THE VALUE AND COST OF INFORMATION

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Introduction

Mathematical models are derived measuring the social benefit and cost of information in comparison to the social benefit or cost of an input (fertilizer) subsidy under different factor market assumptions. In 1975, 54 countries subsidized fertilizers (FAO). In the following countries, the subsidy was as high as 50 percent of the average price of all fertilizers: Ghana, Libya, Niger, Tanzania, Uganda (certain farmers), Iran, and Sri Lanka. In Togo, the subsidy on urea in 1974 was 82 percent (FAO).

Economic Model

The economic model is an industry demand and supply relationship for an input (fertilizer) where the area under the demand function is assumed to measure income generated through the application of the resource while the area under the resource supply represents opportunity costs of resources.

Statistical Model

Demand functions for fertilizer have been estimated for various countries; for example, the United States (Griliches; and Tweeten), Japan (Hayami), the United Kingdom (Metcalf and Cowling), and South Africa (Nieuwoudt and Behrmann). Input demand elasticities estimated in these studies showed a remarkable conformity. The phenomenal increase in the application of fertilizers during the post-war period was largely attributed, in all these studies, to a fall in the fertilizer product price ratio. These findings indicate that fertilizer purchases are sensitive to fertilizer price changes as through a subsidy.

Social Cost of a Subsidy Under Equilibrium Conditions

In the following analysis, it was assumed that farmers, on the average, apply fertilizers at optimum levels (figure 1). In figure 1, AB represents the industry demand curve for an input and S_1 the supply, assuming that the supply is not entirely elastic. A percentage subsidy shifts the supply from S_1 to S_2. Supply shifts more at higher prices because the input subsidy represents a constant proportion of cost.

The social cost of an input subsidy--triangle GHD in figure 1--can be approximated by:

$$(1) \quad S_c = (1/2)S^2 \varepsilon\phi\, X_1/(\varepsilon + \phi)P_1,$$

where S is the subsidy as a fraction of input expenditure, ε the elasticity of input supply, ϕ the absolute value of elasticity of input demand, X_1 the initial consumption, and P_1 the initial price of fertilizer. Wallace and Johnson adopt a similar mathematical procedure in determining the welfare cost of product price supports. Use of integration to obtain the social cost would require complete specification of demand and supply functions.

Equation (1) is in agreement with economic theory in the sense that if either ε or ϕ is zero, implying that if either demand or supply is inelastic, then social costs become zero. Social costs increase with an increase in either S, ε, or ϕ. The squared subsidy term means that social costs increase at an increasing rate if the subsidy is raised. Elasticities of demand and supply in equation (1) carry equal weights in determining social costs. In the long run, both demand and supply would be more elastic, implying that social costs would be greater in the long run.

Because of the distinction between long and short run elasticities and the uncertainty concerning the input supply elasticity in particular, social costs were calculated with different parameters.

Certain qualifications need to be made in the above analysis. If the average cost of the industry supplying the input falls over the entire range of output, then a subsidy would promote welfare and not reduce it (Hyman). The above analysis is also of a partial nature in the sense that no other input subsidies were assumed to exist. In reality, other inputs in agriculture are subsidized in many countries, and Friedman shows where other market distortions (subsidies) exist; it is not clear whether a further distortion (subsidy) reduces or promotes welfare.

Welfare Benefit of a Subsidy Under Non-Pareto Conditions

In the following analyses, it was assumed that farmers underrate the true value of fertilizer applications as portrayed in figure 2, and respond according to demand ab and not to AB. Slopes of ab and AB are drawn to be parallel but in the subsequent analyses this assumption is relaxed. Figure 2 depicts the situation where a subsidy increases welfare. The subsidy stimulates consumption from Q_1 to Q_2 which is still to the left of the optimum consumption (point H, figure 2). The social welfare area NMGD is approximated as follows:

$$(2)\quad [\text{Welfare gain}] = [(1/2)SQ_2\eta\varepsilon/(P_1\varepsilon + P_2\eta)][2P_3 - 2P_2 + S\eta(P_2\phi + P_3\varepsilon)/\phi(P_1\varepsilon + P_2\eta)],$$

where ε is the elasticity of supply, η the elasticity of demand ab, ϕ the elasticity of demand AB, and Q_2 the current fertilizer expenditure with a subsidy. Social benefit is positively related to absolute values of demand and supply. Equation (2) is in agreement with economic theory in the sense that if either η, ε, or S is zero, then social benefit becomes zero.

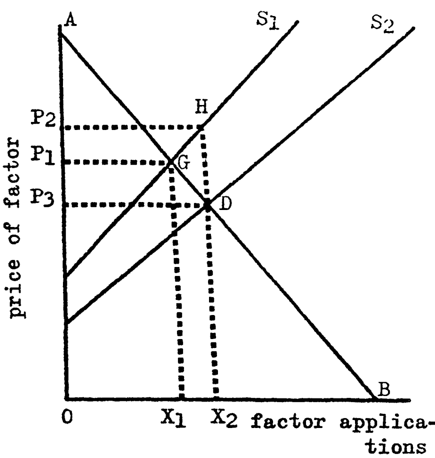

Figure 1 Social cost of an input subsidy under equilibrium conditions

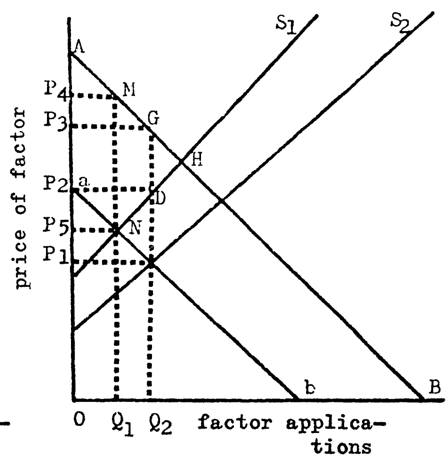

Figure 2 Welfare effects of information and of an input subsidy under Non-Pareto conditions

Value of Information

The annual benefit of information is measured by triangle NMH in figure 2. The procedure adopted to measure NMH was to determine GHD separately before adding it to previous estimates of NMGD. Area GHD is approximated by the following equation:

$$(3) \quad [\text{Area GHD}] = (1/2)(P_3 - P_2)^2 Q_2 \phi\varepsilon/(P_3\varepsilon + P_2\phi).$$

Estimates of the benefit stream of information increase with an increase in assumed values of P_3, ε, ϕ, and η.

Yields of crops in most countries have increased substantially in post-war years (FAO), and over time curve AB (figure 2) shifts outward, while curve ab may shift toward AB. In order to introduce some dynamic elements into the previous static analysis, an attempt was made to estimate the capital value of information as the present value of a stream of annual benefits. The following proportionate adjustment pattern was assumed:

$$(4) \quad [\text{Capital value}] = A_0 + A_0M(1 + g)(1 + i)^{-1} + A_0M^2(1 + g)^2(1 + i)^{-2} + \ldots + A_0M^n(1 + g)^n(1 + i)^{-n} = A_0/(1 - K),$$

where $K = M(1 + g)(1 + i)^{-1}$, which is a converging series if K 1.

A_0 represents annual benefits of information (triangle NMH, figure 2) measured in monetary values at constant prices. The inflation premium cancels out from the discount rate and the benefit stream (Howe). M measures the proportionate shift of the ab curve towards AB (figure 2) in the absence of an additional expenditure on information. It is thus assumed that farmers are in the process of adjusting to an optimum level of fertilizer, and that an expenditure on information expedites this process. The introduction of new technologies increases the benefit of information annually by a proportion g through a shift in the AB curve to the right.

Empirical Results

According to expert opinion such as the South African Fertilizer Society, the South African Sugar Association, and numerous research reports too extensive to mention (Mohr; and Nieuwoudt and Behrmann), sugarcane producers in South Africa apply fertilizers at approximate optimum levels, while maize farmers underrate their value. Mohr summarized the findings of 143 different fertilizer trials, the majority carried out over long periods. The Sugar Association alone analyzed 33,000 soil samples during 1977. Cane farmers have reached the point where excessive fertilization depresses the quantity of sucrose. This conflicting phenomenon could partly be attributed to the fact that the Sugar Association supplies free soil testing to its members while maize farmers have to pay for such an analysis. The marginal product of fertilizer application on maize was estimated between 1.2 - 1.5 UK pounds for 1 pound spent on fertilizer.

In the case of sugarcane, social cost estimates (figure 1 and equation 1) as a percentage of fertilizer expenditure varied from a low of 0.059 percent with an input supply elasticity of 0.25 and a short run input demand elasticity of -0.75, to a high of 0.78 percent if input supply is perfectly elastic and the long run input demand elasticity is -2.50. The current subsidy is 7.9 percent of the average price. For estimates of short and long run fertilizer demand elasticities refer to Nieuwoudt and Behrmann.

Welfare benefits of a fertilizer subsidy as a percentage of fertilizer expenditure in the case of maize producers were estimated for two extreme sets of parameter values (refer to equation 2). Social benefit was estimated between a low of 0.05 percent if the value marginal product (P_3) = 1.2, η = -0.75, ϕ = -2, and ε = 1, and a high of 5.7 percent if VMP (P_3) = 1.5, η = -2.50, ϕ = -1, and ε = 4. Elasticity of demand AB (ϕ) is of lesser importance in determining social benefit because prices and quantities depend on the intersection of the supply and demand ab, and thus the elasticities of the latter relationships. The smaller social benefit with a higher ϕ value is because P_3 in figure 2 is a fixed point leading to a smaller gain, the more elastic the curve AB.

The fact that about 65 percent of South Africa's fertilizer consumption is applied to maize suggests that the social gain created by the present subsidy outweighs the social cost. A possible solution may be different subsidies on different crops as prevailing in Spain, Cameroon, and Fiji (FAO). Different farmers in the same industry may, however, have different perceptions of the value of the input. Further, according to expert opinion, many farmers tend to overfertilize low potential soils and underfertilize high potential soils in the maize areas. Subsidizing the information service would thus be more efficient than subsidizing fertilizers.

Estimates of the annual benefit of information (area NMH in figure 2) as a percentage of fertilizer expenditure were derived from equations (2) and (3). Using the two previous sets of extreme parameter values, estimates ranged from a low of 1 percent to a high of 14 percent. The annual monetary benefits of fertilizer information to maize producers were estimated to be within the narrower range of 4 million to 11 million pounds.

The cost of providing this information needs to be considered. According to experts at the Sugar Association, a soil sample should ideally be taken for every 10 hectares of land once every 3 to 4 years. Using the current area under maize of 4,453,000 hectares, the number of soil samples taken every 3.5 years comes to 127,000. Experts at the Fertilizer Society independently estimate the optimum number of soil samples at 30,000. Fertilizer firms offer a soil testing service at 3.3 pounds per solid sample, which is probably below cost because it is furnished in anticipation of future sales. Other private firms undertake soil testing on a profit basis at 6.7 pounds per sample. Estimates of the cost of information thus derived range from a low of 105,000 to a high of 851,000 pounds. The annual benefit of information thus exceeds the cost of supplying it by more than tenfold. The current annual fertilizer subsidy is 14 million pounds while a free soil testing service may cost a fraction of that.

Estimates of the capital value of information were estimated from equation (4) for two extreme sets of parameter values. Estimates ranged from a low of 13 million pounds if i = 0.07, g = 0, M = 0.75, and A_0 = 4 million pounds, to a high 268 million pounds if i = 0.04, g = 0.05, M = 0.95, and A_0 = 11 million pounds. An M value of 0.95 implies that after each year the benefit of information is reduced by 5 percent as farmers adjust towards an optimum input level. It is clear from these estimates that the payoff from an investment in information could be significant.

As a last thought, furnishing of soil testing information on an individual farm basis should be seen in a wider context such as in systems analysis whereby fertilizer information is supported by other information; for example, recommended suitable varieties.

Conclusion

Using mathematical models, the welfare effects of fertilizer subsidies were compared with a subsidy on information. Empirical estimates indicate that in the case of South African agriculture, social benefits of a fertilizer subsidy outweigh social costs. A subsidy on information is clearly superior to that of an input subsidy as the benefits of information exceed the cost of supplying the information, through a free soil analysis service, by more than tenfold.

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RAPPORTEUR'S REPORT—Michael S. Igben

This paper does not violate any important neoclassical assumptions relating to the economic analysis of the value of information, and in this respect the empirical evidence presented here, although circumspect, provides a good study of the economic use of information.

Since information has differential distribution, with several factors playing important roles in the capacity of the individual to absorb information (such as different abilities and education), the methodology needs to be modified to take this into account. This is especially so because there is other empirical evidence of differential absorption of information, even when the cost of providing information about a given innovation is the same. Since the high cost of information is not the only reason preventing farmers from adopting a given innovation, the quality of this paper could have been improved if other possible factors were identified. The nonuse as well as the differential use of fertilizer by farmers was due principally to the existence of an information gap.

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