FOOD SECURITY, TRADE AND AGRICULTURAL COMMODITY POLICY

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National agricultural policies are often rationalized on "food security" grounds. This paper evaluates such rationales. For example, I show investments in local agricultural productivity may not significantly improve food security when trade can substitute for local production. Policymakers often claim reliance on local food production enhances food security. An Index of National Food Security incorporates variable market prices, but shows that for South Korea, blocking imports clearly lowers food security, although world rice prices are quite variable.

No agricultural issue is more important than food security. Reflecting the importance of the topic, the literature on food security is long, broad, and deep. Many disciplines make contributions in the area. Technical agricultural sciences focus on food production and the contribution of new agricultural knowledge and practices to more abundant food supplies. Nutritionists focus on the consumption side and how food intake relates to human wellbeing and health. Others, including economists, emphasize diffusion of production or nutrition information, intra-family relationships, income distributions, and a myriad of factors that affect poverty and food prices. Recent papers included in El Obeid, et al. provide perspectives on food security from a variety of disciplines.

Economists have made major contributions to understanding and perhaps even improving food security. Economic contributions have included analysis of poverty and income growth, as well as food supply and food prices. Some of the work of economists takes a global perspective as reflected in Duncan or Tweeten, others take a local, household or even individual perspective as reflected in much of the literature surveyed by Barrett. Time horizons also differ. Some deal with long-term global progress on food production relative to human population, others consider periodic famine or local dislocations.

Food security may be defined roughly as reliable access to a nutritionally adequate diet now and for the future. The second part of this paper deals with the stochastic nature of this definition as represented by the term, "reliable," and the explicitly dynamic nature of the definition represented by the reference to access to food in the future. But, first, I want to narrow the scope of this paper by discussing the population over which we consider access to an adequate diet. The focus of this paper is *national* commodity policy, but of course, there are other, perhaps more natural or important, aggregations to consider.

A global perspective on food security examines aggregate food production on the planet, productivity growth affecting the time-path of food supply, and the time-path of per capita income growth, especially for the world's poor. Global population growth provides a denominator in these calculations. Global policy issues include investments in agricultural science and infrastructure, investments in human capital, institutional reform, macroeconomic and political stability and other contributions to global economic growth and the level and variability of global food prices.

At the other end of the aggregation continuum is food security for households and even individuals within households. Again, the issues relate to access to food and the resources available to that individual or family. But, to understand individual or household food security much of the focus must be on distribution. In particular, food security for a particular household requires not that there is adequate food on the planet, but that the household in question has the resources to get access to an adequate diet at the prices (and other constraints) it faces. Policies to deal with food security of particular households may address the incomes of and effective food prices faced by a subset of the population that is particularly vulnerable.

This paper deals with an intermediate aggregation. Because I want to consider national agricultural policies, I will focus on issues of food security defined for a single nation. I am motivated in part by the observation that national farm commodity and trade policies are often justified or at least rationalized with reference to national food security objectives. I do not claim that the policies and issues discussed here are necessarily the most important considerations for food security. This paper does show, however, that reforms of commodity policy can contribute to food security. It also shows how commodity policy reform may affect the food security consequences of other government policies. Finally food security claims associated with some commodity polices may divert attention and resources from alternative policies that could make larger food security contributions.

Food security is a stated objective of agricultural commodity policy in virtually all countries. Rich and poor, importer or exporter, all governments seem to state food security of their population as an objective for agricultural policy. This has been true for several millennia as even a cursory look at ancient history or even fiction will attest (Diamond, Smith, Lee and De Bary).

The range of contemporary domestic and border policies tied to food security objectives is equally impressive. Subsidies for research, income redistribution, rural infrastructure, price floors, price ceilings, government stockholding, import barriers and export subsidies are all listed as national food security policies. In the United States, as recently as the 1985 the law that renewed farm commodity programs, conservation programs, domestic food assistance programs, export subsidies and a host of other loosely related policies and programs was titled the “Food Security Act”. In China, food security is often listed as the key objective of state trading in grains, a grain delivery quota system under which farmers receive less than market prices for part of their grain, and policies to encourage self-sufficiency for the nation and even for individual provinces. In South Korea, food security is listed as a primary reason that agriculture must be treated as a special case in WTO negotiations. Food security is now discussed in the WTO under the currently popular rubric of the ”multifunctionality” of agriculture.

Agricultural productivity growth and policy reform

It is generally accepted that investments in agricultural science and similar contributions to agricultural productivity are fundamental to progress on global food security. Often there seems to be a presumption that the same logic and evidence means that national investments in agricultural productivity are necessarily important contributors to national or even local or regional food security. For example, at a national conference on commodity policy in 1999 the Dean of Agriculture at a major land grant university argued that food security for the people of his state was a strong reason for increased research funding for his college. Economists may be inclined to dismiss such arguments as transparent sophistry and special pleading, but I suggest that we take such statements seriously because they may well be influential. This part of the paper compares implications of commodity policy reform with improvements in farm productivity, including implications for food security.

Economists have made considerable effort to assess the contribution of science to agriculture. This line of inquiry applies economic reasoning about long-run investments to costs and returns from agricultural research and extension and especially to public investments in research. Alston, Norton and Pardey; Huffman and Evenson; and Alston and

Pardey, among others, document and represent progress in this area. The consensus is a relatively high rate of return.

Investments in public policy reform have much in common with investments in agricultural science. For example when Stigler poses and responds to the question, “Do Economists Matter,” he includes a rate of return calculation by Coase that is quite favorable to the overall contribution of economic analysis that contributes to policy reform. A few papers have recently examined this question with respect to agricultural economics (see the session introduced by Smith and Pardey.)

Before turning to an example, it may be useful to review some more general considerations. Few innovations create Pareto improvements. This is clearly true for farm policy reform. But, even when agricultural research clearly raises world wealth, and even improves the lot of the poor, some suffer losses. For example, most scientists and economists laud the contribution of the green revolution to food security for more than a billion people, but there are detractors who argue that these innovations lowered welfare rather than improved it. They argue that certain new varieties were particularly well suited to farms that were already favored or that were owned by the relatively wealthy. In that situation, they argue, the poor suffer when a new seed improves the absolute and relative performance of these already favored farms. Distributional considerations complicate the assessments of returns for any innovation.

Agricultural policy reform that increases total social income almost always shifts income between groups. As with biological innovations, there are almost always losers. Those likely to suffer if policy were changed often argue (implicitly) that national welfare would be reduced with a reform because their wellbeing is more important to national welfare than that of others. Nations often use agricultural policy explicitly to affect income distributions. Thus, it may be reasonable to argue in some cases that the revealed social welfare function of society indicates which are the favored people. Of course, such an argument is based on a view that takes the existing political system as a legitimate reflection of social welfare. In that case, almost by definition, what is, is optimal. Policy change only occurs when the constraint set changes, (or is thought to change), when the effective social welfare function itself changes due to some political change, or when new information become available.

Notwithstanding these concerns, in many real cases there is (almost) consensus. For example, few would argue that food price policy in Africa is optimal when it favors the urban elite to the detriment of the rural poor, because the political system itself is insufficiently representative. In general, however, it remains problematic how to incorporate the existing or potential political structures and outcomes in a social welfare function used in policy evaluation.

The natural approach for economists is to focus on aggregate national income as a welfare criterion even though no nation or social group maintains policies consistent with that social welfare function. But, the next step for economists is to argue that the potential for compensation implies that creating aggregate wealth, say through agricultural policy reform provides welfare gains, and if a society chooses not to redistribute that wealth that is a separable policy choice independent of the agricultural policy reform.

Issues similar to those involving income distribution are often raised in the context of environmental impacts of agricultural innovations. The externality considerations that affect the calculation of returns to agricultural innovations also apply to policy reform.

Environmental concerns about new varieties or pest control measures are often more troublesome than the concerns raised with respect to policy reform. Indeed, policy reform is often seen to be environmentally benign.

Ex ante **evaluation of productivity versus policy innovation**

Methods used for evaluating *ex post* contributions of investments in agricultural research or policy reform, are also applicable, with appropriate adjustments, to *ex ante* projections of costs and benefits, and therefore for allocation of resources. Such *ex ante* evaluation must always be conducted (explicitly or implicitly) whenever resources are allocated. Factors in the evaluation include: cost of the effort, likelihood of achievement of results, likelihood of adoption of the results, schedule of adoption, and net payoff to the adoption for the adopters and for society generally. These issues and the difficulties they raise are very similar whether the *ex ante* allocation decisions are among plant genetics projects or among efforts that contribute to policy reform.

An example will help illustrate evaluating the payoff to policy reform compared to, say, biological research leading to agricultural productivity growth. To help fix ideas, I take a simple set of policy options and perform a simple analysis. Nonetheless, the example illustrates some real food security issues. First let us consider equilibrium in a commodity market situation that has a common agricultural policy in place. We then consider the effects of introducing an agricultural productivity innovation stimulated by an investment in plant genetics and compare these with policy reform.

In Figure 1, the demand function is labeled Demand for Food. The initial marginal cost of domestic production is represented by the curve S_0, which starts at marginal cost Pmin, and then, after a short horizontal segment, proceeds along the upward sloping portion of the curve. The potential import price facing this small country is P_w, but, in the initial situation, imports are banned by trade barriers justified on food security grounds.

Now, let us evaluate the projected benefits of genetics research applied to this commodity market. Assume the research would be adopted by producers. Crop yields would increase and cost of production would fall relative to the pre-research situation. The direct impact of plant breeding research is shown in figure 1 by a shift of the marginal cost function down and to the right. The new marginal cost curve is shown by S_1. For simplicity, I leave the minimum marginal cost at Pmin, but the horizontal segment of the curve now extends a bit further to the right. The genetics research and the supply shift it would cause have no effect on government policy, so imports are still not allowed. Market price now falls from P_0 to P_1 and consumers benefit from the price decline. Most economists would consider this a positive food security result. Of course, the innovations also benefit producers by lowering marginal costs and increasing equilibrium output.

How we view the social benefits from this research may depend on the total gain to society relative to the initial position, but our views may also be influenced by the distributional impacts. In figure 1, consumers gain from a lower market price and producers gain so long as the area between the two marginal cost curves is larger than the profits forgone from the lower price. Producer gains are more likely the higher the elasticity of demand (in absolute value) and the lower the elasticity of supply.

Figure 1 has focused on the distribution of annual income flows. We have not discussed the costs of research or the timing of the benefits flow. With such information we may calculate an aggregate net return and evaluate the payoff of this research relative to some target rate of return. Instead imagine that the same resources could be devoted to policy reform that changed the trade policy associated with the commodity and, for simplicity, that the timing of the policy reform impacts are the same as for the genetics project.

As with the genetics project, let us assume that the policy reform effort would be successful and the implication would be a change in the policy. And, as with the plant genetics project, the policy change would affect both overall social income and the distribution of income. In this case, there is a large gain for consumers as price falls from P_0 to P_w. But producers lose from the lower price and the lower domestic quantity produced. Society as a whole gains the large triangle bordered by S_0 and the demand curve down to the base at P_w.

As drawn in Figure 1, the policy change has a higher payoff in terms of the net present value of social income if and only if the smaller triangle bordered by S_1 and the demand curve down to the base at P_w is larger the area between the two supply curves from Pmin to P_w.

It is instructive to consider how issues other than net present value of national income might affect the comparison of policy reform and genetics research. From Figure 1 it is clear that consumers of food would prefer policy reform while producers would lose from the policy reform. Which project is chosen might hinge mainly on the welfare or political weights applied to the change in income or wealth of the competing groups. Note also that the benefits of the policy change would be smaller if the plant breeding research were undertaken and supply function S_1 applied to the question of the benefits from policy reform. Likewise, the benefits of the genetics project would be much smaller in an open trade environment. Therefore, in this example, the social incentive for pursuing each innovation is smaller if the other is also achieved.

Now let us turn to the food and nutrition implications of research versus policy reform. This example shows that for a small country importer, investments in local agricultural productivity do approximately nothing for access to food for the population. This is an extreme case, but is broadly applicable. For example, it applies to almost all research conducted by individual U.S. states. Research done that applies to local productivity of a crop grown widely elsewhere does not affect the market price and does not benefit consumers per se. Such research may have a social payoff by increasing producer profits and the value of land, but generally, it will not improve food security. When access to outside supplies are limited, research will lower the price of food, but in that starting situation, opening the border is a much more effective tool.

Of course, innovations may improve the returns to owners of farming resources and thus add to the income of this group in society. In some cases farm resource owners are themselves vulnerable to hunger and thus aid to them can be positive. But, if, as in the case of trade barriers, the cost is raising the price of food to the whole population, the trade off is almost surely negative for national food adequacy. This idea is explored in more detail below.

My point here is *not* that agricultural science is unimportant for global food supply, or that productivity investments do not contribute to national or global welfare. My point is that as a matter of *national* food security policy, agricultural productivity growth is often over rated.

An Index of National Food Security

Let us now broaden our notions of food security from looking simply at the price of a food commodity. This section defines and uses an index that links commodity policy, especially border measures, to common national objectives on food security. I incorporate random aspects of future food prices into this index. Only the barest outline is presented here. More detail and some background is provided in Sumner, 2000. Also, see the Website http://aic.ucdavis.edu/research/foodsecurity.html. As background to this discussion, I refer to reader to Duncan or Tweeten, who provide assessments of the status of global food adequacy and patterns and prospects for food security. (See also FAO 1999 and data provided at www.fao.org.) Barrett reviews food security definitions and relates nutritional adequacy to food security for vulnerable individuals. He also reviews the evidence on domestic and international food aid. Sumner and Tangermann review the aspects of agricultural trade policy and the WTO that are used below.

In order to develop a workable index of food security, let us begin with threshold food intake f_i* above which a person, i, has adequate nutritional health. This means that the person has satisfied whatever standards are considered appropriate based on demographic, exercise, or medical conditions. Naturally, different countries may define the threshold diet differently depending on the local situation.

To consider national implications of agricultural policy we need to aggregate food adequacy to the population of interest. Let us define the degree of population food adequacy as the share of the population consuming at least the minimum food required for nutritional health. That is, for a given year t, the degree of national food adequacy, Fa_t, is measured as the probability that an individual from the population has $f_{it} > f_i^*$. The food intake distribution across the population is closely related to the income distribution.

Now define a threshold of national food adequacy, Fa*, against which comprises the goal or policy objective of the nation. Any time this threshold is less than 100 percent, the nation acknowledges that it may not be possible to eliminate hunger or the possibility of inadequate diets for some share of the population over the relevant time policy horizon. But, in every country, if the share of the population suffering food inadequacy is too large, as defined within that country, policy makers are willing to say there is an issue of nationwide food inadequacy.

Now, we must add the stochastic nature of "security" to our notion of population food adequacy. I define the Index of National Food Security (INFS) as the probability that some given share of the population will be able to achieve adequate food intake in the future. Note all three parts of our analysis, individual food adequacy, a share of the population and the stochastic nature of food supply and demand each have a role here. The stochastic future is introduced by defining the INFS as the probability that $Fa_t > Fa^*$ in the future. This index may be measured using the probability distribution of future events that affect food intake among those individuals most vulnerable to food shortfalls.

I claim that this index reflects in a reasonable way the concerns of agricultural and food policy makers who are responsible for agricultural trade policy. Other operational indexes that approach food security in this general way would share many of the same implications as INFS.

Commodity trade policy and food security

With this potentially measurable index of national food security, we may now investigate how market conditions and policies affect food security on a national level. The supply and demand for food are natural ingredients to this investigation. Food demand is a function of the price of food and income and such variables as demographic characteristics and relative prices of other goods. We may consider food prices as mainly exogenous to the household or individual and as varying mainly over time and less across individuals. Income does vary widely across individuals and is endogenous. In many countries income is mainly based on labor market earnings. However, to be applicable to poor rural populations, we may explicitly consider the income of farm households who sell food. For these households the price of staple food crops affects both the cost of consumption and the family income.

The role of income in food adequacy may be introduced as follows. The functional form of the demand equation implies a specific relationship between the income distribution and the food intake distribution. For the point f*, which defines adequate food intake, holding price constant, there is an income I* which is the threshold income required for adequate food intake. The area of the income density function that is below I* maps into the area in the food intake distribution below f*. That is, the share of the population with less than adequate food intake is the share of the population with income below I*.

Next, consider the distribution of food price over time with income held constant. The distribution of price reflects the randomness inherent in agricultural markets. Unanticipated variation in price follows some probability distribution. Now, with the income distribution fixed, food intake relative to the threshold food-intake quantity, f*, is just a function of food price. The probability distribution of Fa is a transformation of the probability distribution of food price. We may say that the probability of a widespread national food shortfall is shown by the area under the price distribution to the right of P*, or the area under the Fa distribution to the left of Fa*.

Policies that increase the income of the poor clearly raise IFNS. Such policies may be those that improve national average incomes or policies that shift income specifically to the poor who make up the left tail of the food intake distribution. Policies that make incomes less variable over time would also reduce the chance of widespread food shortage and thus raise INFS. Cross-national observations demonstrate clearly that the most important strategy for national food security relates to economic growth and widespread improvement in income. Thus, any food security policy must be evaluated against what it does to economic growth and particularly the opportunity for improving incomes of the poor.

Agricultural commodity policies affect incomes, but even more directly these policies often affect the price of food. For example, although import barriers raise the price of food many policy makers, and even some economists, claim that trade barriers that emphasize food self-sufficiency contribute to food security. There are two possibilities that could validate this claim.

First, if farmers were to comprise a large share of the poorest part of the national population and if these farmers derive a large share of their income from production of staple grains higher grain prices could improve national food security and raise the INFS. Note, this is not improved food security for others, but rather for the farmers themselves through an income effect. For farmers who consume all or almost all of their production at home, trade barriers cannot help, and for consumers who purchase food, trade barriers are positively harmful. But, in some poor countries, food security policy must pay close attention to the income of food producers.

Second, import barriers or other policies to enhance food self sufficiency may, in some cases, reduce the variability of food prices or, at least, reduce the perceived likelihood of a high price spike or other access interruption. That is the right tail of the food price distribution may be shortened. Thus, the left tail of the probability distribution of the share of the population with an adequate diet is shortened. In this case, INFS may rise although the mean price of food increases. This is a theoretical possibility. Its practical application depends on the facts of internal and global commodity price distributions.

As an example, let us consider the behavior of the INFS with reference to rice import policy in South Korea. (For earlier analysis of South Korean data, see Adelman and Berck.) Import barriers (essentially a ban on imports of table rice for human consumption) raise the price of rice for Korean consumers to about four times the average world price. In fact, the average price of rice in South Korea exceeds by a wide margin the highest level the world price of rice has reached in the past 30 years or more. Furthermore, the price of rice in Korea is potentially quite variable, given a variable climate and a relatively small rice-growing region. But, Korean policy makers point to the potential of a dislocation in the world market that could cause an extreme and never previously observed import price spike facing South Korea if it were an importer. This is illustrated as a very long right tail on the implicit import price distribution. In terms of the INFS, this translates into a long left tail in the probability distribution of the share of the population with inadequate diet and a higher INFS than under autarky. Let us turn to data to examine the INFS for South Korea under autarky versus open trade.

In the following analysis I calculate and compare the INFS for South Korea under two stylized policy rice regimes. The application of the INFS requires data or assumptions about a number of parameters of income and price distributions and how these are different under alternative policies. Here, the INFS calculations are for illustration only, and I make several severe simplifying assumptions.

The first policy considered is close to the current trade policy. Under the Uruguay Round Agreement on Agriculture of 1994, South Korea limits imports of rice to a small fixed quantity and that quantity is not used for direct human consumption (Sumner and Lee). To compute the INFS for South Korea under this policy, the internal mean price of rice is taken from FAO data and bears no connection to international prices. I use the internal price of rice in South Korea in 1995 as the mean of a log normal distribution (log price = 13.8532 per ton). In order to determine the prospective price variability I take the rice yield history for Korea for the past 20 years and calculate a variance around the trend. This variance is used to provide supply shocks in a log linear supply and demand system with a price elasticity of supply 0.25 and a price elasticity of demand of –0.25. With these data and assumptions, the variance of the change in log price is 0.037. This may be interpreted as a percentage variation in price.

To characterize the INFS, I use an individual threshold that defines a household as having adequate access to the staple grain if they spend less than five percent of their income on rice. This threshold may be readily adjusted to any criterion that policy makers or analysts prefer. I use data on the 1995 income distribution for South Korea and an income elasticity of demand for rice of 0.25 as the basis for simulations. For simplicity, I assume that all consumers face the same price and that rice producers who get a major share of their family income from rice production comprise a negligible share of the total population of the country. (In recent years, farmers comprise less than 10 percent of the South Korean population.)

With these data and assumptions, I am able to calculate an INFS for each threshold share of the population that spends less than the five percent of their income on rice. For example, with the share threshold, Fa*, set at 0.96, INFS is 0.9. Under the current autarky policy and with the data and assumptions outlined above, there is a 90 percent probability that

96 percent of the population will spend less than 5 percent of their income on rice. When the FA* is lowered slightly to 0.95, INFS increases to 0.95, which says that there is a 95 percent probability that 95 percent of the population will spend less than 5 percent of their income on rice.

Now let us turn from autarky to a policy of open import markets for rice. For this analysis, I assume South Korea is a small country and thus a price taker facing a variable world price of rice. I use the mean price of japonica rice on the world market converted to Korean won as the central tendency of the price distribution, (the mean world price is about one fourth the internal Korean price). The variance of the log price with these data is 0.060, about 62 percent above the variance calculated under autarky. I do not calculate an INFS under some probability that South Korea faces a rice embargo, but that could be easily done. The other parameters, relating to the income distribution and demand function are the same as in the autarky case. I, thus, ignore the effects of a more liberal trade policy on real incomes in South Korea.

Under these free trade assumptions, there is a 99.9 percent probability that 99.8 percent of the population would spend less than five percent of their income on rice. In other words, with access to the world market, and using the past 20 years as a guide to price variability, there is essentially no chance that as much as 0.1 percent of South Koreans would spend more than five percent of their income on rice.

That is, even though world prices are substantially more variable than implied autarky prices, the lower mean more than makes up for the higher variance in assuring food security for the poor in South Korea. With autarky, there is a significant probability that four or five percent of the population must spend more than five percent of their incomes on rice. If we take such an event as indicating national food security concerns, these concerns can be eliminated with an open border.

Two further comments are useful with respect to this example. First, the autarky policy banning imports would also require an export ban to keep food from flowing out of the country in the case of high world prices. As a policy to reduce high domestic prices caused by world price spikes, it is the insulation on the export side that is key. Of course, this point does not apply when a country-specific embargo is the source of access problems for imports. Further, if the domestic industry is much smaller under open borders, as may be expected for Korean (or Japanese) rice, the potential for exports is relatively remote. Second, an import dislocation that interrupted access to rice would also affect agricultural inputs and thus affect domestic production as well as imports. Thus, staple grain self-sufficiency is ineffective even in the case that may seem most favorable for its support.

Finally then, under almost any food adequacy threshold and population share threshold, raising the average price of rice to four times the world price almost surely lowers the nutritional adequacy of the poor and lowers food security as measured by INFS or any other reasonable index.

Concluding comments

This paper has examined two kinds of policies that are often supported by agricultural interests as contributing to national food security. I find that access to international markets can be a more effective contributor to food consumption than agricultural R&D. The point of this part of the paper is that national food security arguments to support improvements in farm productivity are often weak. Indeed, with access to international markets, food security for a nation may hinge on agricultural R&D on a global basis rather than locally. With this approach trade and R&D can work together to contribute to lower food prices and lower probabilities of high price spikes. This suggests support for a system supporting agricultural productivity growth wherever it can be most effectively achieved, and not tied to the locale of consumers.

The Index of National Food Security that I use in this paper emphasizes that policy makers often express concerns about the stochastic nature of food prices. Even in nations with relative low shares of income spent on staple foods, farm support policies are rationalized on reducing the prospects of food shortages. The INFS incorporates these considerations in a consistent way that shows the effects of parameters of the food supply distribution on national food security. Thus, we are able to evaluate through simulations how claims about food price variability translate into effects on food security of the poor.

Food security is a huge and important topic. This paper provides only a few ideas that require more development to be operational. Nonetheless, I argue that emphasis on local food production for food security is often misguided and harmful to the world's poor.

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Figure 1: Returns to cost-reducing innovation relative to trade liberalizing policy reform