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WHAT DO WE KNOW ABOUT SUPPLY RESPONSE IN AGRICULTURE?*

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Knowledge is useful if it helps us to make the "best" decision. Many of the decisions confronting us in the policy area today are concerned with supply response. Economic conditions are such that at current prices large surpluses are being accumulated each year. As policy makers attempt to deal with this problem, useful information to them is in terms of the supply response of the agricultural industry to these various economic forces. It is with this in mind that this paper attempts to bring together what we do know about supply response at the present time.

Confusion can be avoided if at the outset we be specific in delineating the subject area and if we reach some agreement on the definition of concepts to be used. A major delimitation of the subject matter area is made by indications that the primary emphasis is to be on product supply response. Overt policy problems today are primarily those of too much agricultural products being supplied at current prices. Consequently, the useful policy information is in terms of the supply response of agricultural products to various economic forces. 1/

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* This paper was originally presented as a seminar before J. Carroll Bottom's Advanced Policy Course. Discussion arising at that time has served to sharpen some of the issues.

1/ Another major policy problem in agriculture today is concerned with the low incomes of some people offering their labor services to the agricultural industry. (In fact, our surplus problems arise directly from our attempts to solve the low income problem.) This, too, can be interpreted as at least in part a supply problem - the supply of factors to an industry. Failure to deal with this problem does not mean that we deem it unimportant. Rather we de-emphasize it because our major emphasis is on the policy problems concerned with surpluses of products at prevailing prices.

This does not mean that we are going to completely ignore the supply response for the various factors of production. Later in the paper it will be shown that knowledge of the supply relations for the factors of production can help in interpreting observed supply response. And it is quite obvious that some of the products produced in agriculture are also factors of production for the agricultural industry. This is perhaps best indicated by corn, which is at once a product sold directly to consumers and at the same time a factor of production for the livestock industry. We shall see later that this dual role of agricultural inputs is one of the causes of the difficulty in reducing output.

Further restriction of the problem area can be made by reaching agreement on what is meant by supply response. Supply response is taken to mean the response in terms of quantity produced to various relevant economic variables. More specifically, it refers to the quantity supplied by a group of producers, per unit of time, at various alternative prices, given certain ceteris paribus conditions. This is typically shown graphically by a positively sloping line drawn in the first quadrant of a cartesian coordinate. The axes are labeled with price and quantity, with no dimension shown for the variables included in the ceteris paribus conditions because these forces are held constant conceptually for purposes of the analysis.

Two points need emphasizing in this definition. First, the supply curve is defined for a group of producers because we are interested in the industry response -- however industry may be defined for the problem at hand. And our interest centers on industry supply curves because their intersection with demand curves determine price and the ultimate quantity produced. We might point out parenthetically that a study of firm supply curves is useful in the analysis of supply only because it tells us something about the nature of the industry supply curve.

The second point requiring elaboration is the content of the ceteris paribus conditions. In the analysis of supply these factors that are provisionally held constant for purposes of the analysis usually include the following: a) prices of products competing closely in production, b) prices of factors of production used in producing the specific product under investigation, and c) technology. We shall see later that the exact content of a) changes as we change our notion of what the industry is that we are investigating.

The supply relation can be expressed in two forms, and in choosing the specific form we are saying something about the generality of the analysis and the number of economic forces provisionally held constant. In one form the price of product is specified as a relative price -- with the price of the product under consideration expressed as a ratio to the prices that compete with it in production. This means that only b) and c) are included in the ceteris paribus conditions. Alternatively, the price of the product can be expressed as an absolute or real price. Then the ceteris paribus conditions include all three forces indicated above. This latter method of expression is more general than the former because it permits not only the price ratios but their absolute level to determine what supply response will be. This latter method permits three forces to be supply shifters while the former permits only two variables to play this role.

Since the principal policy varible is the price of product, this is the most important relationship that we want to isolate. But this does not mean that we should ignore the ceteris paribus conditions. Economic forces are provisionally held constant in a conceptual analysis only because it permits us later to analyze their effect separately. It is an analytical device that permits us to deal with our problems one at a time.

And just because we provisionally hold some economic forces constant for purposes of conceptual analysis it does not follow that these forces are assumed to be constant in the real world. As long as variables that are included in the ceteris paribus conditions are changing in the real world, they must be taken account of explicitly in any empirical analysis. In fact, the unwillingness and/or the difficulty in accounting for the ceteris paribus factors is one of the principle reasons why we have failed to obtain good supply response estimates.

This point is so important that it bears further amplification. Many of our empirical supply studies have fit simple functions between price and quantity -- as would be dictated by a naive interpretation of the supply curve. Doing this has produced two results: (a) zero or near-zero elasticities of supply, and (b) failure to explain but a very small proportion of the variance in the dependent variable -- quantity. This latter is represented by low R^2's in statistical studies. From these two bits of evidence it is concluded that farmers do not respond to price.

From our earlier definition of supply response and some information that will be presented later, it can be shown that this is a mongrel relationship, and does not isolate the true response of farmers to price. 2/ Consider the supply response of corn as an example, and refer to figure 1. A true supply response relation, S, is postulated, with the original price at P. Now suppose that the price of corn declines to P'. If the price of competing products and the prices of factors decline as the price of corn declines -- a very likely situation -- the result is that the true supply curve will shift downward to S'. What is fit empirically, then, is not the true price response, but a mongrel relationship that cuts across several true supply response relations.

2/ Technically referred to as failure to solve the identification problem.

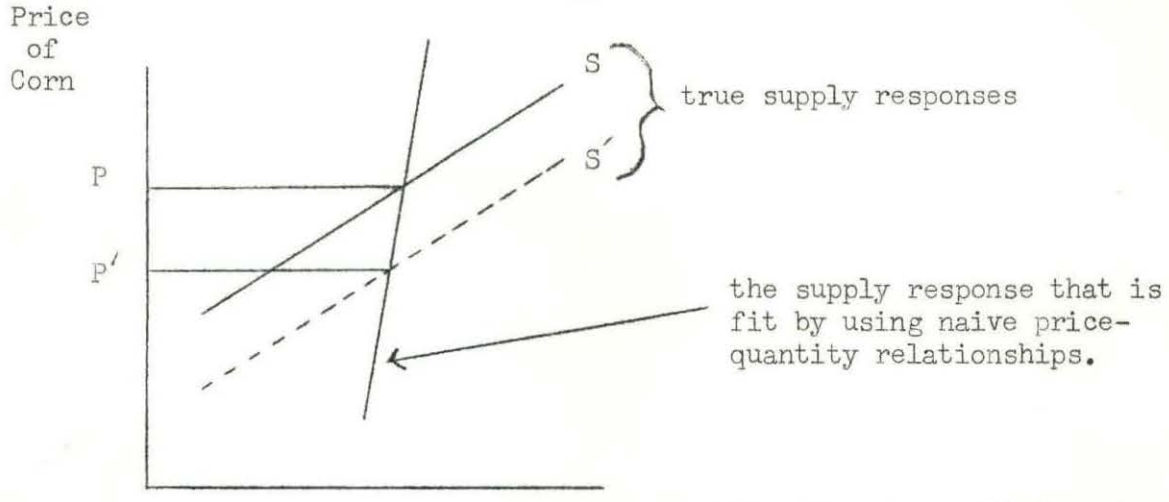

Figure 1

A more precise model would include prices of competing products, prices of factors, and technology as explicit variables, and bring to bear the tools of multivariate analysis. The failure to consider these additional variables in most supply analyses is one of the reasons that the supply function has been considered to be more unstable than the demand function. The few cases where these additional variables have been incorporated in the models have resulted in somewhat higher price elasticities and have resulted in an increased explanatory power for the model. 3/

By way of an intermediate summary, the burden of what we have put together to this point is to argue that useful information in this area is in terms of the supply response to price of product, and to argue that in searching for this information we should be careful to isolate the true price response relation and not compound shifts in other economic forces with it. The econometricians refer to this as obtaining the true structural relationship.

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3/ Cromarty, in a recent study at Michigan State University, estimated demand and supply models for twelve categories of agricultural products. In this study he incorporated these supply shifters as explicit variables in the equations, in addition to estimating them in a simultaneous equations context. He concluded that his supply equations were more stable than his demand equations -- counter to the usual folklore.

Now let us turn to seeing what we know about this supply relation. At the outset, it is useful to consider at what levels we might ask the question. This is relevant because we get quite different supply relations and elasticities depending upon what level the analysis is made, and because we use different kinds of information in answering the question at the different levels.

In agriculture we can approach the problem at two levels:

a. Aggregative -- which is in terms of the entire agricultural industry. As long as there are resource flows between agriculture and the rest of the economy, this response is defined in terms of the relative price of agricultural products compared to product prices in the rest of the economy.

b. For particular commodities within agriculture. This approach takes the resources devoted to agriculture as a datum and inquires as to the response of individual commodities. The response is defined in terms of the relative price of the individual product to other commodities in agriculture competing for the resource use. And the resource flows are among the several products within the agricultural industry.

One need not take a position as to which of these is more useful. It depends to a large extent upon the particular structuring of the policy programs. Both kinds of information are useful, with emphasis being one of degree rather than in terms of strict alternatives. The separation here is primarily one of analytical convenience.

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We next turn to a consideration of the kinds of analyses that can give us the information that we would like to have. These can be grouped under two headings:

1. Qualitative. By this we mean a combination of our theoretical knowledge of production relationships and direct observation of real world phenomena. There are two primary sources of information:

a. The nature of the production function -- particularly as it determines the nature of the product-product transformation curve. Though largely intuitive, this information can be useful both for individual commodities and for aggregate agricultural production.

b. The nature of the supply curves of the factors of production. This source of information is primarily useful in the analysis of the aggregate industry response.

2. Quantitative. Obtaining actual empirical estimates of supply elasticities. Sources of information might be classified according to:

a. Direct estimation of response relations

(1) Linear programming

(2) Regression techniques

(a) Time series

(b) Cross sectional

b. Indirect estimation of response relations.

This can be done by an appropriate weighting of the demand elasticities for the inputs. It is most useful at the aggregate level.

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Now let us in turn consider each of these sources of information and see what they tell us about supply response.

1. Qualitative

a. The nature of the production function.

As indicated earlier the most useful information here is the product-product transformation curve. See Fig. 2.

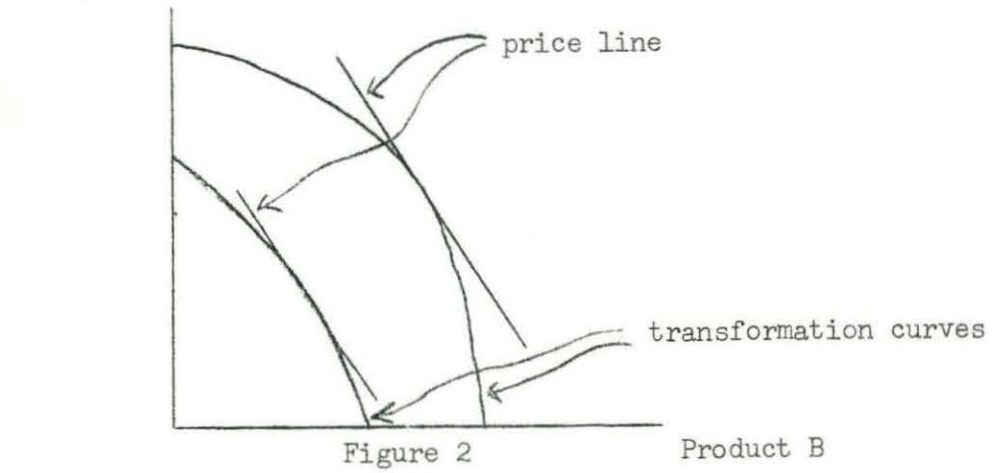

Figure 2

As we can see, the slope of this transformation curve is what determines the responsiveness of farmers to changes in relative prices of product. A flat curve dictates that small changes in price relatives will call for large changes in production and hence result in high supply elasticities. Transformation curves with more curvature or with a kink call for small changes in the proportions and hence imply low elasticities.

This suggests that a relevant question is what determines the shape of the transformation curve. It has to do primarily with the specificity of the resources used in production. If the resources or inputs used are highly specific to a particular line of production, this curve will be highly curved, or possible contain a kink. If the resources can be used in many lines of production, then the transformation curve will be comparatively flat.

From this kind of information it is commonly inferred that individual commodities in agriculture have a high degree of elasticity of supply in response to changes in their relative prices. For example, corn and soybeans use essentially the same inputs in their production. Consequently, changes in their price relations can call forth rather large shifts in production.

This is generally true of commodities within agriculture. There is a high degree of substitutability of inputs among most agricultural commodities. Tractors can be used in practically any line of endeavor. Combines can reap almost all of the grains. And the same applies to many other inputs.

But there are exceptions. A large proportion of the dairy industry is located in areas where alternative production possibilities are rather slim. And this is especially true if one has invested heavily in highly specific inputs such as stanchion dairy barns, milking equipment, etc. The same is true of wheat. The production alternatives for it in many cases are nothing but grass.

This points up the fact that in many cases climate becomes one of our most specific inputs. And because of this a large measure of our supply elasticity for specific crops comes from the midwest corn belt where conditions permit a wide diversity of production possibilities.

On the aggregate level, we get quite a different answer in terms of the transformation curve. Many of the inputs in agriculture can not be readily transferred to the nonfarm sector. Land, for the most part, has few alternatives. Many capital goods are very specific to agriculture in general -- you can not use combines in automobile manufacturing. This suggests that resource flows between agriculture and the nonfarm sector are likely to be small -- at least in the short run. The transformation curve between agriculture and the nonfarm sector probably has a high degree of curvature.

In conclusion, this qualitative evidence suggests that we should expect the supply response of specific commodities to have a reasonable degree of elasticity, but that the elasticity of aggregate agricultural production would have a quite low elasticity.

b. The nature of the supply curves of the factors of production.

Major emphasis to this was given by Gale Johnson in an article in the American Economic Review in September 1950. It is closely related to the above problem fundamentally, but differs in the kind of inference drawn. (More on this later.)

This approach argues that if the supply curves of the factors of production are highly inelastic, the entire supply curve will decline as the price of the product declines, and farmers will continue to produce at their old level. The causal mechanism is somewhat as follows: The level of the supply curve is determined by the prices of the factors of production. These prices are of course determined by the intersection of their demand and supply curves. Since the demand for inputs is a derived demand from the demand for product, the demand curves for the inputs will shift downward as the price of the product declines. If, as postulated, the supply curves are inelastic, price will decline in almost the same proportion as the decline in price for the product. Alternatively, if the supply curves of the factors of production have a high degree of elasticity, the product supply schedule will not shift down as much, and we will get some decline in the supply forthcoming as price of product declines, i.e., we actually will move along a supply schedule as price of product declines.

Johnson argues rather convincingly that most of the inputs in agriculture do have highly inelastic aggregate supply curves, and that this is the reason why farmers "apparently" do not respond to price. His argument can be appreciated more adequately if it is put in the context in which he originally dealt with it. It had been observed for a considerable period that no matter what the price of agricultural products, the farmers continued to produce the same amount. This became especially obvious during depressions when farmers continued to produce, while the nonfarm sector shut down.

From this it was inferred that farmers were not responsive to price. Johnson argued that quite the contrary was the case. He argued that it was the farmers' very responsiveness to price that gave the observed behavior, and that what we were seeing were not observations on one supply schedule, but a series of points on different supply curves. See Fig. 3. Further, he argued that a monopolist, with control over price and quantity, would behave in much the same way if faced by similar factor supply relations.

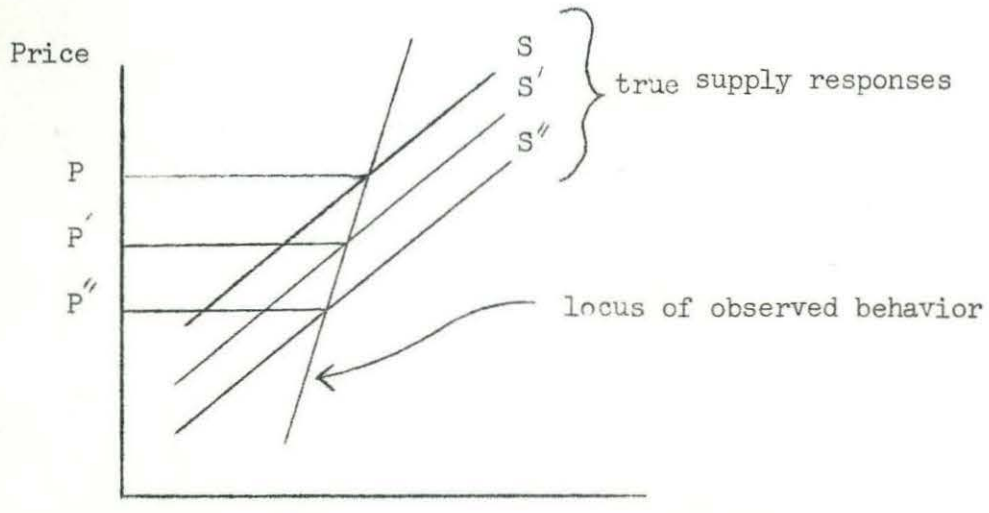

Figure 3.

In his article, Johnson presents considerable evidence to show that these supply curves of factors are quite inelastic.

This inelasticity of supply for the factors is of course primarily determined by the specificity of the resources. But note that we are making a quite different inference than was made under the previous point. There we argued that resource specificity resulted in a supply curve that might be inelastic. Here we are arguing that the supply relation itself might be rather elastic, but that the curve shifts quite readily.

2. Quantitative

This is noted primarily for its scarcity and simplicity of approach, rather than for any degree of sophistication which it obtains. We will not go into the reasons for this at this time, What we want to present here is some of the evidence available at the present time, so that we can get an idea of what supply responses look like. We have both direct evidence and indirect evidence, the former for both aggregate agricultural production and for individual commodities.

a. Direct estimation of product response

(1) Individual commodities. Earlier in the paper we mentioned the work of Cromarty at Michigan State. A summary of his supply elasticity estimates are presented in Table 1. His results are presented because they are indicative of what has been obtained in empirical work, because they are consistent with each other, and because in many respects they are the best estimates available.

Table 1. Supply Elasticities for Major Commodity Categories

Product Category	Relevant Price	Elasticity
Feed grains	ratio feed grains to wheat lagged one year	.364
Beef cattle	current price beef	.037
Dairy products	current price milk	.212
Hogs	current price hogs	.130
Eggs	price eggs for December of previous year	.298
Poultry meat	price broilers lagged one year	.678
Wheat	ratio wheat to feed grains, weighted average of previous 3 years	.129
Soybeans	price soybeans lagged one year	.171
Cotton	price cotton lagged one year	.361
Flue tobacco	price flue tobacco lagged one year	.516
Burley tobacco	price burley tobacco lagged 1 year	.381
Fresh vegetables	price fresh vegetables lagged 1 year	.316
Processed vegetables	price processed vegetables lagged one year	.416

These estimates will not be discussed other than to point out that in many cases Cromarty was not satisfied with the estimating equations that he had to finally settle for, and to emphasize that these are all "short run" elasticities.

(2) Aggregate agricultural response

A little background of the results presented here will provide orientation. Historically, of course, one of the major problems in doing empirical estimation in the area of supply has been weather. It is an important factor in determining total supply, and yet only recently were any attempts made to quantify it. The major impetus to this attempt at quantification was a Ph D thesis done at Michigan State in which an index was constructed to measure the effects of weather in the past. This index was based on yields data at experiment stations. Though this index does not help us to predict weather for outlook work, it does offer some potential for isolating the effects of weather from present data, and this will permit the isolation of the true economic forces.

To see how useful this weather index would be, Griliches has estimated some very crude aggregate supply functions as a test. These results are preliminary and have not been published. Their primary emphasis has been in ascertaining the workability of the weather index rather than an attempt to develop satisfactory supply models. But some of the results are presented in Table 2.

Table 2. Estimates of the Aggregate U.S. Farm Supply Function

Period	Coefficients of: "Real Price"	Weather	Trend	Lagged Output
1921-1957	.095 (.045)	.383 (.065)	.0047 (.0007)	.298 (.096)
1937-1957	.168 (.045)	.160 (.071)	.0076 (.0010)	.006 (.108)

Notes to table:

1. Equations are estimated in logarithmic form, with the exception of trend. Coefficients therefore are elasticities - except trend.
2. Numbers in parentheses are standard errors of the coefficients.
3. "Real price" is the index of prices received by farmers divided by the index of prices paid by farmers for items used in production.
4. Lagged output is used as an independent variable as part of a distributed lag model. This permits the estimation of long run elasticities.
5. Trend can be interpreted as a proxy for technology.

Comments on the results:

1. The weather variable looks promising. In each of the many models estimated by Griliches the weather variable is significant.
2. There is some evidence that elasticity has increased in later years. This is consistent with the findings of Heady and Dean in the case of pork supply.
3. The distributed lag model breaks down in recent years. This can be interpreted as a result of the price support programs. So long as farmers know with certainty what their price is going to be, it doesn't make much sense to hypothesize that they base their decisions on past price relationships.
4. The elasticity obtained is small, but significantly different from zero and positive. This is further evidence that we should discard the notions of a forward falling supply curve for agriculture and farmers unresponsive to price.

b. Indirect estimation of product response

(1) Aggregate agricultural supply response

It can be shown that any supply elasticity can be expressed as a weighted average of all the elasticities of demand for inputs with respect to the price of the product. This gives us an additional means of circumventing the weather problem by measuring the supply elasticity indirectly.

Data limitations preclude our doing this for individual commodities, but Griliches has done some work for the aggregate supply response. Though these estimates are based on rather tentative demand equations, the supply elasticities he obtains are:

Short run	.28
Long run	1.20

This concludes the presentation of empirical results. We have made no attempt to make a comprehensive survey of all empirical work in the field. Rather, we have attempted to present illustrative examples to give us a notion of the magnitude of supply elasticities.

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In concluding this presentation I want to make three points.

1. In both theoretical and empirical work on supply response to date, the studies are noted primarily for the fact that they fail to tackle important problem areas rather than that they approach the selected problems in an inappropriate manner. Areas that have been largely overlooked or in which little or no progress has been made include:

a. Expectation formation

b. Weather

c. Measuring technology, its adoption, and its effect on the supply relation.

d. Problems of fixed assets or investment at the firm level. Supply relations are defined only for a given length of run. A theory of fixed assets will explain how we move from one length of run to another, and perhaps enlighten us on one of the major sources of supply response.

e. Estimation of long run elasticities.

[Conceivably, this could be taken as a sales pitch for more work in the area of supply response. Our ignorance in this area dwarfs our knowledge.]

2. In the course of my presentation and in the discussion evolving out of it, I have given the impression that there might be more elasticity than we presently think there is. In support of this thesis it is useful to cite two pieces of evidence. One is our intuitive notions of the production function and the product-product transformation curves derived from them. These tell us that, at least for individual commodities, there is considerable room for substitution in production and consequently some degree of elasticity. Second, our present commodity surpluses suggest either a much higher degree of elasticity than present empirical studies indicate, or prices set substantially above equilibrium levels. The historical record would not suggest that present supports are significantly above the equilibrium level.

3. Finally, I have argued quite strongly for developing more complex models in order that we might obtain true structural relationships. It might be argued in apposition to this, that, since the mongrel relationship is what we observe, this is what we should measure, and does constitute useful policy information. The argument would proceed as follows in this case: since competing product prices and factor prices are strongly correlated in actual fact, it does not make sense to attempt to separate out the separate effects, and to obtain structure.

This argument would be perfectly valid so long as there were no change in the underlying relationship or structure. But as soon as there is a change in the underlying relationship, knowledge of the true structure becomes very

important. The best example of this is in our present wheat program, where the surplus problem is perhaps the most severe. A possible interpretation of this is that the price of wheat has been set high relative to competing products. 4/ If this is the case, then there no longer is the strong correlation between the price of wheat and the competing commodities, and the mongrel relationship is no longer valid. Consequently, it is important to have the true supply relation, since what we now have is a movement along the supply curve, not a shift of the entire supply relation.

In addition, if the true relation is a rapidly shifting elastic supply function moving in accordance with shifts in the product price, our policy recommendations might be quite different than if the true response is a stable, but perfectly inelastic supply relation. In the former case we might well argue for a support program in the factor markets, with the product markets free to go where they will. In the latter case, we might well agree that there is nothing wrong with the present support program. The point is that we will reach quite different policy recommendations depending upon what the real world looks like. Therefore, it behooves us to attempt to obtain measures of the real world, or what is the same thing, measures of economic structure.

4/ This is quite possible since our present policies are structured on a commodity basis.