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POLICY RESEARCH WORKING PAPER

Aggregate Agricultural Supply Response in Developing Countries

A Survey of Selected Issues

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Time series estimates can provide an accurate picture of past behavioral relations, but they are not an adequate basis for forecasting the impact of policy reform. They typically generate a downward-biased estimate of the response to a credible reform.

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Summary findings

Schiff and Montenegro review several studies of the aggregate agricultural supply response.

Using both economic and econometric reasons, they argue that time series estimation typically generates a downward-biased estimate of the response to a credible reform.

Even though time series estimates can provide an accurate picture of past behavioral relations, they do not provide an adequate basis for forecasting the impact of policy reform. This is especially true in developing countries, where policy reforms involve large changes and have included agricultural price reform, industrial

trade liberalization, financial sector reform, and macroeconomic stabilization.

Under those circumstances, parameter values obtained under the former policy regime have little relevance in the new regime.

Schiff and Montenegro also argue that investments in public goods should be viewed as complementary to, not competitive with, price policy.

They claim that to select the policy with the biggest impact on output makes no sense. They provide what they consider to be better criteria for choosing the best from alternative policies.

This paper — a product of the International Trade Division, International Economics Department — is part of a larger effort in the department to understand the impact of policy reforms. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Jennifer Ngaine, room R2-052, telephone 202-473-7947, fax 202-676-1341, internet address JNGAINE@WORLDBANK.ORG (25 pages). July 1995.

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**Aggregate Agricultural Supply Response in Developing Countries:
A Survey of Selected Issues**

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I. Introduction

A large number of economists have argued that even though the price elasticity of supply of individual crops may be large, the aggregate agricultural supply response is low. While studies on individual crop response abound, studies on aggregate supply response are few and far between. Despite the paucity in the number of studies, the belief in the low aggregate supply response was almost universal in the past. And this belief constituted one of the main arguments for selecting agricultural and industrial policies in developing countries which turned the domestic terms of trade against agriculture. The impact of these agricultural, industrial and macroeconomic policies was examined for eighteen LDCs in Schiff and Valdés (1992a).

Starting with Schultz (1964), a number of studies on developing countries showed that if farmers did not respond much to changes in incentives, it was not so much due to their inability to adapt to changing circumstances but rather to the constraints they were facing, and that the potential for a significant supply response did exist if the constraints were relaxed. (These findings imply complementarity between higher prices and removal of constraints rather than substitution between them, an important issue to which we return below). However, the controversy has certainly not been put to rest. A large number, if not a majority, of agricultural economists still argue that aggregate supply response is very low. A main reason is that the supply of most factors, and land in particular, is fixed in the short run. A related issue is the length of time needed to obtain a given response. A number of economists have argued that the response is not negligible but takes time to materialize.

A similar controversy also took place in the developed countries in relation to agriculture's aggregate supply response during the Great Depression. For instance, Galbraith and Black (1938) argued that aggregate agricultural supply was inelastic in the U.S. since the fall in agricultural prices during the Great Depression only had a negligible effect on output and the output effect took long to materialize. However, Johnson (1950) - in his classic paper on the nature of agricultural supply - showed that the reason for the lack of output response was that factor prices in agriculture had fully adjusted to the reduction in demand. With factor prices in agriculture adjusting in parallel to output prices, it is no surprise that the effect on agricultural output was limited. This was not the case in the urban sector where factor markets were generally less competitive (e.g., due to labor unions) and where prices were generally less flexible.

The objective of this paper is to review a number of issues on aggregate supply response which are still open. The remainder of the paper is organized as follows. In Section II, we critically review the literature on aggregate supply response. We also review the importance of non-price factors or constraints for supply response, as well as the interaction between price and non-price factors. We argue that the debate over whether aggregate supply response is high or low does not make much sense unless the conditions under which the price change is undertaken are specified. These conditions include the provision of public goods, factors affecting the credibility of the reform, world market conditions for the main agricultural exports and imports, the price variability under which the reform is undertaken, and more. These conditions will also affect the speed of the response. We also argue that estimates of supply response obtained from time series data are generally not useful for predicting the impact of a price reform and are generally downward biased. Our argument is based both on economic and econometric considerations.

We also provide limited empirical evidence on some of the hypotheses examined in Section II. The data consist of over four hundred observations from eighteen developing countries covering

the period 1960-1985. These data are from the World Bank research project "A Comparative Study of the Political Economy of Agricultural Pricing Policies", and more specifically from Schiff and Valdés (1992a). Conclusions are presented in Section III.

II. A Survey of Selected Issues

A. Cross-Country Estimation

In a well-known study, Peterson (1979) estimated a cross-country supply function and obtained an aggregate supply elasticity E of 1.66. He also estimated the regression with a technology variable, with E equal to 1.27. Peterson concluded that E is between 1.27 and 1.66, and is much larger than the value of 0 to 0.2 obtained in most time series studies. He makes the important point that the prices obtained from time series data are mainly drawn from a given price regime -- reflecting mainly short-run variation in price -- while prices obtained from cross-country data better reflect differences in price regimes. The latter will therefore provide estimates which better reflect long-term phenomena.

There are however a number of problems with Peterson's results. If supply shifters are positively correlated with prices across countries, then omitting these shifters will result in an overestimation of E . Chhibber (1989) tested the hypothesis using Peterson's data and adding several shifters. When he added an irrigation variable, E fell from 1.27 to 0.97. Including other variables had a similar effect. However, even after these adjustments, the value of E was still larger than in most time series estimations. Thus, despite some problems with his analysis, Petersen's contribution was to show the problem of estimating long-term elasticity with time series data. We return to this issue below.

B. Aggregate Supply Response in Sub-Saharan Africa

Much of the controversy on the aggregate supply response relates to Sub-Saharan Africa (SSA). Therefore, we examine the studies on this region in more detail. Several papers have claimed that SSA agriculture exhibits a low aggregate supply response. However, these studies do contain a number of apparent inconsistencies. In a frequently cited paper, Bond (1983) claims that the aggregate supply elasticity in seven of nine SSA countries examined is not statistically significant. However, her dependent variable is not output but output per capita. Unless population is uncorrelated with output, the coefficient obtained is a biased estimate of the elasticity parameter. If, as would be expected, output and population both increased over time, it would imply a positive correlation between them, resulting in a downward bias in the elasticity estimate.

Delgado and Mellor (1984) and De Janvry (1986) also claim that aggregate supply is highly inelastic in SSA, though they do not provide their own estimates. However, Delgado and Mellor implicitly assume that private investment is not responsive to price and they only consider the short-term impact of prices on output through increases in variable factors. On the other hand, they and de Janvry claim that the Dutch disease phenomenon (due to booming export sectors and foreign aid) and industrial protection have led to massive outmigration of agricultural labor to other sectors of the economy. This seems to contradict the claim of low aggregate supply response.

In order to resolve this apparent inconsistency, a number of economists have argued that hysteresis is present in the sense that the outflows of labor from agriculture, once they have occurred, are irreversible. Hence, they argue that there is a basic asymmetry in supply response: low for price increases and high for price decreases. The same claim has been made in another context by Boussard (1985) who states that "... there is no reason for believing that elasticity obeys the same rules when supply is increasing as when it is decreasing". However, this claim does not seem to be supported by the available evidence for Africa. First, there is evidence that reverse migration back to

agriculture has occurred in a number of countries. For instance, Jaeger (1989) reports the findings of Ghana's Living Standard Survey carried out by the World Bank. It shows that since the reform program was implemented in 1984, the number of people moving from non-agricultural occupations back to agricultural occupations has been twice as large as the number of those moving in the opposite direction. Jaeger also reports evidence of such reverse migration in Nigeria and Tanzania.

Second, the proposition of low aggregate supply response to a price increase can be tested by comparing the agricultural performance of countries which have carried out structural adjustment programs with those that have not. Basic elements of these programs have typically been industrial trade liberalization and real exchange rate depreciation, and thus a reduction in the indirect taxation of agriculture (Schiff and Valdés 1992a, 1992b).¹

Have the higher relative prices for agriculture led to higher growth rates in the reforming African countries, or does Africa suffer from low aggregate supply response with respect to price increases? Cleaver (1988) tested this proposition by comparing sixteen adjusting countries with the non-adjusting countries. While the agricultural growth rates for the two groups were about the same in 1970-80, the reforming countries experienced a higher annual growth rate following the reforms, with the difference in growth rates being 0.9 percentage points in 1980-85 and 2.6 percentage points in 1987. As stated by Binswanger (1989) in his review paper, the difference in growth rates between the two groups clearly increases over time and shows the high degree of responsiveness of African agriculture to policy changes which raise agriculture's domestic terms of trade.

Interestingly, Cleaver found that most of the increased growth was for exportables rather than for food crops. Binswanger (1989) suggests two explanations for this result. First, as shown in Krueger, Schiff and Valdés (1988) and in Schiff and Valdés (1992a, 1992b), direct protection of

¹ Indirect taxation of agriculture is defined as the reduction in agriculture's domestic terms of trade due to expansive macroeconomic policies and industrial protection policies.

staples was positive in most Sub-Saharan African countries in their sample, so that total taxation was small -- an average of about 10 percent. On the other hand, direct taxation of exportables was about 20 percent and total taxation averaged over 40 percent. Hence, overall reform raised exportable prices significantly more than staple prices. Thus, in addition to an increase in aggregate supply, one would expect a shift in resources from staples to exportables. Second, since adjustment is often associated with contraction of aggregate demand, it may lead to lower demand for food, thereby resulting in a contraction in the supply of nontradable staples. In other words, the price of tradable food products rose relative to non-agricultural prices but fell relative to agricultural exportable prices. Hence, the net effect on output is ambiguous. Furthermore, non-tradable food prices may have fallen due to lower demand.

In some countries, long-standing adverse conditions and policies may have resulted in a considerable deterioration of the infrastructure, including rural roads and research and extension systems. The countries where this deterioration has been worse will have a lower (and slower) supply response (see the next section) and will require rehabilitation of the infrastructure in order to generate a significant response. Assuming that the adjusting countries were generally those which had worse economic policies, infrastructure would have suffered more in the adjusting than in the non-adjusting countries, and one might have expected little impact from economic reform on agricultural growth, at least for a while. Nevertheless, Cleaver found higher agricultural growth rates for adjusting than for non-adjusting countries.

In the case of exportables, Balassa (1986) found a high elasticity with respect to incentives. He found that the elasticity of the share of exports in total output with respect to the real exchange rate was 0.68 for LDCs as a whole and about double (1.35) for Sub-Saharan Africa. In contradiction to the belief by many economists that the supply response in Africa is extremely low, the results of both Cleaver and Balassa imply a significant response in Sub-Saharan Africa. These findings are also

supported by Jaeger (1990) for the period 1982-88. He states that countries which adopted or maintained favorable policy environments (FPE) experienced higher agricultural output and export growth and higher overall economic growth than countries with unfavorable policy environment (UPE). Between 1982 and 1988, agricultural exports and value added rose 4.15 and 3.50 percent, respectively, in FPE countries, while both indicators fell in UPE countries.

Platteau (1993) also examines the agricultural performance of FPE and UPE countries in Sub-Saharan Africa for exports, food and total agricultural output. He finds a difference in the performance of the two groups of countries but not a statistically significant one. However, his result may be due to the small sample of countries examined, in which case rejection of the null hypothesis (no difference in performance of FPE and UPE countries) is hard to obtain.

Markets in Africa and other developing countries are often in disequilibrium and quantitative controls prevail. This provides another reason why prices have a positive impact on output, as in the case of inefficient banking and financial systems with widespread quantitative controls (or as Boussard 1985 calls, liquidity constraints). If small farmers have no access to credit or if it is rationed, then even if there are profitable investments to be made on their own farm (at reasonable interest rates), no investment will be made. In that case, a higher price for their product will generate higher profits for the small farmers which can be reinvested. This issue is more important the larger the difference between the lending and borrowing rates for those whose access to the credit markets is limited. Thus, this issue will be of less importance in developed countries where financial markets operate more efficiently, and it is most important in the economies where financial sectors are the least developed (such as in SSA). However, it is relevant to developing countries in general as credit rationing exists or has existed in one form or another in those countries.²

² Even in the absence of credit rationing, if the financial system is small and undiversified, such as rural banks whose portfolios are concentrated in loans with highly correlated returns, the risk premium charged small farmers will be high and investments will only be profitable if financed out of

C. Prices versus Public Goods

Based on the view of a low aggregate supply response, both de Janvry and Delgado-Mellor claim that publicly provided inputs are more effective than prices in raising agricultural output. As mentioned above, these authors abstract from the impact of incentives on private investment decisions. But more importantly, why is so much of the profession focused on the dichotomy between prices and public goods? It has been shown (Schiff, 1987) that prices and public goods are complements in the sense that a higher level of public goods raises the impact of prices on output, and vice versa, that higher agricultural prices raise the impact that investments in public goods have on output. The same point is made by Oyejide (1984) and Braverman (1989). Commander (1989) also argues for "... the combined role of price and other policy variables in raising output levels" (page 236). He also recognizes that investment and technical change will at least in part be price-driven. The issue of induced innovation, with technical change depending on prices, was examined in detail by Hayami and Ruttan (1985).

Chhibber (1989) summarizes the empirical literature and finds evidence on complementarity. He states that the long-run aggregate supply elasticity in the poorer LDCs with inadequate infrastructural facilities is 0.3 to 0.5. On the other hand, in the more advanced LDCs with better provision of public goods, the elasticity is 0.7 to 0.9.

We use data from Schiff and Valdes (1992a) to test the complementarity hypothesis. The sample covers the period 1960-1985 for eighteen countries. These are: Argentina, Brazil, Chile, Colombia, Chile and the Dominican Republic in Latin America; Korea, Malaysia, Pakistan, the Philippines, Sri Lanka and Thailand in Asia; Cote d'Ivoire, Ghana and Zambia in SSA; and Egypt, Morocco, Portugal and Turkey in the Mediterranean area.

own profits.

For the public goods variable, we use an index GIB, defined as

$$GIB \equiv (GIA/GI)/(AGDP/GDP), \quad (1)$$

where GIA/GI is the share of public investment expenditures on agriculture GIA relative to total public investment expenditures GI, and AGDP/GDP is the share of agriculture's GDP (AGDP) in total GDP. A value of GIB equal to (smaller than) one means that the share of public investment funds going to agriculture is equal to (smaller than) the share of agriculture in GDP.

As a price variable, we choose agriculture's domestic terms of trade PAPNA, defined as

$$PAPNA \equiv PA/PNA, \quad (2)$$

where PA is an index of agricultural prices and PNA is an index of non-agricultural prices.

We make use of country (intercept) dummy variables because the index PAPNA is comparable over time but is not directly comparable across countries. Another reason is that the GIB index is comparable over time but may not be comparable across countries because of possible definitional problems. These cross-country differences are then captured by the country dummies. We also used country slope dummies but they turned out to be non-significant in almost all cases and did not improve the estimation results. We ran a regression of AGDP (agricultural GDP) on a constant (not shown), PAPNA (lagged), GIB, and on an interaction term INT of GIB and PAPNA. The results are shown in equation (3).

$$\log AGDP = 0.47 \log PAPNA + 0.08 \log GIB + 0.20 INT, \quad R^2 = 0.98 \quad (3)$$

(6.40) (1.28) (2.11)

We found that all variables have the correct sign (positive). The price variable is significant at the one percent significance level, the interaction term is significant at the five percent level and the public goods variable GIB is significant at the 20 percent level. A positive coefficient for the interaction variable implies complementarity. The aggregate price elasticity of supply is $E = 0.47 + 0.2\log GIB$, and E increases with GIB.

Those authors who have argued that public goods are more effective than prices in raising aggregate output (Delgado-Mellor, de Janvry) have based their argument on the fact that the price elasticity is smaller than the elasticity with respect to non-price factors. As Chhibber (1989) states: "If farmers cannot respond sufficiently to higher prices because of constraints due to inadequate irrigation, unimaginative and inefficient research and extension services or poor transport facilities, then improvement of these goods and services may do more for agriculture than a policy of higher prices" (p. 55). The above is certainly possible. However, deciding which of the two policies to pursue based on a comparison of the two elasticities will inevitably lead to a misallocation of resources.

First, the relative size of the two elasticities has no one-to-one relationship to the relative budgetary cost of achieving a given output increase. The reason is that the elasticity of output with respect to the stock of public goods does not capture what the cost of these public goods is. Say the elasticity with respect to public goods is 0.8 and the elasticity with respect to price is $E = 1.0$. Assume also that the annual budgetary cost of raising output by a given quantity is the same whether prices are used or public goods. Alternatively, assume that the elasticity with respect to public goods doubles to 1.6 and the price of public goods triples. In this case, the budgetary cost of obtaining a given output increase will be lower with price policy than with public goods, even though the elasticity with respect to public goods is higher in this case. What is missing from the elasticity comparison is the unit cost of public goods versus the price of the relevant agricultural products. For

given elasticities, the higher the price of agricultural products relative to the unit cost of public goods, the more attractive the public goods option becomes.

This idea of comparing the budgetary cost of these two policies in raising output has been suggested in the literature. We argue that such a comparison is problematic as well. The reason is that different types of costs are being compared. Raising the price of agricultural output entails a transfer to producers from consumers or from taxpayers. On the other hand, investing in public goods entails the use of real resources which have a real opportunity cost. Therefore, the correct comparison is between the amount spent annually on public goods to raise output by a given amount and the value of the privately provided resources needed to increase output by the same amount in response to the higher price. In fact, both should be used in such a way that the real rates of return to public and private resources are equalized. And these rates of return should also equal the rates of return to public and private resources outside agriculture. Then, the total level of public goods and its allocation across sectors will be optimal. It should also be remembered that because of complementarity, the return to private resources will rise with the level of public goods and vice versa. It is essential to note that the conditions given above will generate an optimal allocation of resources if and only if the prices reflect the actual opportunity costs for the economy, i.e., if they are free of intervention.

Returning to the budgetary issue, it has been argued that price reform and investment in public goods compete for scarce public resources. It is true that if food price reform implies higher producer prices which are not passed on to consumers, it will involve food subsidies. However, as noted earlier, Schiff and Valdés (1992a) found that direct (or sectoral) intervention protected food production in most LDCs, with countries such as Egypt, Argentina and Zambia being the exception rather than the rule. Thus, food price reform would entail lower rather than higher producer prices in most countries and would thus have little budgetary impact. And in countries such as Egypt where

food imports are subsidized, higher producer prices, if passed on to consumers, will lower the amount of subsidies. As discussed in Schiff and Valdés (1992b), for those countries where agricultural export taxes still provide a significant share of government revenue, price policy reform will have to be accompanied by a tax reform.

Moreover, the same paper argues that to provide transparency and credibility, agricultural price reform should be accompanied by reforms in the marketing and distribution of inputs and outputs. This includes the dismantling of inefficient and bloated parastatals, examples of which abound in the literature (e.g., Krueger 1992). Many of the services provided by these parastatals can be better provided by the private sector once prices are allowed to reflect true opportunity costs. For instance, a practice followed in a number of SSA countries is to charge constant prices over space (panterritorial pricing) and over the crop year. Liberalizing those prices will provide incentives for, and will lead to, private transport and storage services. Thus, if the public sector were to limit its activities to the provision of true public goods, the large revenue savings could finance part or all of the revenue losses from the price reform and the latter would not necessarily impose a burden on the budget.

Furthermore, the above deals with the removal of direct price interventions. As reported in Schiff and Valdés (1992a), agricultural price interventions in LDCs were dominated by indirect interventions. The latter were dominated by industrial protection policies which resulted in an average tax on agriculture relative to industry over the period 1960-85 of 28 percent. Reduction of that tax on agriculture would entail a policy of trade liberalization. An import first step in the process of trade liberalization is tariffication, whereby import quotas, licenses and prohibitions are replaced by equivalent tariffs (so that the price structure is maintained). Such a process would generate additional government revenues. In a second stage, the degree of uniformity of the tariff structure would be increased. And the impact of that on revenue would depend on the level of the uniform

tariff which would be chosen and on the import response. The level of revenues at the lower, more uniform tariff need not be lower than at the higher protection level dominated by quantitative restrictions. Hence, the process of raising relative agricultural prices through a reduction of industrial protection need not have adverse fiscal implications. Thus, if accompanied by public sector reform and trade reform, price reform need not compete with the provision of public goods for scarce public funds.

D. Time Series Estimation and Price Reform

Another question is whether most analyses based on single-equation regressions are able to capture the long-term effects of price reform. Long-term aggregate supply response depends on the response of private investment, labor migration and the adoption of new techniques. These phenomena can only be captured in a dynamic general equilibrium framework which allows for intersectoral resource flows in response to changes in incentives. This approach was launched by Mundlak in a number of studies on Argentina and Chile (Cavallo and Mundlak 1982, Coeymans and Mundlak 1992, Mundlak, Cavallo and Domenech 1992). Other studies using such an approach include Cavallo (1988) and Hurtado, Valdés and Muchnik (1990).

Based on Mundlak, Cavallo and Domenech's study for Argentina, Cavallo found that the aggregate price elasticity is 0.07 after one year, 0.16 after three years, 0.36 after five years, 0.71 after ten years and 1.78 after twenty years. He concludes that the long-run elasticity is large but that reaching that level takes a long time. Over the period 1960-84, removal of the total tax on Argentina's agriculture would have raised its domestic terms of trade by about 65 percent (Schiff and Valdés 1992a). This would have implied an output increase of 4.5 percent after one year, 10.3 percent after three years, 23 percent after five years, 45.6 percent after ten years and 114.3 percent after twenty years. Thus, even though the short-term and medium-term elasticities may be low, the

extent of agricultural taxation was such that removal of total agricultural taxes would have led to a substantial aggregate output response in a relatively short period of time. In the case of Chile, Coeymans and Mundlak found higher medium-term elasticities (0.6 after four years) but lower long-term elasticities (1.4 after nineteen years) than in Argentina.

These dynamic general equilibrium models generate higher supply responses than the single equation time-series regressions. Nevertheless, there are several reasons why even these higher supply response estimates would be expected to be biased downwards. First, the general equilibrium models assume that total private investment is given and it is only the intersectoral allocation of that given total that responds to incentive changes. Agricultural price reforms have recently been part of wider reform packages which include stabilization as well as trade and domestic market liberalization measures. These reforms are designed in part to increase domestic and foreign investment over time as credibility in the package grows. For instance, Chile has experienced significant increases in domestic saving and in domestic and foreign investment following its reforms, part of which has gone to increase agricultural output and exports. And foreign investment in Latin America has more than quintupled from 1986 to 1994. These potentially important effects are not captured by these models, though they could conceivably be incorporated in them.³

Second, and this applies to all time series studies, estimates of aggregate supply response are a poor instrument to forecast the impact of a price reform. For instance, Argentina experienced a very high degree of inflation and of relative-price variability over the period examined by Mundlak et. al., and one would expect a low degree of price response under such conditions. On the other hand, one would expect a larger response to a credible reform. In other words, if farmers operate

³ On the other hand, if the estimation period was one of high availability of unused land (as, say, in Thailand) and if the availability of such land was significantly reduced over time, then the parameter value will provide an upward-biased estimate of the supply response to a future price increase.

under a given price regime or distribution, they will not react to random annual price changes within that regime as significantly as they would if the entire price distribution were raised due to, say, the permanent elimination of export taxes or import subsidies.

And if the change in policy regime is part of a larger macroeconomic stabilization package that reduces overall and relative price variability (so that the mean price increases while its variance falls), one would expect the supply response to be higher still.⁴ The effect of price variability on output was examined in Just (1974) and the effect of price uncertainty on output was examined in Schiff (1986). Both found the impact to be significantly negative. Similarly, in a study of aggregate supply response in the Ajmer district in India, Bapna (1980) found much lower supply elasticities (from 0.2 to 0.25) when using the volatile lagged price as the expected price than when using a (more stable) moving average (with elasticities of 0.5 to 0.6).

We are thus arguing that the supply response models estimated from time series data are subject to the fundamental "Lucas critique" (Lucas 1976). In estimating the relevant parameters, the objective is to estimate the outcome of the joint interaction of optimizing agents' decision rules and market clearing conditions (world prices, trade barriers, etc.) for a given policy regime. Any change in policy regime will affect the decision rules and thus will affect the parameter estimates. Hence, the time series parameter estimates will not be useful for appraising the impact of policy changes which affect the economic environment. The Lucas critique is particularly relevant for developing countries which are undergoing comprehensive reform. Under those circumstances, it is unrealistic to expect the past to be a good predictor of the future.

⁴ On the other hand, Schiff and Valdes (1992a) found that removal of direct interventions results in higher agricultural price variability in most countries examined.

To illustrate the point, take the example where producers expect the price to be 50 with 0.2 probability, and 10 with 0.8 probability.⁵ This is the low price regime, and the expected price is 18. The expected price is independent of the actual price as long as the regime is unchanged. In that case, a change in price from 10 to 50 should have no effect on output as the price change is considered entirely random, and the estimated value of the elasticity of supply based on observations generated by the low price regime will be very low. On the other hand, assume a price reform that results in a high price regime - say a price of 50 with 0.8 probability and 10 with 0.2 probability. In this case, the increase in price from 10 to 50 signals a change in price regime (a reform). It will result in a higher expected price (42 rather than 18) and will thus result in a larger supply response.

There is a deeper sense in which the past may not be a good predictor of the future. The elasticities are estimated for a bundle of goods. These may very well change with price reform. No econometric method exists which can estimate the response to a price reform of goods and services which were not produced before the reform took place. Thus, all empirical methods are subject to the "output mix" critique.⁶

This issue is highly relevant for agriculture. For instance, who would have thought that following its reforms, Chile would become a major supplier of Winter grapes, kiwis, and a host of other fruits and vegetables? And that Mauritius would be expanding from sugar exports to exports of exotic flowers and fruits to the EC? And would Egypt - a country with a limited amount of highly valuable irrigated land along the Nile - continue to produce basic staples following a comprehensive reform? One might expect that it would experience a significant shift in output mix towards high value added export products (fruits, vegetables, flowers). It would seem that the only method available to assess the effect of price reform on output mix would be to observe the change in output

⁵ This example was suggested to us by J. Quiroz.

⁶ This important point came to our attention through conversations with A. Valdes.

mix which occurred in comparable countries which undertook an earlier reform. Hence, econometric estimates of aggregate supply response based on time series estimation - whether single equation reduced forms or general equilibrium models - are of limited use for evaluating the impact of changes in policy both because of the Lucas critique and of the "output mix" critique.

Recent economic reforms have not always had the expected impact on agricultural output. However, reforms do not occur in a world of "ceteris paribus". In fact, commodity prices fell to low levels until recently. Second, successful economic reforms have led to capital inflows in a number of countries and to real exchange rate appreciation, thereby lowering relative agricultural prices. This is examined in detail in Valdes (1993) for Chile and New Zealand. Hence, the output response to the economic reform in those cases has been dampened by the fall in world prices and by real exchange rate appreciation.

So far we have examined the size of the aggregate output response to a price reform. What about the speed of the response? First, measuring the speed of the response to a price reform is also subject to the Lucas critique. As time series estimates may not accurately reflect the size of the response to a reform, the same is true about measuring the time path of the response. Second, the speed of the response will be affected by the credibility of the reform. If there is little credibility, producers will prefer to wait and see before making irreversible investment decisions. Also, from the time a reform is announced by the executive branch of government, the speed of the response will also depend on how quickly the reform package goes through the legislature, how the package changes through that process, how quickly it is put into place, and how effective the implementation actually is.

E. Size of the Agricultural Sector and Supply Response

It is generally argued that the larger the share of agriculture in GDP, the less elastic the supply of factors to agriculture and therefore the lower the aggregate supply response (Valdes, 1989). To test this hypothesis, we ran a regression of agricultural GDP (AGDP) on agriculture's domestic terms of trade PAPNA and on an interaction term INT of PAPNA and the share SHAG of agriculture in GDP. As a sample, we used the annual observations over twenty five years and eighteen countries described in the context of equation (3). The results are shown in equation (4).

$$\log \text{AGDP} = 0.42 \log \text{PAPNA} - 0.6 \text{INT}, \quad R^2 = 0.96. \quad (4)$$

(7.83) (-10.2)

Both variables are highly significant. As predicted, the regression results imply that the supply response is negatively related to the share of agriculture in GDP, with the elasticity being $E = 0.42 - 0.6 \text{SHAG}$.

Since we use country (intercept) dummies, ours is essentially a time series analysis, and the results cannot be used to make cross-country inferences. However, the negative relation between price elasticity and the share of agriculture in GDP is generally assumed to hold in a cross-country framework as well. The problem with such an inference is that the share of agriculture in GDP is assumed to be given exogenously when it is in fact determined endogenously, in part by the availability of agricultural resources such as land. Thus, Country A may have a larger agricultural share in GDP than Country B because of more elastic supplies of agricultural resources and a higher elasticity when measured for a same agricultural share in both countries. To know what happens at the equilibrium, one needs to estimate a model which endogenizes the agricultural share variable as well as the supply elasticity.

F. Supporting Framework

Supply response depends also on the availability (quantity, quality, cost) of supporting services and on the legal and institutional framework. Some of this was examined in Section C above in the discussion on the complementarity between prices and public goods. Another aspect is the legal and institutional framework. For instance, restrictions on land tenure rights and other tenurial arrangements have been found to severely dampen the supply response by limiting private investment. Valdes (1993) argues that despite favorable trade and macroeconomic reforms, the impact on private investment in agriculture in Chile would have been very limited had it not been for the land market reform which provided legal commitment to secure property rights and a free land market. Restrictions in the labor market can also limit supply response (more on this below in the discussion on ports). Also, in a number of reforming countries, rural infrastructure had been allowed to deteriorate in the period preceding the reforms, and this deterioration is expected to limit the response of agricultural output to the reforms.

An efficient management of these resources is also important. A price increase provided by a marketing board may have little impact on aggregate supply if the board is inefficient in transporting and distributing inputs and output, if it is not adequately financed and if bottlenecks are common. In that case, a reform should be enacted which would at a minimum allow the private sector to compete with the marketing board. Of course, if the board sets constant prices over the crop year and over space (panterritorial pricing) - both quite common in SSA - and therefore subsidizes both storage and transport, then no private entrepreneur will be able to compete and there will be no private provision of transport and storage services. Thus, in order for the private sector to compete, the marketing board's pricing rules must become more competitive and reflect true opportunity costs. Some marketing boards may be unable to survive private sector competition under

such conditions. In that case, the best solution might simply be to allow the marketing board to go out of business.

Port management may also be important, especially for agricultural exports. Labor in many ports are (or were) unionized, with high wages and quantitative restrictions on labor supply (e.g., one eight-hour shift per day). Reforming the labor market in those ports can significantly reduce costs, by reducing wages and by allowing three shifts to operate. Such cost reductions at the port entail a non-negligible reduction in the overall cost of exporting agricultural products. Such infrastructural bottlenecks may sometimes be relaxed simply through improved legislation and operating rules. In the case of ports, such an improvement will result in an increased supply of portuary services for a given level of port facilities and will result in an increased supply of exportables. The same is true of the removal of monopoly power in air transport.

The entire issue of an adequate supporting environment and its impact on aggregate supply requires more systematic study. A first step might be to realize that what matters is not simply the efficiency of producing a given commodity but also the efficiency of delivering it to the consumer. This includes transport, storage, quality control, and more. And the relevant cost of production is not the farmgate cost but is the cost at the consumption point, whether consumption is domestic or not.

III. CONCLUSION

In this paper, we provided a survey of selected aspects of the literature on aggregate agricultural supply response in developing countries and presented some limited evidence. The latter is based on data from the World Bank research project "A Comparative Study of the Political Economy of Agricultural Pricing Policies", and more specifically on Schiff and Valdés (1992a).

First, we argued that the time series and other studies claiming a highly inelastic aggregate supply for agriculture in Africa are flawed. Second, a number of authors have looked at price policy and investment in public goods as competing alternatives, and have compared the output elasticity with respect to the two policies in order to determine which of the policies is more effective. We have argued that these two policies are in fact complementary. We have also argued that comparing the output elasticity with respect to prices and public goods makes no sense whatsoever. We proposed an alternative criterion in order to achieve an optimal use of both policies. Our empirical results provide some support for the argument of complementarity between prices and public goods. We found that an increase in the share of public expenditures going to agriculture had a positive impact on the aggregate supply response.

We also argued that dynamic general equilibrium models (a la Mundlak) - where intersectoral factor movements respond to incentives - are necessary to obtain a more realistic representation of the real economic phenomena underlying aggregate supply response. In fact, such models have generated higher aggregate supply elasticities than single-equation time series regressions. However, both the single equation and general equilibrium time series estimates are, for two reasons, poor instruments for forecasting the impact of a price reform. The first reason is known as the Lucas critique. For instance, if the reform affects the variability of prices as well as its level, then the price level parameter will not provide a reliable estimate of the supply response to the price change. And if the reform affects the manner in which expectations on prices and other variables are formed, the same problem will arise. The second reason is the "output mix" critique.

Thus, even though time series estimates can provide an accurate picture of past behavioral relations, they will not serve as an adequate basis for forecasting the impact of policy reform. This is especially true for developing countries where policy reforms have included agricultural sector price reform, industrial trade liberalization, financial sector reform and macroeconomic stabilization.

Under those circumstances, parameter values obtained under the past policy regime will have little relevance in the new regime. Models free of the Lucas critique have been formulated in order to estimate the impact of trade liberalization on the real exchange rate (Quiroz and Chumacero 1993). Formulation of similar models to be applied to the issue of aggregate agricultural supply response is part of these authors' research agenda.

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