Agricultural trade policy and food security

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1. Introduction

Few topics are more widely discussed than globalization, trade and the WTO, and few issues are more important than food security. A better understanding of the nexus of these topics contributes to agricultural economics and economic policy.

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. The range of internal and border policies rationalized by food security objectives is equally impressive. Subsidies for research, income redistribution, rural infrastructure, price floors, price ceilings, import barriers and export subsidies are all explained as part of national food security policy. This universal significance of food security objectives extends to trade policy and the WTO. Major WTO participants all have framed positions on agricultural trade negotiations and food security.

In the United States, as recently as 1985 the law that renewed farm commodity programs and related policies was titled the "Food Security Act." In China, food security is often listed as the key objective of state trading in grains 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 a special case in WTO negotiations. Many countries include a discussion of food security under the currently popular rubric of the ”multifunctionality” of agriculture.

Nonetheless, some liberal economists, especially among those of a more academic nature, consider the relationship between import access and food security as a settled issue. They assert that economists have long known that open access to international markets

improves food security and that there is no more to be said on the topic. The case against trade barriers can be made with reference to a few well-known theorems and a few well-known facts. They implicitly (sometimes explicitly) claim that anyone who disagrees with this position is ill informed, disingenuous or both. Despite some merit in this economic argument, in this paper, I take the food security claims of policy position papers and government officials seriously and ask how farm trade barriers may be analyzed in terms of food security objectives.

This paper has a few limited objectives. First, I examine the concept of food security and highlight the long and complex linkage between contributions to a high probability of nutritional adequacy for vulnerable populations and trade policy for agricultural commodities. Next, I define an operational index of national food security that may be readily measured and related to agricultural trade policies and the WTO. Some limitations of this index are also listed. The third section shows how trade policies relate to the Index of National Food Security (INFS) and assess how limiting access to imports affects the INFS, including conditions under which such policies may contribute positively to food security. Finally, I mention briefly how alternative policies can contribute to food security and may be cost effective relative to access restrictions.

This paper is part of a larger research effort where the analytical approach is developed in more detail and where we examine policies and data from China, South Korea and North Korea. Unfortunately, there is no space here to develop these cases in any detail.

Throughout the paper I make only limited reference to the vast literature on food security or agricultural trade policy. Fortunately, some recent survey articles deal with many of the important issues and provide many useful references. Duncan (forthcoming) provides an assessment of the current status of global food adequacy and patterns and prospects for food

security. Barrett (forthcoming) 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 (forthcoming) review the aspects of agricultural trade policy and the WTO. Other useful sources include the websites of the FAO and the USDA and the data and publications that they make available.

2. An operational index of national food security

The purpose here is to discuss definitional issues only as much as needed to present some analysis of agricultural trade policies that may affect food security. Barrett's survey article (forthcoming) reviews much of this ground and so we will skip many complexities.

The concept of food security is as complex as it is fundamental. As with many basic ideas, "food security" seems intuitively simple yet turns out to be analytically complex once we begin to examine the idea in some detail. To begin, food is not an end in itself and food adequacy is often framed in terms of nutrition. Therefore, the link from food demand to nutrition must be considered. Notice, this focus on nutrition already simplifies the issue by ignoring the recreational aspect of food demand. Further, food security means more than a current absence of hunger or even the current possession of nutritional health. Food security concerns potential food intake into the future and is thus inherently dynamic. In addition, as implied by the word "security" itself, any concept of food security must include the stochastic nature of food supply and demand.

Nutritional health of an individual i depends, in part, on intake of food per unit of time t (say, week or month), f_{it}. More food intake contributes to more nutritional health up to some threshold after which more food does little for nutrition. This simplified notation also ignores the fact that there are a variety of foods and nutrition itself is multidimensional. We

also do not consider the span of time over which food intake has a measurable, if not permanent, effect on nutritional health. For example, we often use annual data but severe food shortfall of a few months is enough to create famine even if the average calorie intake for the year is adequate. Consistent with the focus on commodity policy, we will consider consumption of staple grains, although more consumption of a staple grain may do little for nutritional health in relatively wealthy populations. Thus, already we see that the complexity of the link to food security from traditional food trade policy, which is almost always associated with particular staple commodities. However, for simplicity of exposition I shall use here a one-dimensional measure of food intake, f_{it}, defined for example in terms of calories and consider policies such as access limits for grain.

Let us now go on to define a threshold food intake f_i^* above which a person has adequate nutritional health. This means that the person has satisfied whatever standards are considered appropriate based on demographic, physical activity or medical conditions. That said, when we consider national policy, we acknowledge that different countries may define the threshold diet differently for food security considerations.

Given the threshold of adequate food intake, an index of food security for an individual may be defined as the likelihood that food intake remains above the threshold. Thus, the degree of individual food security at time n (for now) may be written as,

$$FS_{in} = prob_n (f_{it} > f_i^*), \quad t > n.$$

This definition focuses on the probabilistic nature of food security and does not incorporate degrees of nutritional adequacy during a period as contributing to additional degrees of food security. Also, by leaving aside any time discounting, this definition treats

food shortfalls as equivalent independent of when in the future they might occur. A more inclusive definition would weight near-term food shortfalls more heavily.

Agricultural policy usually deals with national totals and averages and so we need to aggregate the individual concepts of food adequacy and food security to the population of interest. First, note that more food for one individual generally does little to contribute to the nutritional well being of someone else. In general, the distribution of food intake across the population is as important as average intake. Thus, while an index of population food adequacy may be correlated with average per capita food consumption, there are limits to the usefulness of the average. Instead, 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, population food adequacy, Fa_t is measured as the probability that a random individual from the population has $f_{it} > f_i^*$. In most cases, this food intake distribution across the population would be closely related to the income distribution, but other factors matter as well.

By this definition we do not consider degrees of malnutrition or hunger. Nonetheless, for simplicity, and without losing too much empirical applicability, we will stick with our purely threshold concept measuring population food adequacy as simply the share of the population with adequate diets (For support see FAO, 1999).

Now, to reflect the issues faced by policy makers, we must add the stochastic nature of "security" to our notion of population food adequacy. Food security of a population is naturally related to the definitions just proposed. We link the share of the population with an adequate diet during some period with the probability of achieving that adequate diet in the future. *Our operational definition of the index of national food security is the probability that some given share of the population will be able to achieve an 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.

To summarize, adequate individual food intake is $f_{it} > f^*$ where i ranges over individuals and t ranges over time periods. For some given time period we can define the share of the population for which $f_{it} > f^*$ as Fa_t. It is reasonable to think of the distribution of income in the population as the main determinant of the distribution of f_i in some time period. Next define a threshold share of the population Fa* as defining national food inadequacy. This threshold 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 trade policy horizon. But, that 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. The stochastic future is introduced by defining the Index of National Food Security as the probability that $Fa_t > Fa^*$ in the future. This probability may be written as

$$INFS = \text{the integral from } Fa^* \text{ to } 1 \text{ of } \phi(Fa_t)dFa,$$

where ϕ is the density function reflecting the uncertainty about the future population share with inadequate diets. 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.[1] 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.

[1] I will not discuss here the relationship between INFS and the social welfare function of the country concerned (or, for that matter, the political welfare function of its government). It may suffice here to note that this

3. Food supply and demand and food security

Next we must consider the economics of food intake that fits within our index of food security. Food demand for individual i in period t, is a function of the price of food and income,

$$f_{it} = f(P_{it}, I_{it}),$$

where, for simplicity, explanatory variables such as demographic characteristics and relative prices of other goods are suppressed. We have also suppressed an error term that would reflect unmeasured determinants of food demand. Recognizing that $\partial f_{it}/\partial P_{it} < 0$ and $\partial f_{it}/\partial I_{it} > 0$, we can consider what affects the distribution of f_{it} across individuals and over time.

We may consider P_{it} as mainly exogenous to the household or individual and as a simplification we might think of P varying mainly over time and less across individuals. We leave the i subscript in place to reflect the more general situation in which food price varies by location within a country. Income does vary widely across individuals and may be affected by price. Income also may vary randomly over time. In many countries income is mainly based on labor market earnings. However, to be applicable to poor rural populations, we want to explicitly consider the income of a farm household who may sell food. Therefore write,

$$I_{it} = P_{it}Q_{it} + V_{it},$$

where Q is household production of food and V reflects earnings from other activities including production of non-food agriculture. We have simplified the contribution of food production to income by simply valuing home-produced food at the same price used in the demand function.[2] We also leave aside cost of food production. For many individuals Q is zero, but for some rural

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relationship is probably not linear: a reduction in INFS is likely to reduce social/political welfare the more the lower INFS was to start with. Moreover, social welfare may also depend on whose food security is affected.

[2] Note, that the (relative) price term is used to reflect the full opportunity cost of food intake and the income term to reflect command over resources that could be used to acquire food. As noted, this income term includes the value of home-produced food and other goods or services as well as wages that are paid in kind.

households a significant share of family income is created by direct production of food. Also, of course, even for farmers, Q_{it} may be greater than or less than the households sum of f_{it} meaning a farm household may be either a net buyer or seller of food.

Holding price constant, the distribution of f across the population at any time follows directly from the distribution of income. Each income is associated with a food intake quantity and each food intake quantity is associated with a particular income. Figure 1 shows an example of such a mapping. The functional form of the demand equation implies a specific relationship between the income distribution and the food intake distribution, but over a significant range of income more income means more food intake and almost certainly a lower share of income spent on food. For the point f*, which defines adequate food intake, 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, under this simplification, 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 P with the income held constant. Here we think of the probability distribution of P as reflecting the randomness inherent in agricultural markets, originating mainly from supply shocks, domestic and international. The variation in P_t follows some probability distribution. With the income distribution fixed, food intake is just a function of P. Figure 2 shows the probability that any individual is food secure as a mapping from the probability distribution of P. There are as many figures like figure 2 as there are individuals with different incomes.

Next consider how price affects the share of the population with $f_{it} > f^*$, Fa_t. Figure 3 shows an example of how the value of Fa_t relates to the price of food. Notice that Fa_t ranges

between zero and one, because it is a share of the population, and P is restricted to be positive. The probability distribution of Fa is a transformation of the probability distribution of P using the function expressed in 3. Figure 4 shows this relationship, where, as in figure 3, a low price is mapped into a high share of the population with an adequate food intake and a high price is mapped into a low share. Share Fa* is defined as the threshold population share below which a country acknowledges it faces widespread inadequate diet among its people. In figure 3, we hold the level and distribution of income constant as we vary P. Such analysis is a good approximation for countries in which the share of national income from production of the staple crop is small. For example, in South Korea about 30 percent of farm income comes from rice production and farm income now comprises less than ten percent of national income. Therefore, a change in the price of rice has little impact on national income. Of course, income of owners of rice production resources are affected by changes in the price of rice. Where national income is related significantly to the price of staple crops, figure 3 should be interpreted as the total relationship with the income of farmers falling as the price of food falls. This would flatten the curve. A reversal of the slope is a theoretical possibility in extreme cases. The condition for a reversal is that the own price elasticity for staple crop demand is smaller in absolute value than the income elasticity times the share of income from production of this crop for the relevant vulnerable part of the population.

In figure 4, we represent Fa* equal to 0.95. With a share this high we are implicitly dealing with a relatively wealthy country with a relatively equal income distribution. Of course, the other threshold of importance is f* which defines the adequate diet for an individual. Policy decisions about this threshold may also vary by the income and other characteristics of a country or region.

In figure 4 the INFS is the area under the density for Fa to the right of point Fa*. This is equivalent to the area to the left of P* in the density function for P. Conversely, the probability of a widespread national food shortfall is shown by the area under the curve to the right of P* or to the left of Fa*.

4. Effects of trade policy on INFS

We may explore the effects of trade policies and WTO agreements on food security using the framework just developed. Focusing on key economic variables, the INFS depends on the parameters of the distribution of prices mainly over time and of incomes across the population and over time. One may easily show analytically and with simulations, and it is intuitively clear, that policies that increase the income of the poor 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 also reduce the chance of widespread food shortage and thus raise INFS.

Cross-national observations demonstrate clearly that the most important strategies for national food security relate to economic growth and widespread improvement in income. In figure 1, if the distribution of income can be shifted to the right, the share of the population with an inadequate diet is lower for any given price of food. Thus, any food security policy must be evaluated against what it does to economic growth and particularly to 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. By their very nature, import barriers raise the price of food in countries that are (at least potential) importers of food. For exporters, import barriers are usually irrelevant. Import barriers shift the distribution of food price to the right in figure 2 and

thus lower the probability that a given individual will have an adequate diet. In figure 4, we see that a shift to the right in the probability distribution of the price of food, say because of an import tariff, lowers the probability that the threshold share of the population will have an adequate diet, and thus reduces INFS.

Given this price effect, how is it possible that policy makers and even some economists can claim that trade barriers that emphasize food self-sufficiency will improve food security? In general such a claim is hard to substantiate. There are, however, two possibilities.

First, in some very poor agrarian regions, farmers make up a large share of the poorest part of the population and these farmers derive a large share of their income from production of staple grains. For those who consume all or almost all their production at home, trade barriers can provide no help, and for those who are net buyers of food, trade barriers are positively harmful to their income and hence their food security. Nonetheless, for that segment of the rural poor who are net sellers of food, import barriers that raise the price of imported food can, in theory, raise their income enough to increase the share of the population with an adequate diet at any given price, and hence raise INFS. This is a rare case because income gains among farmers who sell food must be enough to offset the direct effect of lowering the food security of the rest of the population who buy food. The lesson of this case is not that many countries use this particular food security justification for farm trade barriers.[3] Rather, the lesson is that in analyzing food price effects of trade barriers we must be sure to include the effects on the incomes of the rural poor who sell food.

A more common claim is that import barriers that encourage food self sufficiency reduce the variability of food prices or at least the probability that some very high price spike

or other access interruption may occur. Figure 4 illustrated the point that the shape of the probability distribution of market price determines the probability distribution of the share of the population suffering inadequate diet. The probability that the market price exceeds some threshold maps into the probability that the share of the population suffering an inadequate diet exceeds a threshold. The claim of some policymakers that they can enhance food security by blocking imports even though this tends to raise the average price of food may be interpreted as a claim that the right tail of the price distribution is shortened, and hence that the left tail of the distribution of the share of the population with an adequate diet is shortened.

Figure 5 illustrates this point with reference to rice import policy in South Korea. Import barriers (essentially a ban on imports of table rice for human consumption) raise the price of rice for South 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 modern data. Furthermore, under an autarky policy the price of rice in South Korea is potentially quite variable, given a variable climate and a relatively small rice-growing region.[4] But, South 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 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

[3] As a matter of fact, many low income countries with significant continuous (i.e. not only occasional) food insecurity among large parts of their population, pursue policies that keep their domestic food prices below those on international markets.

[4] Even though not implemented in Korea, the area under the high price tail of the price distribution resulting from import restrictions could be reduced significantly by importing selectively in years of domestic production shortfalls.

than under autarky. This model thus provides some (tenuous) conceptual grounding for the food security claims of self-sufficiency advocates.

Two comments are required before turning to concluding remarks. First, the autarky policy banning imports would also require an export ban policy 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. However, for the countries concerned this would also pose a serious dilemma in the WTO negotiations, as they have much of an interest to prevent (regular) exporters from imposing export bans when they face a domestic shortage.

Second, it is very hard to characterize or parameterize a realistic situation where the data would support the theoretical possibility just specified. That is, under almost any food adequacy threshold or population-share threshold, and, given reasonable data on the share of the diet from rice, raising the average price of rice to four times the world price year after year lowers the nutritional adequacy of the poor and lowers food security as measured by INFS or any other reasonable index. Furthermore, even if one accepted a relatively high probability for an embargo in the near further, such a dislocation would almost surely 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.

Concluding remarks

This paper defines and uses an Index of National Food Security that can help understand how trade policies affect food security. We find it is theoretically possible that trade barriers for staple foods could raise the INFS, but in practice this seems a remote possibility at best. That said, what can agricultural policy makers do and what can the WTO

contribute to food security? The most important step by farm and food policymakers is to encourage rapid economic growth for the poor. For most of the rural poor that probably means help moving to non-farming occupations, or if they remain within farming, it means off-farm employment as well as policies that enhance their farm productivity.

Trade policy has a major role to play by opening markets and building international relationships that are proven stimulants to economic growth. Thus trade policy can be a part of a general economic environment to encourage secure incentives for investment. Income or food redistribution has a role in short run and emergency situations, recognizing that such policies may have costs in terms of economic growth unless managed carefully. Stocks policies, and specifically, security for private stockholding, has an important potential role in dealing with price variability and the potential for short run dislocations.

Probably the most important contribution of the WTO to food security is to keep farm and non-farm trade barriers falling, to encourage the secure flow of international investments, and to improve access to low cost food markets by the world's poor. Finally, to deal with the reality and perception that access to imports may be unreliable, the WTO could contribute a strong and explicit ban on food export taxes or export embargoes in the next trade round if not before. Such an agreement would be a very positive early harvest for this trade round to establish the commitment of all nations to the secure access to world food markets.

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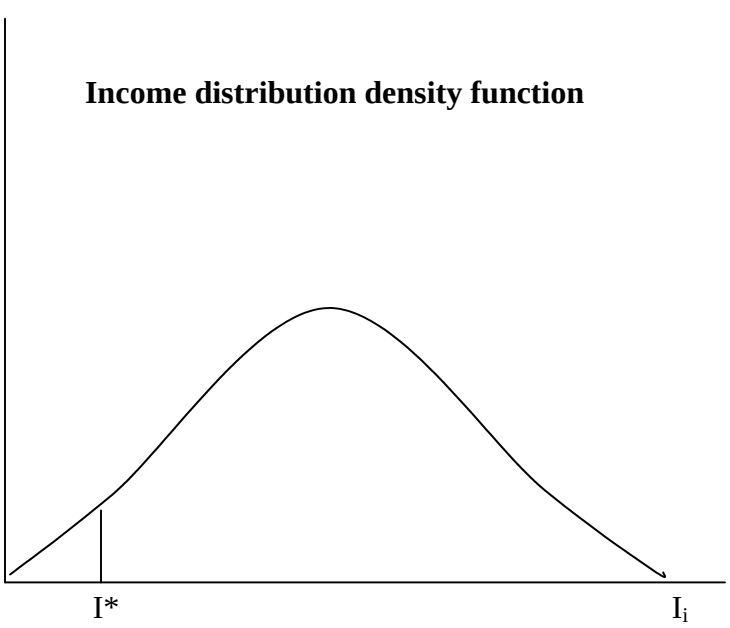
Figure 1: The Linkage from Income to Food Intake with Price Fixed



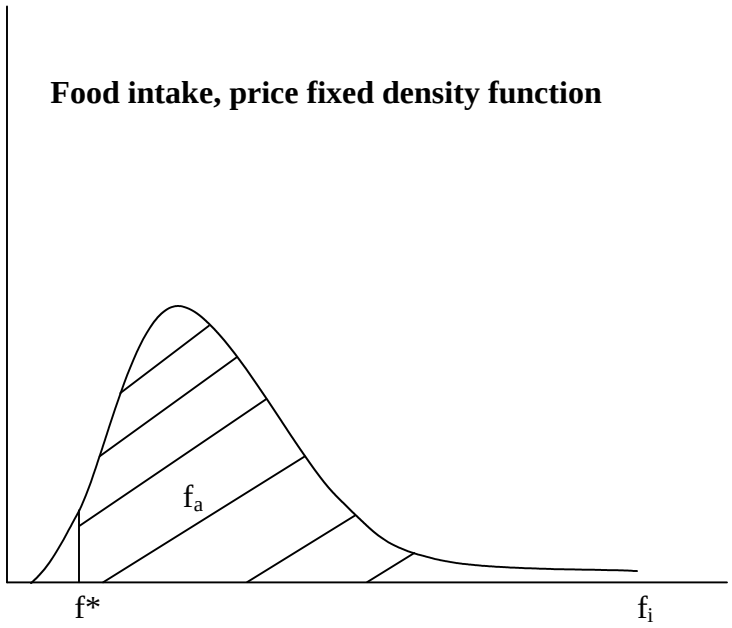


Figure 2: Linkage from the Food Price Probability Distribution to the Individual Food Intake Probability Distribution

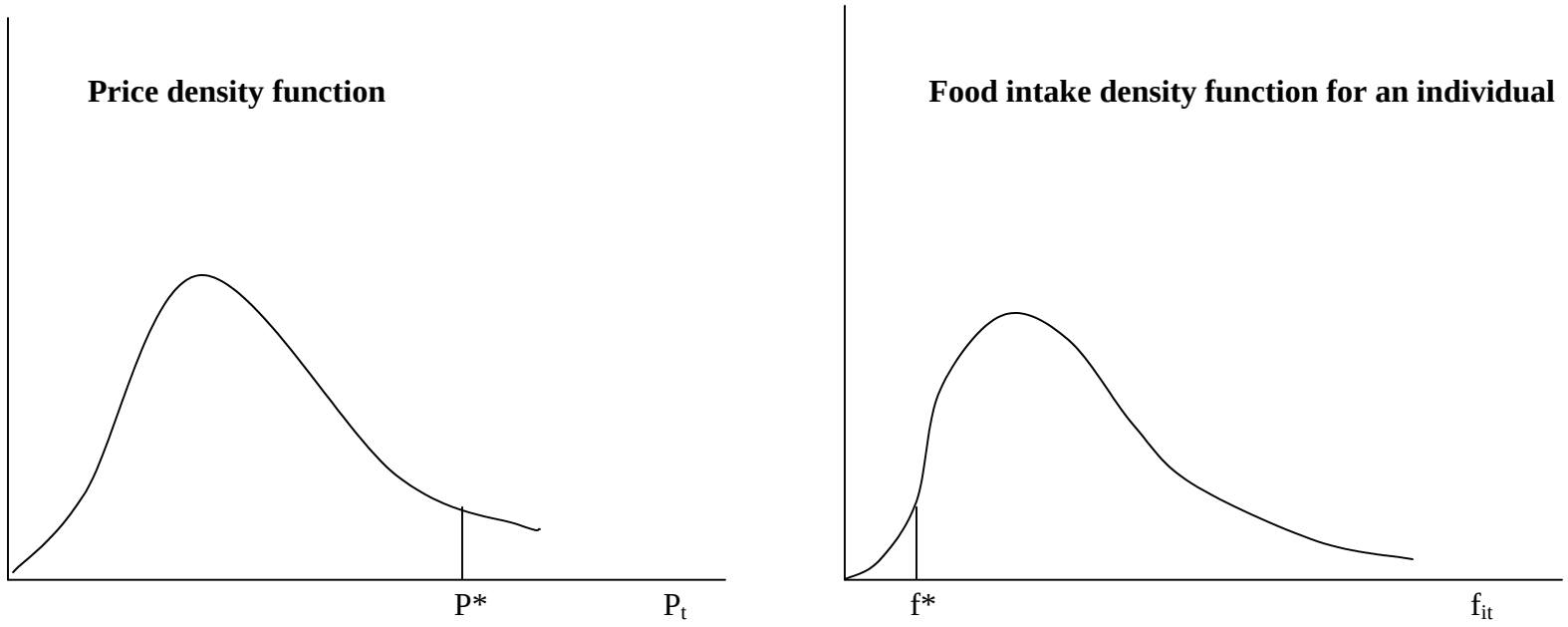


Figure 3: Functional Relationship between Food Price and the Population Share with Adequate Diet

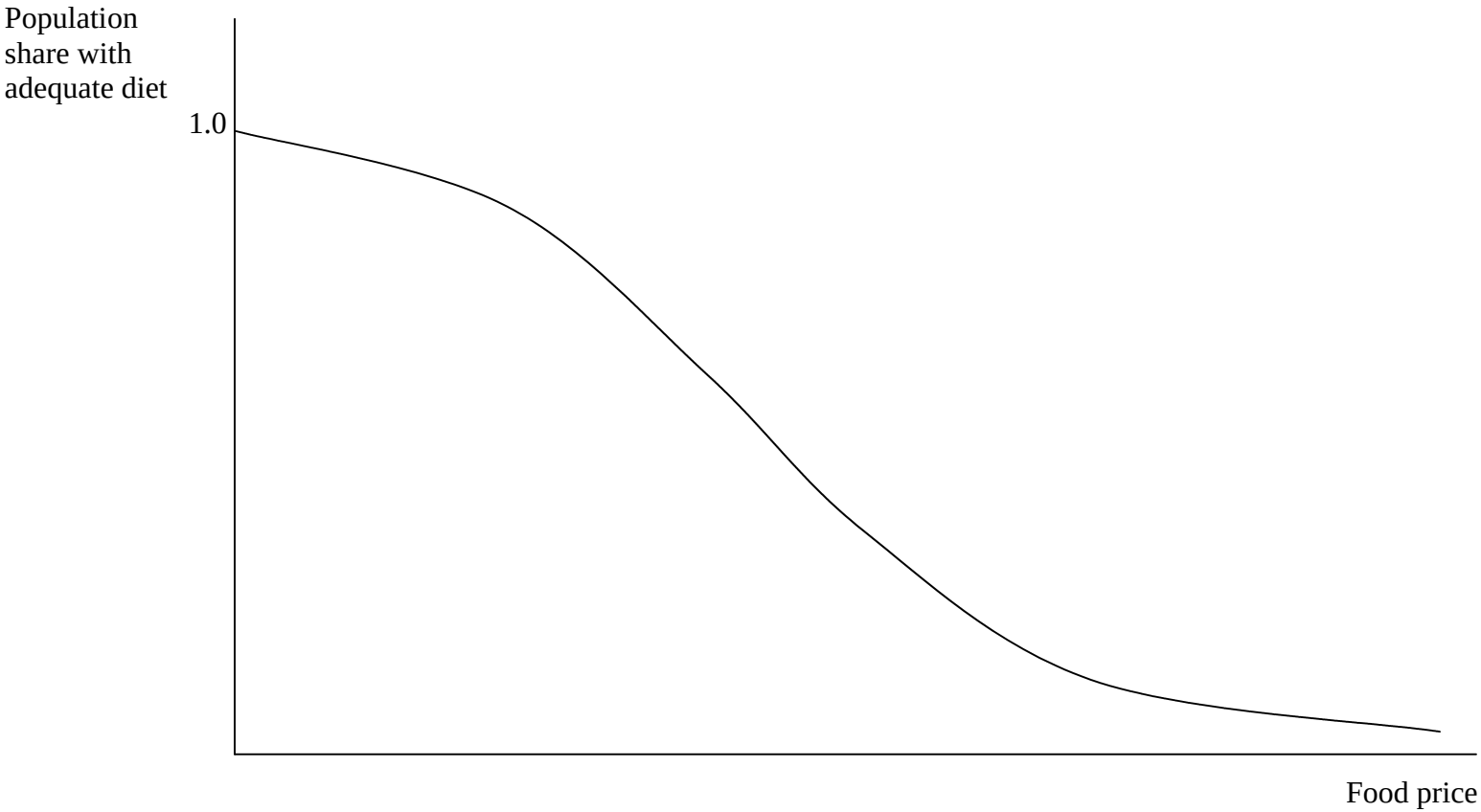
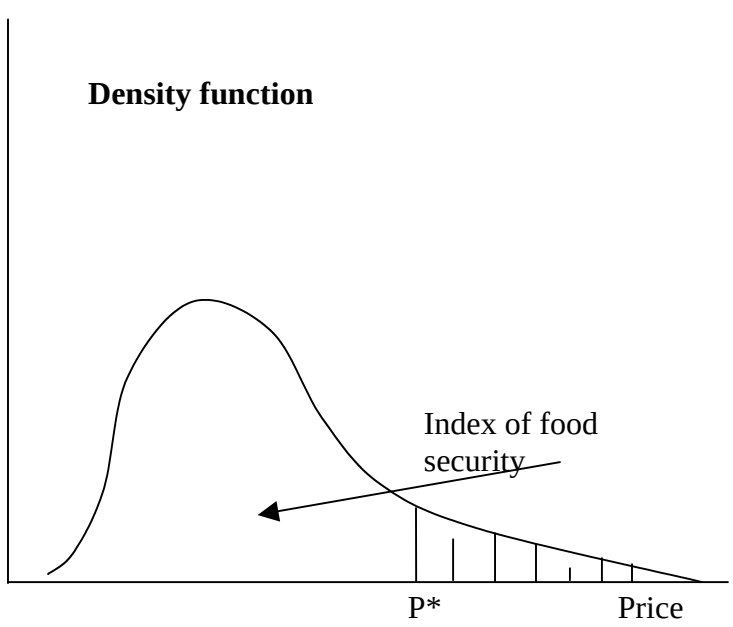


Figure 4: Probability Density Functions for Food Price and the Share of the Population with an Adequate Diet



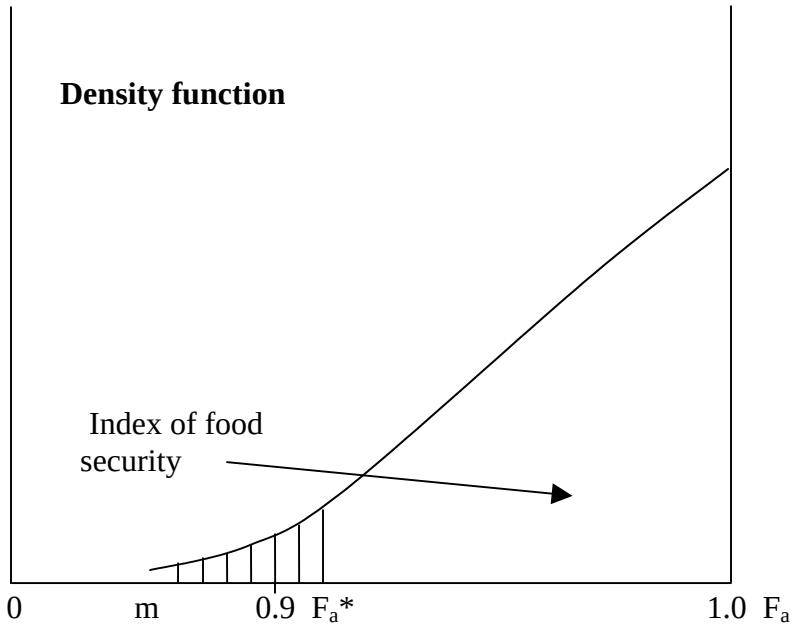


Figure 5: Autarky, Self-Sufficiency and Food Security: An Analysis of Alternative Price Distributions