1980 (fig 4) Alternatively, when $\sigma = 0\ 9$, the yield in the year 2000 is 86 percent higher than in 1980 As σ becomes larger, the average product of land increases as nonland inputs are substituted for land in producing the target level output, given the relative increase in land prices

Land Use

In figure 5, land used to produce 30 percent more output increases 24 2 percent when $\sigma = 0\ 1$ Farmers must bid land away from alternatives, given the experiment preconditions However, if $\sigma = 0\ 9$, land use actually declines to slightly less than 70 percent of the 1980 requirement by 2000 Similarly, for σ = 0 5, land use declines over the simulation period despite the increase in output, once again illustrating the importance of the substitution measure If for some reason it is desirable to limit land used in agricultural production for soil conservation or another reason, the higher the elasticity of substitution the fewer incentives will be required to cause farmers to switch from land to nonland inputs, an interesting implication if one is determining farmer participation in land set-aside programs

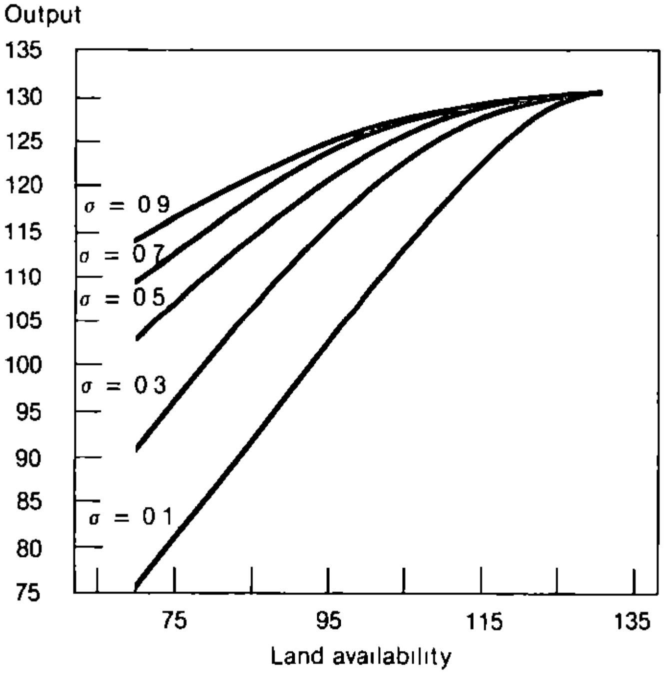
Output Effects

To illustrate the effects of a land restriction policy on output, we need to modify the model Farm output was assumed initially to be exogenously determined Let us relax the assumption of land price growth and hold land and nonland input prices at 1980 levels Assume, furthermore, under constant returns to scale that a 30-percent output increase would raise land and nonland input requirements and consequently costs of production by 30 percent Given these assumptions, consider a land policy which restricts land use, assuming a budget constraint of 130 percent of the 1980 budget Note we are now assuming that farmers maximize output subject to a budget constraint Farmers theoretically may substitute nonland inputs for land in an attempt to maximize output subject to this budget constraint Figure 6 depicts the results of this exercise, assuming the same underlying technologies

The smaller the elasticity of substitution the greater the reduction in output for any given land restriction For example, when σ = 0 9, farmers can still produce 26 percent more output, given the budget constraint substituting nonland inputs for land inputs when land use is restricted to the 1980 level (fig 6) However, when σ = 0 1, farmers can produce only 7 8 percent more output If land is restricted to 70 percent of 1980 levels, production decreases to 75 6 percent of 1980 production when $\sigma = 0.1$, but if σ = 0 9, production increases 13 7 percent with the same restrictions The higher the elasticity of substitution the smaller the output effect of a land restriction program Alternatively, the higher the elasticity of substitution the greater the agricultural output despite acreage constraints

Figure 6

Output Reductions with Land Restrictions and Substitution



The slope measurements of the output curves for any particular land use in figure 6 take on a particular economic meaning if output prices are fixed (subsidized through a target price system) In this case, the slope values when multiplied by output prices are equal to the incremental value or marginal revenue product of an additional unit of land Marginal revenue products are greater when σ is smaller, indicating the relatively greater economic importance of an additional unit of land to a farmer faced with limited substitution potential

Conclusion

With a relatively simple model, I have demonstrated the importance of the substitution concept in the discussion of agricultural capacity Although there are many econometric and agricultural engineering studies of input substitution, each empirical study has a variety of defects, and no definitive estimate of the elasticity of substitution is available The weight of evidence suggests that this elasticity lies between 0 3 and 0 7 By presenting the agricultural economic impacts of alternative land use restrictions in figure 6 as well as the impacts of the assumed input price trajectories for target output levels in figures 2-5, I have illustrated the dramatic differences that result from alternative elasticity measures encompassing this range The input substitution potential measured by the elasticity of substitution, therefore, is particularly important when one assesses the economic impacts of relative input price changes and land use policies However, the issue as to value(s) of the elasticity has not been resolved, there is some evidence of slightly higher and lower values than the 0 3-0 7 range It is essential, therefore, that any improved analysis of agricultural capacity provide careful specification of input substitution potential Moreover, as the knowledge base increases and more ways of producing a given output become available, there is indeed potential for the elasticity of substitution to grow over time Higher elasticities of substitution imply greater farmer flexibility in the long run to produce sufficient food at relatively low prices If such elasticity measures are accurate, the agricultural capacity debate may be less important than it appears

There are, of course, aggregation and separability problems when one assumes the existence of either cost or dual production functions This article merely offers a simple abstraction that may help sharpen the agricultural capacity debate in world food outlook analysis For we often assume that $\sigma = 0$, yet we observe here that relaxing this assumption can dramatically change the results of an economic analysis We do so because of data limitations and other reasons, but the results can be most damaging to policy analysis I submit that one of the reasons for the ineffectiveness of land programs designed to deal with crop surpluses is that we typically underestimate the value of σ Moreover, substitution can go both ways Although the growth rate of yields of many domestic crops appears to be slowing, this slowdown may be attributed to relative input price changes as land is substituted for nonland inputs and not necessarily to a slowdown in technological change In countries where the rental price of land and capital are substantially higher than in the United States, it is not uncommon to find higher yields, more fertilizers, and more labor used in crop production Yet experiences of farmers in Japan, Western Europe, Israel, New Zealand, and other countries contributes to the knowledge base in North America and provides the potential for greater agricultural flexibility in the upcoming decades Other problems, such as current economic and agricultural policies in both developed and underdeveloped countries, could take precedence in the debate over the ability of the U S agricultural sector to supply greater quantities of food at profitable farm prices

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Appendix

I employ a CES cost function which is self dual as an example of a knowledge base parameterization Self dual simply means that the cost function is associated uniquely with a CES production function of the form

$$Q = (a_N N^{(\sigma-1)/\sigma} + a_L L^{(\sigma-1)/\sigma})^{\sigma/(\sigma-1)}$$

Let the cost function be defined as

$$C(P_N, P_L, Q) = Q^{1/r}(a_N P_N^{-b} + a_L P_L^{-b})^{-1/b}$$

where a_N, a_L, r, and b are parameters In this expression, r denotes the degree of homogeneity of the underlying production function and $b = 1-\sigma$ where σ is the elasticity of subsitution The optimal input equations for N and L are given

$$N = Q^{1/r} a_N P_N^{-\sigma} \left\{(a_N P_N^{-b} + a_L P_L^{-b})^{-1/b}\right\}^{\sigma}$$

$$L = Q^{1/r} a_L P_L^{-\sigma} \left\{(a_N P_N^{-b} + a_L P_L^{-b})^{-1/b}\right\}^{\sigma}$$

Note if $\sigma \to 0$ and $r = 1$, then the demand functions for N and L are simply given as a fixed coefficient Leontief input demand function with no input price sensitivity

$$N = a_N Q$$
$$L = a_L Q$$

Alternatively, if $\sigma \to 1$, then a_N and a_L take on a new meaning as constant cost minimizing factor shares given by

$$P_N N/C = a_N$$
$$P_L L/C = a_L$$

Because the benchmark values of C, Q, P_N, P_L, N, and L are set equal to 100 for 1980, it is possible to solve for parameters a_N and a_L in the cost function if we impose constant returns to scale—that is, $r = 1$ Imposing the trajectories of Q, P_N, and P_L for 1980-2000, it is possible to solve for C, C/Q, Q/L, and L, for each time period for each σ These results are contained in figures 2-5

For the results displayed in figure 6, I fix C at 130 and solve for the parameters a_N and a_L in the CES production function where N and L are set initially at levels 30 percent greater than 1980 levels and input prices are held fixed Once values for a_N and a_L are obtained, I restrict the land use to between 70 percent less and 30 percent more than 1980 land use Recall L in 1980 = 100 I then solve for Q subject to the constraint that $P_N N + P_L L = 130$

Wheat Price: Past and Future Levels and Volatility

By Clark Edwards*

When world food markets were burgeoning during the seventies, people became concerned about longrun food shortages and higher real food prices When the markets collapsed during the early eighties and food surpluses were again forthcoming from U S agriculture, people became concerned about longrun excess capacity and the prospect of declining real prices received by farmers Through the muddle, a third and more reasonable view emerged Although shortrun changes in the real level of food prices can be relatively large, the longrun pressures either up or down are not great and the changes are too close to call The best bet is to predict that the real food price will not change in the long run regardless of how volatile it is in the short run or how wide the swings are in the intermediate run

I wondered what history has to say about these three views I decided to examine the price history of a single commodity I arbitrarily chose wheat despite inherent difficulties with using the price received by farmers for wheat as a proxy for consumers' food prices Wheat products account for a small percentage of total food outlays, they even account for a small percentage of retail outlays for products that include wheat. Given the trend for increased value added to wheat products in the form of transportation, processing, packaging, and other services, the margin is rising between the price received by farmers for wheat and retail prices of wheat products Therefore, a stable consumer price level is consistent with a decreasing price of wheat It is unfortunate, for the purposes of this analysis, that there is no retail price of wheat Nonetheless, wheat is an important staple in the world food supply, and it is a substitute for other foods as well as for feed for livestock Furthermore, it is the price received by farmers that induces the quantity supplied, not the retail price General economic phenomena such as wars, depressions, and world food crises are reflected in the price of wheat This relationship implies that an enduring worldwide scarcity of food will be reflected in a rising wheat price and worldwide abundance will be reflected in a falling price

Agricultural Statistics 1983 lists the price of No 1 Hard Winter wheat, ordinary protein, at Kansas City, as far back as 1968 The 1972 issue shows the series to 1929 *Historical Statistics of the United States Colonial Times to 1970* takes the series back to 1800 However, the footnotes to the tables warn that the data source changes from time to time For example, the series reports No 2 wheat prior to 1961, and there are other changes in market reporting However, a change of a different nature occurred in 1913 Immediately prior to 1913 the Chicago market was used, and still other markets and other classifications of wheat were used in earlier years I decided to stop there and use the series as reported for Kansas City from 1913 to the present (I am telling you this because I think it is an important principle of agricultural economics research that what we study and what we conclude depend a great deal on what data are available) The series is shown in figure 1

The price of wheat at Kansas City shows the relatively high price of food during and immediately after World War I The agricultural depression of the twenties is clear as is the further downward pressure on price during the Great Depression of the thirties The price held close to its World War II high throughout most of the fifties and sixties, a gradual downtrend is apparent through that period It is also apparent that annual price fluctuations were limited during that period The fifties and sixties were years of massive Government programs which bolstered the domestic price above the world price and supported farm income One effect of these programs was to reduce price fluctuation The downtrend during the fifties and sixties reflects policy adjustments to work off accumulated stocks of wheat that had not cleared the market at the supported price, and it reflects accommodation to the fact that the domestic price

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*The author is an economist with the National Economics Division, ERS was above the downward-trending world price Exposure of the domestic price to world trade during the world food crisis of the seventies drove the price of wheat to a historic high and reintroduced wide annual price fluctuations

General economic phenomena are reflected in this commodity price series, phenomena that also affected prices of other commodities at both the producer and consumer levels For this reason, I intend to derive some general inferences about the future price of food from this history of the price of wheat at Kansas City

One gets the sense from figure 1 that the price of food has been rising during the 20th century and that the major swings in price reflect major influences such as wars and depressions The major swings are real, but the price level rise may be illusory, it is important to know the price of wheat relative to other prices From the producer's point of view, the price of wheat relative to the cost of production is important To the farm family, it may be the price of wheat relative to the cost of food, clothing, and shelter The nonfarm consumer's view is close to that of the farm family What happened to the price of food relative to other things consumers buy? This comparison suggests deflating the price of wheat with the consumer price index *Historical Statistics of the United States* supplements current U S Department of Labor sources with the consumer price index to 1913 Figure 2 shows this series World Wars I and II are apparent in the series as is the Great Depression However, the dramatic portion of the figure is the rapid rise in the cost of living since the midsixties Deflating the current wheat price in figure 1 with the consumer price index in figure 2 produces the real price of wheat in 1967 dollars, shown in figure 3

The years of war, depression, and food crisis appear in figure 3 as clearly as in figure 1, as do the periods of relatively high annual price fluctuations before the fifties and after the sixties What is different is that figure 3 gives the impression of a downtrend in real price whereas figure 1 gives the impression of an uptrend in nominal price Whether you conclude from figure 3 that the real price of food is trending downward or not depends on which years you pick for the end points Certainly if you accept the arbitrary beginning point shown in the figure, 1913, the real price decreases over the years A regression of the real price of wheat on time reveals that the downtrend averages more than 2 cents per bushel per year, the coefficient is significant with a t ratio of 5 However, if you start with the early twenties, the downtrend is not so clear, and if you start with the early thirties, you can almost see an uptrend Figure 4 shows one way to think about this dilemma

Figure 4 depicts a 10-year moving average price of wheat To interpret a moving average, consider an observer during the year 1980 The expected price of wheat for the year 1980 is taken to be the central tendency for the years 1970 to 1979 A year later, 1970 is dropped from the calculation and 1980 is added to form an expectation for 1981 The moving average concept strikes some as fuzzy because a single observation keeps showing up with the same weight in different sample means For example, the relatively high wheat price of 1973 is in the 1980 sample and is there again in the 1981 sample It will suddenly be dropped from the 1983 sample Some researchers prefer, therefore, to show, for example, an average for each decade Either technique can be used to tell the story The moving average technique has the advantage of depicting a continuous flow which removes the annual fluctuations and makes the major real price swings related to war, depression, and food crisis more readily discernible It also gives the clear impression that the peak real price following World War II was below the World War I peak and that the price of wheat during the seventies was below the depressed price of the thirties This way of thinking about the real price of wheat clearly suggests a longrun downtrend

What about price volatility? Inspection of nominal price in figure 1 suggests that the price of wheat was relatively stable during the fifties and sixties and was relatively volatile before and after Inspection of real price in figure 3 suggests the same conclusion Annual volatility, of course, is removed in the 10-year moving averages in figure 4 The standard deviation is a useful measure of dispersion A range of plus and minus one standard deviation around a central value captures about two-thirds of the observations Figure 5 shows the 10-year moving standard deviation for the nominal wheat price

To see how figure 5 is interpreted, consider that the standard deviation was about 50 cents per bushel for the decade that ended in 1950

This means that about 7 of the previous 10 prices for wheat were within (plus or minus) 50 cents of the 1950 price. Figure 5 shows the variation in wheat price was relatively small from the mid-fifties through the early seventies Figure 6 shows the 10-year moving standard deviation for the real wheat price It also suggests relatively stable prices through the fifties and sixties The major difference in the interpretation of figure 5 relative to figure 6 is that the nominal price series suggests a very large increase in volatility during the seventies, whereas the real price series shows a rise that may be called moderate in comparison with the volatility associated with the post-World War I period

The coefficient of variation is the ratio of the standard deviation to the mean The advantage to using the coefficient of variation instead of the standard deviation as an indicator of dispersion is that because the unit of measure (dollars per bushel in this case) is in both the numerator and denominator, it cancels out, and a relative measure of dispersion is achieved which is independent of the unit of measure This property means that the measure is invariant with respect to whether quantity is measured in bushels or tons and whether price is measured in dollars or yen And it raises the question as to whether the general price level (inflation) is also removed

The coefficient of variation for the nominal price is shown in figure 7 and for the real price in figure 8 Both figures show what was already clear from figure 1—that the wheat price was more stable during the fifties and sixties than before or since Figures 7 and 8 each tell about the same story with respect to the degree of volatility before the fifties and after the seventies The question raised by comparing standard deviations of the nominal and real series is resolved We do not need to decide whether or not the post-World War I period was more volatile than the seventies, figures 7 and 8 suggest that the relative degree of volatility was about the same Inasmuch as the coefficients of variation for the nominal and real prices tell approximately (but not exactly) the same story, whereas the standard deviations for nominal and real prices tell different stories, one can infer that the coefficient of variation for the nominal series approximately (but not exactly) removes the effect of inflation

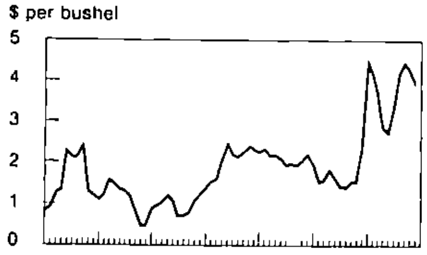
Figure 9 summarizes everything I have said about the price of wheat However, figure 9 is a fairly abstract way of presenting information about the actual series shown in figure 1 Let's assume for the sake of argument that the series in figure 1 represents the real world which we seek to describe and that we know concretely what the data in figure 1 represent I deflated that series by the index number known as the consumer price index and then calculated a 10-year moving average of the real wheat price I also calculated a 10-year moving standard deviation Consider, for each year since 1923, a range of wheat price from one standard deviation below to one standard deviation above the 10-year average Now, like the Cheshire cat, let things start to vanish—the nominal price of wheat, the real price, and the moving average—until nothing is left but the end points of the range It is the remaining smile that is depicted in figure 9

Figure 9 indicates the longrun downtrend in the real price of wheat, the major swings related to war, depression, and food crisis, and the degree of annual volatility around the expected price One can see that the range of annual fluctuation was relatively narrow during the fifties and sixties During the seventies, the degree of shortrun price volatility appears to have returned to its earlier character

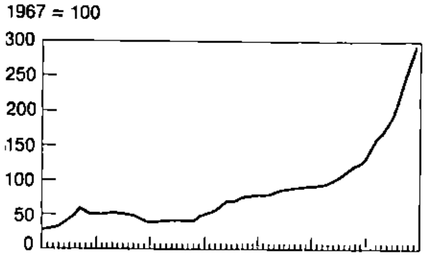
Several views of future food prices have been aired in the literature The history I have reviewed here of one major food commodity in one major market over most of this century suggests a longrun downtrend and a relatively high degree of volatility If the price of wheat at Kansas City is a useful proxy for food prices, then those who predict increasing real food prices in coming decades, who suggest that the best bet is to predict that real food prices will not change, or who anticipates a return to the relative price stability of the fifties and sixties are really calling for a fundamental change in the longrun trend

A Graphic History of the Price of Wheat: 1913-83

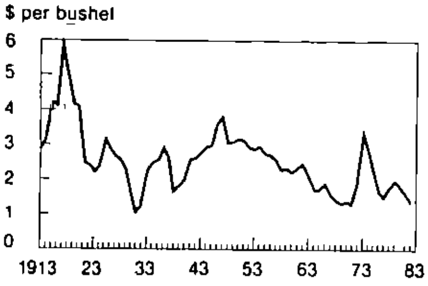
1 Wheat Price Current Dollars



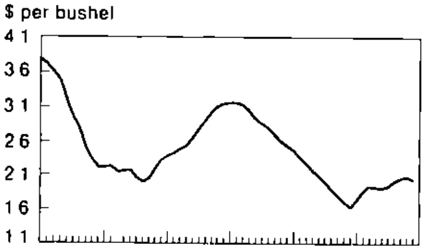
2 Consumer Price Index



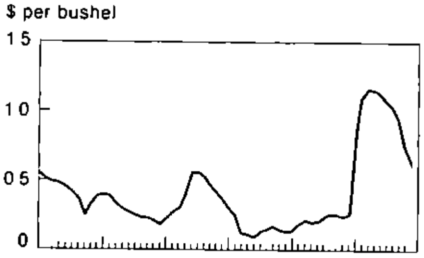
3 Real Wheat Price 1967 Dollars



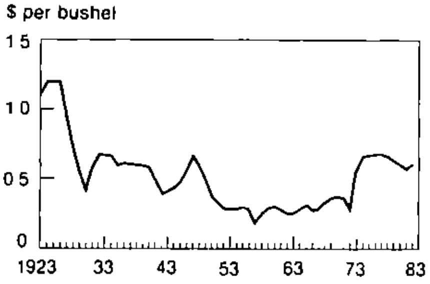
4 Real Wheat Price 10 Year Moving Average, 1967 Dollars



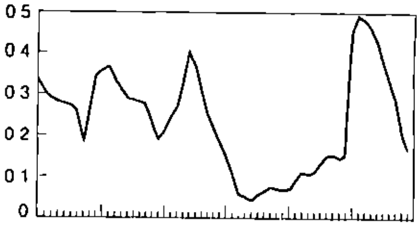
5 Wheat Price 10-Year Moving Standard Deviation



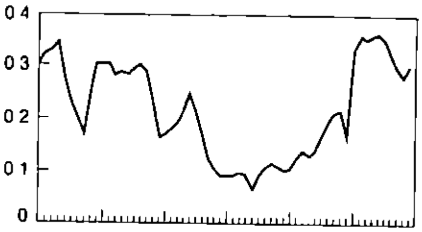
6 Real Wheat Price 10-Year Moving Standard Deviation, 1967 Dollars



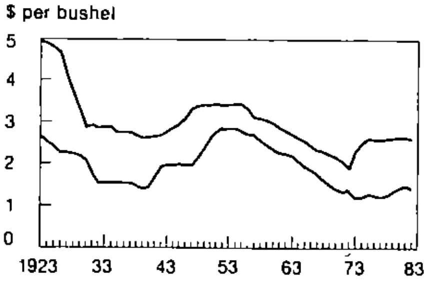
7 Wheat Price 10-Year Moving Coefficient of Variation



8 Real Wheat Price 10-Year Moving Coefficient of Variation, 1967 Dollars



9 Moving Average Real Wheat Price Plus and Minus One Moving Standard Deviation



The Federal Lands Revisited

Marion Clawson. Washington, D C.: Resources for the Future (distributed by the Johns Hopkins University Press, Baltimore and London), 1983, 302 pp , $25 00 (cloth), $8.95 (paper).

Reviewed by Robert F. Boxley*

At the beginning of the current administration, much was made of the Sagebrush Rebellion and the drive for making public lands private As an observer with at least a passing interest in the issue, I recall my frustrations with the sketchy documentation of the proposals by those arguing for privatization and with the tendency of the debate to be cast in absolute all or nothing terms

Although the Sagebrush Rebellion has since been quelled, Marion Clawson's new book, *The Federal Lands Revisited*, provides a lucid commentary on both the battle past and the war ahead Clawson states that, some 20 years from now, the late seventies and eighties may appear as an important juncture in the evolving Federal land history He believes that now is a propitious time to reexamine basic Federal land policy, and he argues "It is wholly possible to invent new institutions and new arrangements for the use of the federal lands" (p xvi)

In three chapters central to this argument, Clawson outlines how changes might be accomplished He presents the retentionist's case for continued Federal landownership, the disposer's case for privatization, and the political economist's case for new institutions and arrangements As enumerated by Clawson, the middle ground is broad Options include retention of current public lands with greatly improved management, transfer to the States, disposal to private ownership, management by public or mixed public-private corporations, and large-scale, long-term leasing The long-term lease alternative receives the most attention from Clawson

Clawson also proposes an innovative "pullback" procedure Under the pullback concept, individuals or groups could apply for a tract of Federal land for any use they choose, but any other person or group would have a limited time between filing an initial application and granting of the lease or making the sale in which to pull back a part of the area applied for Clawson sees the pullback provision as a device for introducing competition among potential users of Federal lands and for promoting bargaining among competitors He argues the pullback provision would reduce collusion, guarantee adherence to bargains, once established, reduce incentives to use delaying tactics, and provide a better mechanism for negotiating among rival private interest groups

A not incidental service Clawson provides in this section of the book is his careful documentation of the rather sparse privatization literature The case for privatization was made principally in speeches and in trade publications rather than in professional journals and books Clawson has done a good job of documentation throughout the book, especially in his discussion of privatization

Readers will get far more than blueprints for new institutions and new arrangements for using Federal lands They will also find a concise minihistory of Federal lands, a comprehensive overview of current Federal land use, planning, and management issues, a discussion of the special problems of intermingled Federal-private landownership, and an analysis of the difficulties of achieving public participation in public land-management decisions Readers will even get what Clawson ruefully concedes is *de rigueur* in books of this nature—a chapter on the need for further research

I assume that most readers of this journal are already familiar with the prolific writings of Marion Clawson For 45 years he has been professionally concerned with the Federal lands of the United States as an economist in the Bureau of Agricultural Economics of the U S Department of Agriculture, as regional administrator and director of the Bureau of Land Management in the U S Department of the Interior, and as a member of the research staff of Resources for the Future (RFF) Of his experiences he says, "I scarcely could fail to have learned something about these lands In

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*The reviewer is an agricultural economist with the Natural Resource Economics Division, ERS fact, I have acquired a great deal of knowledge, perhaps a little wisdom, and surely my fair share of biases and prejudices " He notes that the book is more personal in tone than the usual research volume from RFF It is, and because it is, it is also a delight to read

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In Earlier Issues

In using statistical procedures in the analysis of prices the student must keep constantly in mind that the numerical or graphic results, no matter how good they may be, tell nothing about the reasons for the relationships. These reasons must be found in the general knowledge of the relationships and the general logic of the situation.

Warren C. Waite and Harry C. Trelogan
Vol 1, No. 1, Jan 1949

advertising may substantially affect national food choice By raising prices on heavily advertised products, many consumers are forced to substitute less desirable brands in the same product category Advertising probably shifts interindustry demand as well as interbrand demand in the long run Advertising may be partially responsible for the notable shift in preference away from milk, fruit juices, and water (which are less advertised) to artificially fruit-flavored drinks, soft drinks, tea, and alcoholic beverages (all of which are heavily advertised)

John M. Connor
Vol. 33, No. 1, Jan. 1981