Technological Change and Price Effects in Agriculture:

Conceptual and Comparative Perspectives

by

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I. SETTING THE STAGE

The importance of technological advance to economic growth has become accepted fact. Yet the answers to questions of *who* adopts new technologies, how *quickly*, and at what *cost* to society remain elusive. While these issues are not unique throughout history, the advent of biological and chemical technologies that are both divisible and scale-neutral and the experiences referred to as the "Green Revolution" in the latter-half of the twentieth century throughout much of Asia have fostered a lively and long debate on the growth and particularly the distributional consequences of technological change in the agriculture of developing countries.

Earlier studies of the impacts of the Green Revolution in rural Asia pointed to the disproportionate benefits accruing to the relatively well off and large farmers as well as to urban consumers (Griffin, 1972; Harriss, 1977) as well as to the displacement of small farmers (Cleaver, 1972). The earlier criticisms were displaced with later studies that identified the direct and indirect benefits of technological advance on poverty reduction (Blyn, 1983; Pinstrup-Andersen and Hazell, 1985; Ahluwalia, 1985) and the benefits accruing from growth linkages with the rural non-farm economy (Bell, Hazell, and Slade, 1982; Haggblade and Hazell, 1989; Mellor and Johnston, 1984). More recently, studies have focused on the respective roles of total factor productivity growth versus factor accumulation in fostering agricultural and broader economic growth (Young, 1994; Krugman, 1994) and the impact of public versus private investment in raising total factor productivity (Fan and Pardey, 1998; Evenson, Pray, and Rosegrant, Evenson, 1999; Fan, Hazell, and Thorat, 1998). David and Otsuka (1994) refute earlier criticisms that the Green Revolution had the effect of worsening income distribution, finding that, when both direct and indirect effects of land, labor, and market adjustments are considered, differential adoption of modern varieties did not significantly worsen income distribution.

An important dimension of this evolving debate is the distributional consequence of technological change on technology adopters that is brought about through changes in relative output prices. With the expansion of output through technological change in the face of relatively inelastic demand, the significant drop in output prices that results has not only adverse income consequences for technology adopters but threatens the very process of sustained technological advance itself. In recognition of these adverse price and income effects, different schools of thought have emerged. Among these are those who letting market forces bring domestic prices in line with border prices (Schultz, 1978); those who favor using price policy as a means of income redistribution (Taylor, 1980; Streeten, 1987); and those who emphasize the need for price intervention in the short term while aligning to long-term international parity (Timmer, 1986).

Agricultural Growth and Markets in Africa

The above debates are far from over. In sub-Saharan Africa, where technological advance of the scale and scope of the Green Revolution in Asia has yet to occur, the questions of who adopts, how quickly, and at what social cost, are critical. In particular, the issue of the negative price effects of technological change on producers are also particularly relevant to African countries as they attempt to increase agricultural productivity and to foster a smallholder-led agricultural revolution in a liberalized market setting. In the region known as the greater Horn of Africa, average regional crop production in 2000/2001 increased significantly, by up to 130 percent, over the previous five-year average since 1994/1995 (FEWS NET, 2002). Subsequently, producer prices fell to record lows in 2001/2002, raising concerns about disincentives to producers in coming years. While part of this increase in production was driven by good rainfall, there is also evidence that production gains in Ethiopia and other countries were also driven by increased area under cultivation and higher yields per hectare, particularly of maize, which is a dominant crop representing 27 percent of total cereal production in Ethiopia.

At the same time, countries across sub-Saharan Africa have undergone extensive market reforms over the past two decades, implying a greater reliance on market mechanisms to ensure the efficient distribution of agricultural output. The extent of market integration is an important determinant of the demand for agricultural output. The more segmented the market, the less responsive demand is to changes in price and the less a share of the gains from increased production will accrue to producers. A major lesson learned from two decades of market reforms in sub-Saharan Africa is that, while aligning prices to their parity levels or “getting prices right” is necessary, it is not sufficient for getting markets right, that is, ensuring that markets work effectively to improve the livelihoods of the poor. In the aftermath of structural adjustment-led market reforms throughout sub-Saharan Africa, recent experience suggests that the free market approach of the complete withdrawal of the public sector has had deleterious consequences for advancing Africa's agricultural transformation (Kherallah et al., 2002; Barrett and Carter 1999).

Market liberalization implies that the potentially adverse price effects of technological change must be borne by the market, a different model than that which prevailed in Asia during its Green Revolution. Expectations that such an agricultural transformation can occur without government intervention at some level in markets are contrary to the history of economic transformation in either the West or more recently in Asia. A serious challenge seems then how best to bring about effective public and private partnerships and to define the appropriate role of the state in the post-reform era in order to generate and sustain an agricultural growth momentum.

Objectives and Organization of Paper

This paper focuses on the price dimension of technological change in agriculture and aims to review both the conceptual or theoretical underpinnings of this dimension as well the empirical evidence of the policy options that have been applied by Asian countries in the course of their respective Green Revolutions. The objective of the paper is to contribute to a better understanding of the price effects of technological change and how to address these effects in policy terms. The paper starts by an introduction to the problem of price variability in agriculture and reviews the conceptual foundations of price relationships in agriculture. In Section IV, we relate the issue of price variability to technological change and present the classic theory of the "agricultural treadmill." Following from this, we review policy options to address the price and income consequences of technological change, drawing on both the conceptual and empirical literature on the Asian experience. In Section V, we review more closely the Asian experience and the underlying components of the Green Revolution, based on yield-augmenting agricultural growth. In this section, we explore the sources of agricultural growth and the policies adopted in specific countries. Finally, in Section VI, the paper highlights the implications for the way forward in promoting an agricultural transformation in Africa.

II. THE PROBLEM OF PRICE VARIABILITY

Neoclassical economic theory leads us to believe that price will always tend toward the point of intersection between the Marshallian upward-sloping supply and downward-sloping demand curves. As excess demand below the intersection drives the price up and excess supply above the intersection pushes the price down, the "invisible hand" is presumed to guide and stabilize the economy. In order for this to happen, theory requires that the economy be comprised of many small units of buyers and sellers, each commodity and factor have close substitutes, and products and factors be perfectly mobile. In reality, of course, a self-adjusting agriculture does not exist and agricultural prices, across countries and across time, exhibit wide and irregular fluctuations. Price variability is revealed in wide inter-annual swings in price levels as well as intra-annual volatility.

Consequences of Price Variability

These different forms of price variability lead to two kinds of economic problems. Seasonal fluctuations in producer price levels lead to a general income problem while year-to-year variations around the moving price level lead to the problem of uncertainty. When producer price levels either rise or fall in absolute terms, this leads to severe negative consequences for either consumers or farmers, respectively In the case of price uncertainty, where a commodity may rise one year and fall the next, farmers are required to make planning decisions without knowing the next year's price, which can lead to inefficient distribution of resources. On this latter problem, there is considerable debate. In the context of high-income countries where small coalitions of specialized producers are highly risk averse and where no commodity is more than 5 to 10 percent of consumer budgets, price stabilization is considered welfare reducing (Turnovsky et al., 1980, Newbery and Stiglitz, 1981). However, if the crop is the key to household earnings or is heavily dominant in consumer diets, as is the case in low-income countries where budget shares of staples may reach 60 to 70 percent, variable prices have a high impact on household welfare. The poverty of small farmers who are net buyers induces a high budget share for staples and price risk aversion, while net sellers unambiguously lose from variable prices (Sandmo, 1971; Barrett, 1999).

Explaining Price Variability: Demand Side

Why do agricultural prices exhibit such wide and irregular fluctuations, especially in low-income countries? The answer lies in the behavior of consumers of agricultural goods and of small-scale producers. On the demand side, consumers behave differently with respect to a change in price of a single food item versus a change in the prices of all food items. In the first case, consumers will substitute from relatively more expensive products to cheaper substitutes and the total quantity consumed is unchanged. In the second case, however, consumers are limited in the degree to which they can substitute for food because of nutritional requirements..

As a consequence, estimates of aggregate demand for food reveal that demand is highly inelastic, meaning that a large percentage change in price is associated with a small change in quantity demanded. Historically, measures of the elasticity of demand in industrialized countries is around –0.2 and in developing countries, around –0.3. This implies that, with a 10 percent increase in food prices, demand will decrease by only 2 to 3 percent. Conversely, a 10 percent decrease in prices will only increase demand by 2 to 3 percent.

The severe price inelasticity of demand for agricultural products is one of the principal factors underlying food price variability. The effect of price inelastic demand is compounded at the producer level by the wedge between retail and producer prices. Thus, with an elasticity of –0.2, retail prices must fall by 10 percent to increase consumption by 2 percent. However, if 60 percent of each consumer dollar is absorbed by the marketing system, farm prices would then fall by around 25 percent (Cochrane, 1958), which is unaffected in the short run by output price changes. Thus, in terms of income, a fall in retail food prices greatly reduces farmers' cash income.

Explaining Price Variability: Supply Side

Analogous to the demand side effects, aggregate price elasticity of supply is typically much lower than the price elasticity of supply of an individual crop since reallocation of factors of production between crops is possible (Chibber, 1989). Treating the supply relation of a farm as related to how the aggregate of commodities produced varies with the prices of the commodities, it is generally agreed that the short-run supply of agricultural output is highly inelastic. This implies that the aggregate output of the farm does not change very much in relation to changes in the level of prices, even though the composition of production may change. The price inelasticity of supply is due to three principal reasons: (1) labor and land and other capital inputs are considered fixed-cost inputs and are employed fully; (2) factors of production are not highly mobile in response to factor price changes; (3) producers are entrenched in agriculture as a way of life. Thus, price elasticity of supply is in the range 0.3 to 0.4. The implications of inelastic supply are that a change of demand is fully reflected in the price level, without mitigating effects of a change in the total supply. Thus unresponsive supply likewise contributes to the wide fluctuations in producer prices (Figure 1a).

The Role of Technological Advance

Technological change is an increase in total factor productivity, which can be due either to a shift in the production function or to improved technical, allocative, scale, or scope efficiency with a given production function. Both sorts of technological change bring increased producer profits, but from different sources. A technological innovation is yield-increasing if it increases yields per fixed factor without reducing optimal variable costs per fixed factor. So a yield-increasing technology relies on increased variable inputs because it will expand the marginal physical product of inputs and therefore their application rate. Modern seed varieties best employed with a package of chemical fertilizers and pesticides or irrigation that stimulate increased use of labor an fertilizer are classic examples. A cost-reducing technological innovation, by contrast, reduces optimal variable costs per fixed factor but does not increase yields per fixed factor. So a cost-reducing technology saves variable inputs. Genetic selection for pest-resistant crop traits or development of more efficient forages for livestock are good examples of cost-reducing technologies.

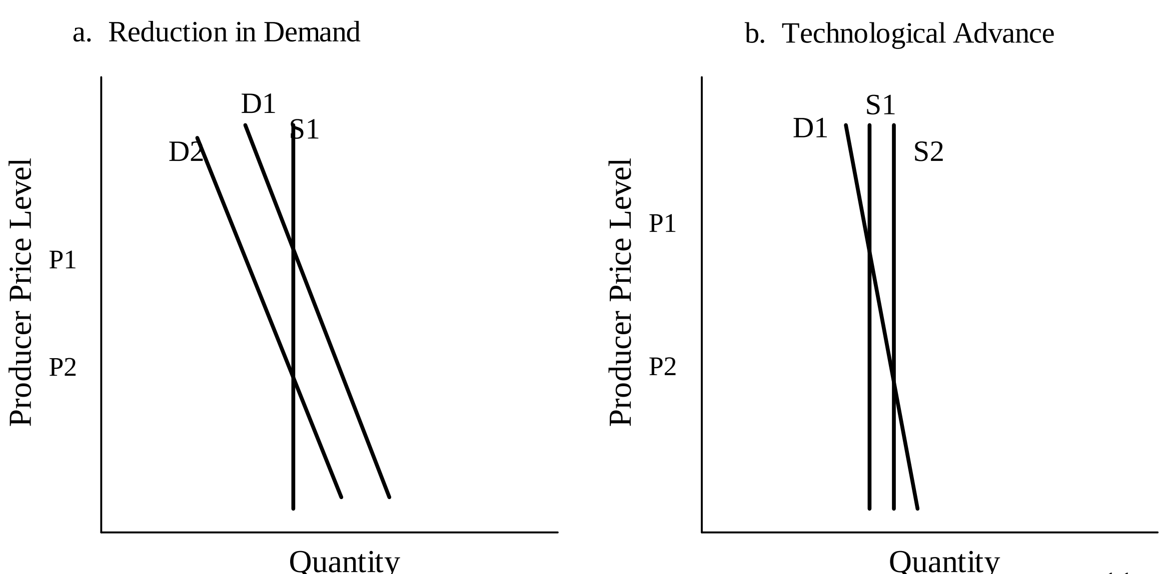
Yield-increasing innovations reduce average fixed costs while cost-reducing innovations reduce average variable costs. The distinction matters in the presence of price risk, which will generally discourage adoption of yield-increasing and encourage adoption of cost-reducing technical change in the presence of risk aversion (Kim et al. 1992). Obviously many technology improvements can be combinations of these two types of technological change, bringing both higher yields and lower variable costs per fixed factor.

The other dimension along which one can distinguish between technologies is their effect on production risk. Some inputs (e.g., fertilizer) may increase both the mean and variance of output while others (e.g., pesticides or machinery) may reduce the variability of yields. Just and Zilberman (1983) find that the likelihood of adoption intensities is jointly determined by risk attitudes, the marginal risk effects of new inputs, and the correlation of yields under new and old technologies. No single, unambiguous prediction emerges as to how risk aversion will affect relative rates of adoption among large and small farmers.

The adoption of a new technology often requires an additional investment. Producers are capable and willing to make this investment under two conditions:

(1) when they have sufficient assets or access to sufficient capital to finance the initial investment and costly experimentation during the initial learning phase, and (2) when the future does not look too uncertain. At the same time, there is also the issue of irreversible fixed costs, which discourage investment in the face of price variability (Dixit and Pindyck, 1994; Chavas, 1994). The effect of technology adoption on the aggregate supply curve is to shift it outward to the right as producers offer more for sale at any price (Figure 1b).

Figure 1. Demand and Supply Effects on Producer Price



III. THE AGRICULTURAL TREADMILL

Cochrane's (1958) classic theory of the "agricultural treadmill" is an apt representation of farmers in a fully commercialized economy. This theory was later extended by Hayami and Herdt (1977) to apply to the context of semi-subsistence economies where a large fraction of the commodity is consumed in the household or local village. The theory is based on the underlying notion of a dynamic process in which over the long run, aggregate demand and aggregate supply are engaged in a race. In this view, the "race" has rarely been equal, and at times it has been very unequal, with extreme income consequences.

Demand and Supply Shifters

Commonly, rising real incomes and population growth operate to expand aggregate demand for food. Holding demographic structure constant, the population elasticity for food is 1, implying that a 1 percent increase in population translates into a 1 percent increase in food demand. The income elasticity of demand is considerably lower, and is declining with rising income levels, according to Engel's Law. Thus, increases in income reduce both the income elasticity of food as well as the price elasticity of food.

In terms of supply shifters, aggregate supply increases as a result of technological advances or an increase in area planted. In the United States up to the early twentieth century, land expansion was the primary cause of supply growth. Between 1914 and 1956, total farm output increased by 90%, resulting almost entirely from technological advances on existing land area, through the introduction of the tractor and later, biological and chemical breakthroughs. Similarly, the Asian Green Revolution, with the exception of Thailand, is primarily a story of output expansion from technological advance.

Whether aggregate demand or aggregate supply wins the race is of great consequence to producers. That is, if population growth outpaces technological advance, producer prices will rise. If technological advance wins over population growth, producer prices will fall. On the global scale and in most countries, the latter scenario has prevailed.

Theory of the Agricultural Treadmill

The idea of the agricultural treadmill is simple but powerful. In an economy where all producers are price takers and where a technological advance reduces the per unit costs of production, enterprising or otherwise able producers who adopt a new technology early on realize increased net returns because the new technique reduces their costs while aggregate supply is not increased sufficiently to lower prices. As the first adopters reap income gains, other producers adopt until widespread adoption of the new technology results in an outward shift in the aggregate supply of that commodity and a decline in its price. Because demand is highly inelastic, gross returns to producers will fall as aggregate supply shifts out. Over this dynamic process, the windfall gains of the early adopters vanish, later adopters must make technological progress just to keep from falling behind, and non-adopters suffer unsustainable losses as their unit costs do not fall while the price they receive for their product does.

When demand is perfectly or highly inelastic, the social gains from technological advance accrue to consumers in the form of lower prices. The agricultural technology treadmill thereby reveals an important fallacy of composition: what is welfare-enhancing and optimal for the single producer is welfare-detracting and non-optimal in the aggregate. The dynamics of adoption are therefore central to the distributional effects of technology adoption. Early adopters benefit, at least temporarily, while late adopters and non-adopters never benefit. This is closely related to Schumpeter's notion of "creative destruction," wherein innovators enjoy temporary profits from change that also destroys the old order by driving less innovative producers out of business.

Sustainability of Technological Advance

Aggregate supply cannot outrace aggregate demand forever. At some point, the pace must slow down to equal the rate of demand expansion. Aggregate supply and demand are essentially related through the asset base of producers. Because new technologies are capital-using, requiring additional cash outlays, producers who have the capacity are willing to invest in order to reduce their unit costs. However, with falling prices and declining incomes, technological advance "sows the seeds of its own slow-down" (Cochrane, p. 100).

Even if governments intervened to maintain prices and incomes, a related issue is that, because the benefits from agricultural technology development accrue in part (often, largely) to consumers, The socially optimal arrangement would be to have some of the costs of technology development paid by consumers. When research and development is private and intellectual property rights protect the rights to profit from an innovation, firms capture this cost through royalties and revenues from consumers. But when research and development is public, as for smallholder producers in low-income agriculture, the means of financing technology development can be a challenge. The domestic tax base is thin and international aid is steadily declining in volume. So the future of technology development for low-income agriculture remains a serious challenge.

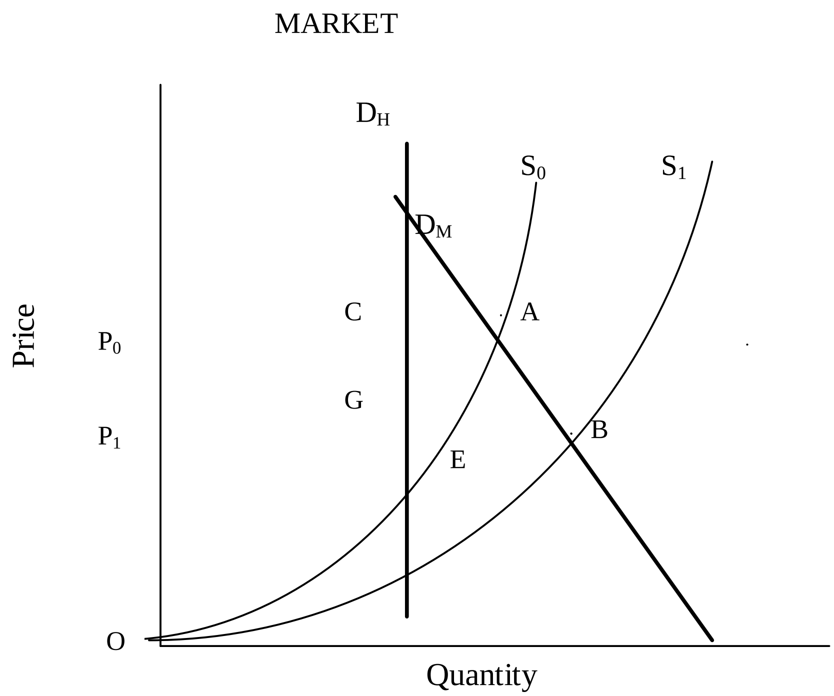
Technological Change with Semi-subsistence Agriculture

While the above theory implies that technological progress benefits mainly urban consumers at the expense of producers, the situation is significantly different when a portion of the commodity is consumed by the producer (Hayami and Ruttan, 1985). In a closed economy setting, a large proportion of the consumer surplus accrues to producers and partially or fully compensates for the loss in producer surplus from the treadmill effect. In Figure 2, D_h represents demand for home consumption by producers, D_M is the market demand, S_0 and S_1 are supply curves before and after technological change. With the shift in supply, consumers benefit from increased consumption and lower price from P_0

to P_1. Consumer surplus increases by the area defined by AP_0P_1B, of which ACGB accrues to non-producers and CP_0P_1G accrues to producers. Producer surplus changes from AP_0O to BP_1O. Although producer surplus can, in theory, increase, the more inelastic market demand is, the more producer surplus decreases. However, if the quantity of home consumption is large, the higher the consumer surplus accruing to producers. This model can also be extended to the case where producers are net buyers of the goods that they produce, in which case they benefit from increased consumer surplus.

In an open economy, in the case of export crops for which home consumption is small and the domestic demand is horizontal, the benefits of technical progress accrue entirely to producers. However, at the aggregate global level, the same technology treadmill comes into effect, eventually leading to consumers in importing countries gaining most of the benefits of lower international prices.

Figure 2. The impact of technological change on a subsistence crop



Source: Hayami and Herdt, 1977.

IV. Price Policy Options

As discussed above, aggregate supply increases are unsustainable with the effects of the agricultural treadmill in the long run. How can policy address the problem of the adverse price effects of technological change? In the context of American agriculture, Cochrane (1958) reviewed five policy options. These are: (1) the free market approach, which is based on no public stocks or price support; (2) the flexible price support approach, which is based on lowering relative prices of selected commodities; (3) the fixed price support approach, which is based on public stockholding to defend a support price; (4) the farm efficiency approach, which is based on promoting large scale efficient farming; and (5) the domestic consumption approach, which is based on raising effective demand domestically through nutritional transfer programs. Of these, he rejects the free market approach as undesirable from a social viewpoint and unviable for a responsible government. He also argues that approaches (2) to (4) suffer from the fallacy of composition problem, which largely negates their impact. The third approach, the fixed price support approach at 90 percent of parity is the best known of these approaches and the most simple. In Cochrane's view, it is the exact converse of the free market approach in that it solves the income problem of producers with no regard to the surplus problem that results. Thus, by itself, it is unviable in the long term. Cochrane considers the fifth approach as a supplement rather than a substitute for the other approaches. These policy options are framed within the context of a closed economy and fully commercialized agriculture.

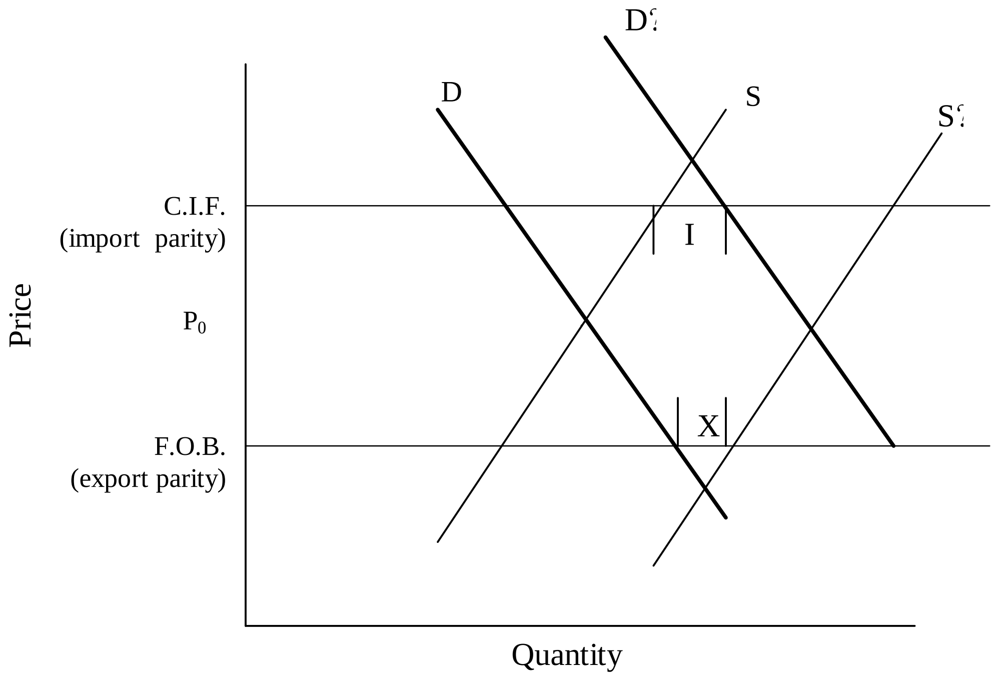
Price policy in an open economy

In a the context of a small open economy and conditions characterizing much of the developing world, an active debate over the past four decades has been centered on three perspectives: the free market school, the structuralist school, and the stabilization school (Timmer, 1989). The free market approach, which seems to have won in the eyes of donors and international agencies from the 1980s onward, argues that agricultural prices should reflect their opportunity costs at the border, regardless of the international processes that determine the prices and of the price levels (e.g., domestic farm support or export subsidy programs that stimulate excess demand in wealthy countries). This school, promoted by T.W. Schultz and others at the University of Chicago, argues this pricing strategy results in the optimal efficiency of resource allocation and minimal rent-seeking activity (Schultz, 1978). Border prices are thus the key intellectual foundation of this approach (Timmer, 1986; Little and Mirrlees, 1969).

The Border Price Paradigm

In forwarding the border price as the “right” price for an agricultural commodity, this paradigm supposes a world of full information, competitive markets, and devoid of political considerations for income distribution. Sources of complexities of pricing issues in reality are that (1) the underlying assumptions do not hold in even the best of circumstances; (2) political concerns for income distribution cannot be ignored; and (3) implementing price policy is a complex task, involving knowledge of international commodity trends, shadow price estimation, and foreign exchange rate considerations. An important caveat to the border price paradigm is that price interventions through border policies can only be implemented if food is tradable, that is, if trade can take place. The parity price band at port is the band between the F.O.B. and the C.I.F. prices. As one moves inland from port, the band expands with domestic marketing costs. If domestic prices are set within a wide parity price band, this implies that the transaction costs from the farmgate to the border are very high, in which case the commodity is likely non-tradable. A commodity is considered non-tradable when either imports or exports would require a subsidy. The width of the export-import parity price band can be influenced by changes in internal market conditions or by world price changes. Thus, commodities can switch from non-tradable to tradable through shifts in either demand or supply (Figure 3) or in the parity band itself, as by exchange rate devaluation (Barrett 1999b).

Figure 3. Switching from non-tradable to tradable commodities



Source: Timmer, 1986.

The Structuralist School

The structuralist school, which has been especially influential in Latin America, argues that the border price paradigm is misdirected for basic food products that have important roles in the macro economy and for consumer welfare. Advocates of this approach argue that, given the very small price elasticities of demand and of supply, allocative losses from misalignment of domestic and border prices are small and that the border prices are themselves influenced by distortionary agricultural policies pursued by countries with global market power. This school advocates setting prices according to income distribution objectives and macroeconomic stability (Taylor, 1980; Streeten, 1987; Lipton, 1977).

The Stabilization School

The stabilization school approach, embraced by many countries in East and Southeast Asia, openly rejects the free market approach for primary staples and favored government intervention to support and stabilize agricultural prices. At the same time, this school also rejects the structuralist approach of wide deviations from the border price, which can entail substantial fiscal costs. The stabilization school approach is based on the premise that, while following short-run international price movements leads to significant efficiency losses, not following long-term trends has equally significant losses. Thus, optimal efficiency is based on market intervention to stabilize short-run prices but allowing flexibility to allow domestic prices to follow long term international price trends (Timmer, 1986; Ellis, 1988). At the same time, this approach favors the development of competitive private marketing over time, so that the role of public intervention declines as price stability becomes less important over the course of economic development.

Indonesia's policy of stabilizing rice prices throughout the 1970s and early 1980s is a classic and well-documented example of the stabilization approach (Ellis, 1993; Falcon and Timmer, 1991; Pearson, 1991). Through a parastatal agency called the Badan Urusan Logistik (BULOG), Indonesia operated a buffer-stock scheme that procured rice locally in order to defend a floor producer price, and saims to soldell rice in the open market in order to defend a ceiling retail price. BULOG also had a monopoly on rice imports and imported rice to fill the gap between domestic supply and demand. In the mid- to 1980s, BULOG exported rice, as domestic supply, spurred by investments in irrigation, spread of green revolution technology and appropriate price incentives, now exceeded demand at the target prices for producers and consumers.

Over these decades, BULOG was remarkably successful in fostering intra-year and inter-year rice price stability. Four key elements of BULOG's success in stabilizing prices were (1) intervening in terms of purchases only at the margin of fluctuations in peak season volumes; (2) close monitoring of price trends and harvest predictions in areas where problems are likely; (3) relatively quick responses to changing local conditions; and (4) reliability and credibility of its purchase operations in defending a floor price (Ellis, 1993).

Yet, BULOG' operations on average were small relative to the size of the rice market: BULOG procured on average 6% of the domestic rice harvest, equivalent to 1.8 million tons in 1990. An abundance of competitively operating small private traders in the private sector was responsible for the remaining 94% of the rice market. Skillful setting of floor and ceiling prices that maintained incentives for private sector trade and storage were a major factor in enabling the private sector trade to develop. In addition, market capacity in Indonesia has been enhanced by years of public investment in market infrastructure, both in terms of transport as well as information and communications (Timmer, 1997).

In recent years, however, BULOG has faced severe financial crises, in part due to macro-economic instability involving massive depreciation of the Indonesia rupiah. While its level of operations is low compared to total output, BULOG owns and operates roughly 3.5 million tons of rice warehouse capacity. With high overhead costs, BULOG has not operated as a profitable enterprise, unable to cover its high per unit costs with trading margins from international rice trade and its peak season purchases and later sales.

Trade and Price Stabilization

Following broad trade liberalization in the 1990s in Bangladesh and neighboring India, Bangladesh has successfully used private sector trade to help stabilize rice and wheat prices following major production shortfalls, reducing need for large government stocks (Dorosh, 2001; Goletti, 1994). In both

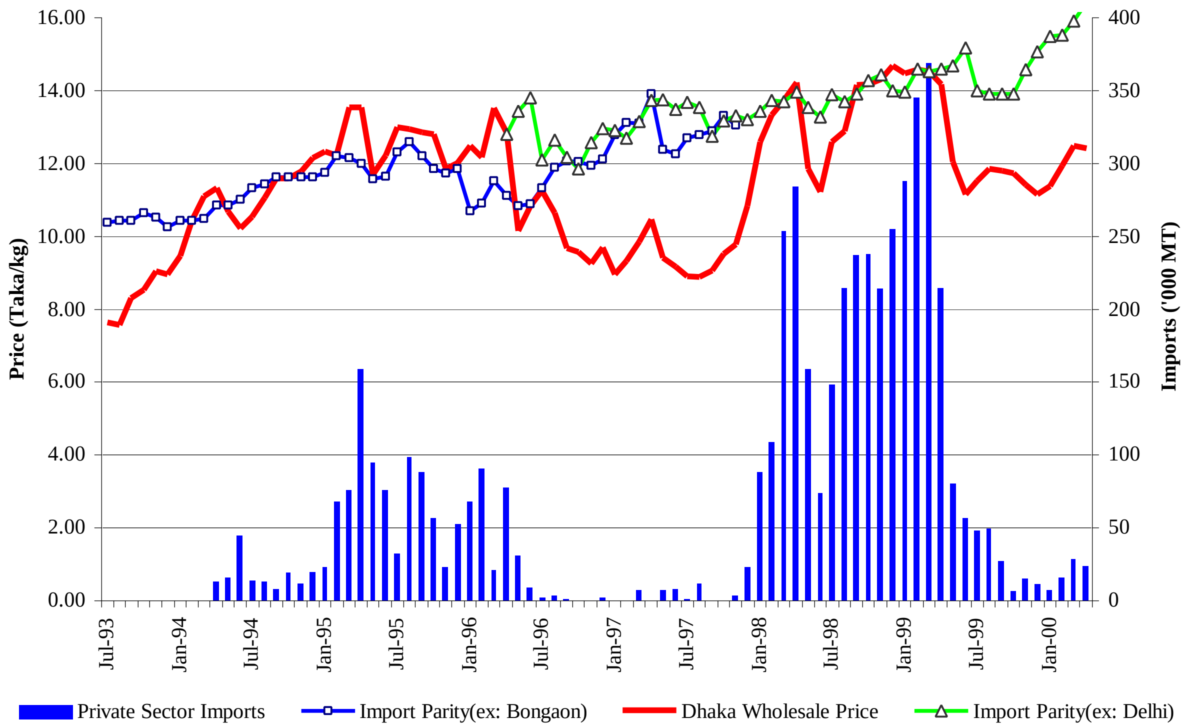
Bangladesh and India, food grain is typically procured at fixed prices through direct purchases of grain from farmers or traders. Until the early 1990s, subsidized sales of grain through ration programs were the major distribution channels in Bangladesh. As part of reforms undertaken in the early 1990s, however, major ration channels were shut down and by the late 1990s approximately 85 percent of public sector distribution was targeted to poor households through direct distribution channels such as Food for Work and Food for Education. Private imports of wheat and rice were also liberalized in the early 1990s. Then, in 1994, private food grain exports were liberalized in India as part of an ongoing broader macro-economic reform including exchange rate depreciation.

As a result of the liberalization of the Bangladesh import trade and India export trade, India replaced Thailand as the main source of Bangladesh rice imports due to lower transport costs and quicker delivery to Bangladesh. Following several large domestic shortfalls of rice, domestic rice prices in Bangladesh rose to import parity levels, providing incentives for private sector imports. Thus, private imports surged in years of large domestic shortfalls and fell to zero in normal production years when domestic prices fell below import parity (Figure 4).

Private sector imports were especially important for national food security following the floods of 1998, which destroyed more than 20 percent of the monsoon season rice crop (about 10 percent annual production). Following the flood, the government of Bangladesh adopted the cautious strategy of moderate government imports to supply government distribution channels while actively encouraging private sector imports through a policy of zero tariffs and other measures. By following this trade-oriented stabilization strategy, Bangladesh was able to increase domestic supplies quickly and successfully stabilize prices (Dorosh, 2001).

Several conditions led to the success of this strategy. First, India had sufficiently good harvests at a lower cost and the policy climate that encouraged private exports. Second, private sector trade in Bangladesh was competitive, involving hundreds of small traders importing small quantities of rice. Third, the government had clear political will to encourage private import trade through removing tariffs and surcharge and pushing customs officials to expedite imports of rice. Fourth, Bangladesh had sufficiently large foreign exchange reserves to pay for rice imports (see del Ninno et. al. 2001).

Figure 4—Rice prices and quantity of private rice imports in Bangladesh, 1993-2000



Source: Dorosh, 2001

Food Aid and Price Effects

Food aid has been an important component of food policy in many low-income, food-deficit countries for the past five decades. On average, global food aid deliveries have averaged 10 million tons per annum in recent years, although food aid peaked at 15 million tons in 1992-1993, fell to only 5.6 million tons in 1996-97, and then rose again to 15 million tons by 2000. The geographical focus of food aid shifted from the 1970s to the 1990s from South Asia toward Africa and the former Soviet Union, as South Asia has benefited from the Green

Revolution and progressed toward self-sufficiency (Barrett 2002a). During the 1990s, Bangladesh remained the largest recipient, receiving 7.2 percent of total food aid, followed by Ethiopia (6.2 percent), Egypt (3.8 percent), and Mozambique (3.2 percent) (Dorosh, 2002).

The empirical evidence on a global scale shows that private food trade stabilizes food availability in low- and middle-income countries far more effectively than food aid does (Barrett 2001). There is some difference in performance across food aid suppliers. In particular, food aid shipments from the World Food Programme exhibit a very modest stabilizing effect (Barrett and Heisey 2001). By contrast, Barrett (2001) finds no evidence that U.S. PL480 food aid distributions stabilize food availability in recipient countries; if anything PL480 food aid destabilizes per capita food availability in recipient economies.

Food aid's efficacy depends fundamentally on how extensive the need for food is within a recipient country and how effectively food aid reaches those in need. Food aid that reaches needy populations having an income elasticity of demand for food near one stimulates local food demand at nearly the same rate it increases local food supply. But as fewer people need less food to satisfy nutritional requirements, effective targeting of food aid becomes more problematic and the consequences of food aid for domestic producers and marketing channels grow more severe. Despite the continued presence of needy populations unable to afford sufficient quantities of food for good nutrition, there comes a time when inflows of food aid begin to have adverse incentive effects of producers and traders in recipient country markets by expanding supply faster than demand.

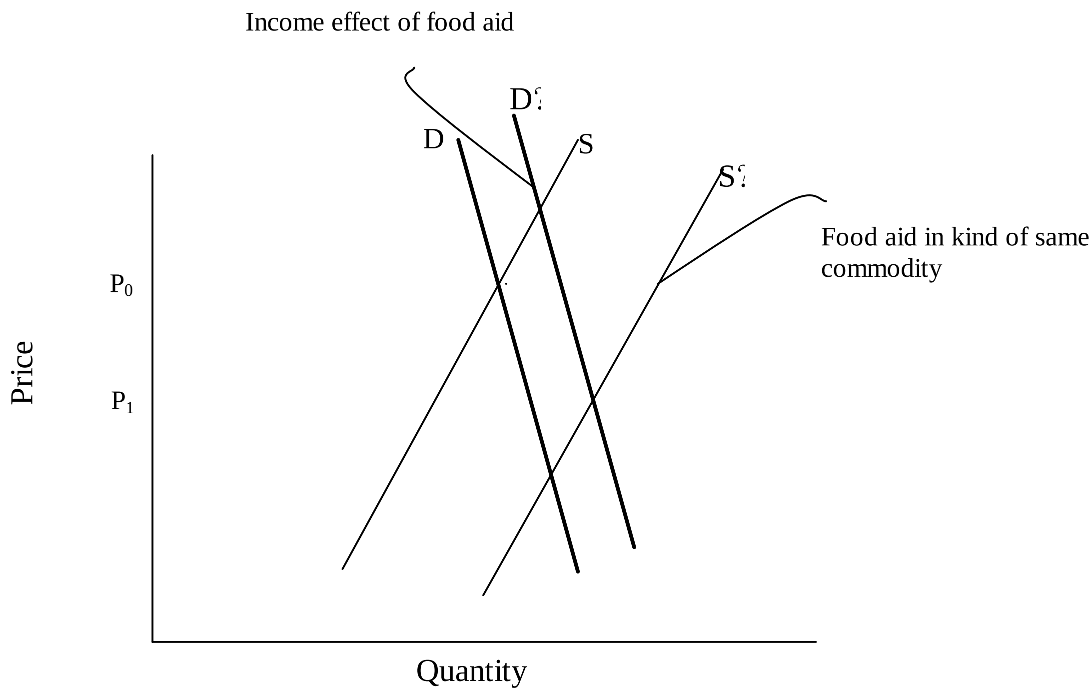
The point at which food aid's adverse effects begin to become significant depends on several factors. One important consideration is the efficacy of the targeting of the food aid transfer. Consider first the impact of food aid on the domestic market for the same commodity, e.g. impact of food aid wheat on the wheat market of Bangladesh. The distributed food aid, whether monetized (i.e., sold directly into the commercial marketing channel) or distributed directly to beneficiary households or individuals, adds to total supply of wheat in the economy, shifting the supply curve in Figure 5 from S to S'. A transfer of food in kind to a household (or a cash transfer funded by the monetization of food aid) adds to household resources, tending to increase demand for the food aid commodity (unless it is an inferior good). The magnitude of the increase in demand depends on who receives the food aid transfer. Since the income elasticity of demand for food falls as income rises and is higher for income received in the form of food than as cash, and since women tend to spend a larger share of an extra dollar's income on food than men do, food aid distributed in kind to the poor and to women tends to have a greater demand-side effect than food aid distributed to wealthier or male recipients. In general, the increase in demand is less than the size of the food aid transfer,[1] so even well-targeted food aid distributions tend to shift the demand curve to the right from D to D' in

[1] Empirical estimates of the marginal propensity to consume wheat out of a wheat transfer in Bangladesh are about 0.3 (del Ninno and Dorosh, 2002).

Figure 5 by less than the amount of the food aid. As a result, prices fall.[2] The more poorly food aid is targeted, the more severe the adverse price effects of food aid distribution. Since even programs intended to reach the truly needy and thereby increase food demand – such as food for work schemes – routinely suffer targeting errors (Barrett and Clay 2002, Barrett, Holden and Clay forthcoming), and since even a perfectly targeted transfer program cannot overcome Engel's Law, which stipulates that food's share of total expenditures is always less than one and falling as income grows, the demand-side effects of food aid are unlikely to offset completely the supply shifter effect of inflows of food aid (Dorosh and Haggblade, 1997).

[2] Note that these results are for a closed economy or a situation where the food aid commodity is not traded internationally by the private sector because the import parity price is higher and the export parity price is lower than domestic prices.

Figure 5. Price Effects of Food Aid in Kind of Same Commodity

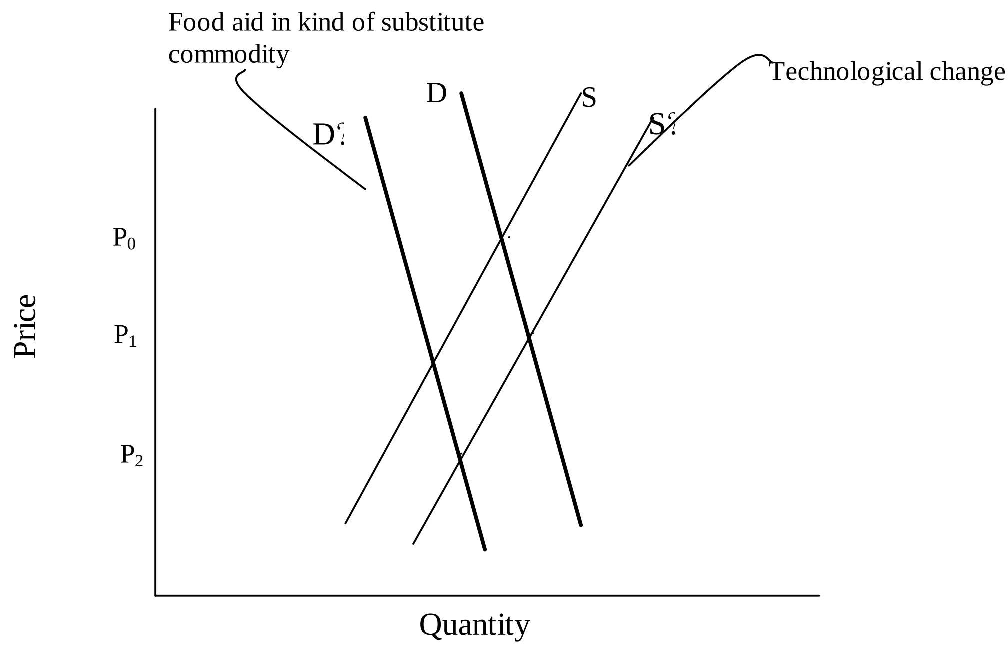


A second issue is the substitutability between major domestic food staples and the commodities imported as food aid. The effects of food aid on other commodities involves no direct supply effects, just demand-side effects. As a consequence, the cross-price effects of food aid (i.e., the effects of food aid received as one commodity on the price of another commodity) are more ambiguous than the own-price effects. Food aid transfers (or cash transfers financed by the monetization of food aid), tends to decrease the demand for substitute commodities (e.g., of rice in the case of wheat food aid), although there are a few foods that are complements for which the cross-price substitution effects can be positive (e.g., of yeast for breadmaking in the case of wheat food aid). The transfer also, however, has the earlier-discussed income effects, which tend to increase the demand for both substitute and complementary foods. The net cross-price effect of food aid therefore depends on the relative magnitudes of the (generally negative) substitution and (generally positive) income effects. That is, if maize production grows domestically while at the same time, maize is also imported as food aid, food aid acts as an additional supply shifter of maize. To the extent that the maize food aid results in a transfer of in-kind or monetary resources to households, maize demand may increase as well, but generally not by as much as maize supply. As a consequence, the maize price will fall.

If, as in the case of Ethiopia, wheat, rather than maize is imported as food aid, demand for maize may fall as wheat prices fall and consumers shift some of their maize demand to wheat. As shown in Figure 6, even in the absence of food aid, the increase in domestic production due to technical change would result in a fall in maize prices from P_0 to P_1 as the supply curve shifts from S to S'. Wheat food aid can exacerbate the fall in maize prices, however, by reducing the demand for maize (shifting the demand curve from D to D'), and lowering the maize price even further to P_2.

The end result is that food aid usually exerts downward pressure on food prices, with that pressure greatest in places where targeting is poor and with respect to commodities received as food aid. The South Asian experience nonetheless demonstrates that, with appropriate government policies, the effects of rapid technological change in agriculture can enable countries to expand food production even in the face of substantial inflows of food aid and their attendant adverse producer price incentive effects (Shaw and Clay, 1993).

Figure 6. Price effects of food aid in kind of substitute commodity



V. AGRICULTURAL GROWTH IN ASIA

From a relatively desperate situation in the early 1960s, where populations were growing rapidly, productivity was low and stagnant, and agriculture was the primary source of income and employment, Asian economies have undergone a dramatic transformation over the past 30 years. Not only was famine averted in South Asia, but foodgrain production rose 92 percent while using only 4 percent more land from the 1970s to the 1990s. In East and Southeast Asia, cereal production nearly doubled in the same period, while using 22 percent more land. As a result, per capita calorie availability has risen from roughly 2,000 calories per day to 2,400 calories and 2,700 calories per day in South Asia and East and Southeast Asia, respectively; real per capita income has risen multiple-fold in China and Indonesia and doubled elsewhere; and the incidence of poverty has fallen from 60 percent to 20 percent in the period from 1975 to 1995 (Rosegrant and Hazell, 2000). While the relative contributions of technical progress, factor accumulation, and government policies are being debated among economists (Krugman, 1994; Young, 1995; Kim and Lau, 1994), some agreement is emerging that factor accumulation was the main source of growth in East and Southeast Asian economies, while total factor productivity growth has been a moderate contributor to growth.

Table 1. GDP per capita, (constant 1987 US dollars)

Year	1970	1995	1967-80	1980-89	1989-95	1980-95
Bangladesh	162	204	-0.50	2.02	2.74	2.31
The PRC	91	473	5.18	8.25	9.59	8.79
India	241	439	1.34	3.61	3.39	3.52
Indonesia	207	706	4.98	4.05	6.28	4.93
Korea, Rep.	967	5,665	8.01	7.46	6.59	7.11
Malaysia	1,001	3,111	4.82	2.79	6.22	4.15
Myanmar*	1,332	1,949	2.36	-0.94	3.71	0.90
Nepal	158	208	-0.02	1.68	2.37	1.96
Pakistan	206	366	2.59	3.03	1.91	2.58
Philippines	495	636	2.70	-0.85	0.37	-0.37
Sri Lanka	247	517	2.95	2.89	3.41	3.09
Thailand	487	1,853	4.32	5.58	7.76	6.45
Viet Nam	..	812	..	..	5.64	..

Note: For Myanmar, constant GDP values are only given in the local currency unit.
Source: Rosegrant and Hazell, 2000.

The Asian Agricultural Transformation

Growth rates in agricultural production have been impressive, though slowing down in recent years, due to high existing input levels and diminishing marginal increases in yield. Within the region, the People's Republic of China had the highest rate of growth, with 4.4 percent annual growth on average between 1957 and 1995, followed by Malaysia (4.3 percent) and Indonesia (4.1 percent). Bangladesh and Sri Lanka had the lowest rates of growth, with 1.6 percent and 1.5 percent growth, respectively (Table 2).

Table 2. Growth in Net Agricultural Production (international 89-91 dollars)

Period	1967-82	1982-95	1982-89	1989-95	1967-95
			(percent per year)		
Bangladesh	1.44	1.83	2.17	1.43	1.62
China	3.43	5.45	4.95	6.04	4.36
India	2.98	3.39	3.68	3.06	3.17
Indonesia	3.95	4.19	4.91	3.37	4.06
Korea Rep	4.17	2.64	2.86	2.38	3.46
Malaysia	4.61	3.97	4.70	3.14	4.31
Myanmar	4.26	1.98	-0.04	4.39	3.20
Nepal	2.36	3.35	4.41	2.14	2.82
Pakistan	3.26	4.61	4.95	4.22	3.89
Philippines	3.79	2.20	1.41	3.12	3.05
Sri Lanka	2.12	0.85	0.03	1.82	1.53
Thailand	4.12	2.15	2.31	1.96	3.20
Vietnam	3.27	4.61	4.18	5.12	3.89
AVERAGE	3.32	4.36	4.18	4.57	3.80
World	2.29	2.15	2.35	1.93	2.22

Note: Net Agricultural Production is gross production minus feed and seed. Growth rates are 3-year centered moving averages.
Source: Rosegrant and Hazell, 2000.

Trends in Input Use

In terms of input use, agricultural growth in Asia has not been greatly influenced by area expansion, with the exceptions of Malaysia, Nepal, and Thailand (Hayami and Ruttan, 1985). Growth in area was negative (area contraction) in Bangladesh, Korea, and Myanmar and very small in India, implying a greater reliance on improving land productivity to achieve growth in output (Table 3). With the exception of Malaysia, the agricultural labor force grew more rapidly than area in all countries. Thus land-to-labor ratios declined from 0.57 hectares per worker in 1970 to 0.45 hectares in 1995 (Table 4).

Table 3. Agricultural Land Use in Asia

Year/Period	1970	1995	1967-82	1982-95	1982-89	1989-95	1967-95
	(1000 hectares)		*(percent per year)*				
Bangladesh	9,097	8,800	0.05	-0.29	0.66	-1.39	-0.11
China	102,505	134,693	0.03	1.98	3.29	0.47	0.93
India	165,060	169,700	0.19	0.05	0.07	0.03	0.13
Indonesia	26,000	30,180	0.00	1.22	2.78	-0.57	0.57
Korea Rep	2,298	1,985	-0.38	-0.70	-0.36	-1.10	-0.53
Malaysia	4,430	7,604	1.03	3.29	4.07	2.39	2.07
Myanmar	10,430	10,110	-0.21	0.03	-0.05	0.12	-0.10
Nepal	1,980	2,968	1.56	1.72	0.16	3.58	1.63
Pakistan	19,332	21,600	0.33	0.44	0.61	0.24	0.38
Philippines	6,952	9,520	1.72	0.53	0.40	0.68	1.17
Sri Lanka	1,894	1,886	-0.05	0.10	0.29	-0.13	0.02
Thailand	13,808	20,445	2.52	0.57	1.15	-0.11	1.61
Vietnam	6,145	6,757	0.54	0.20	-0.44	0.96	0.38
TOTAL	369,931	426,248	0.28	0.80	1.34	0.18	0.52

Note: Land use includes the FAO categories 'arable area' and 'permanent crops'. Growth rates are 3-year centered moving averages.
Source: Rosegrant and Hazell, 2000.

Table 4. Land to Labor Ratio and Growth in Economic Actively Population in Agriculture

Year/Period	1970	1995	1967-82	1982-95	1982-89	1989-95	1967-95
					(percent per year)		
Bangladesh	0.33	0.25	1.07	1.03	0.87	1.22	1.05
China	0.31	0.27	1.92	1.39	1.99	0.70	1.67
India	0.94	0.68	1.59	1.21	1.03	1.42	1.41
Indonesia	0.86	0.64	1.41	2.01	2.52	1.42	1.69
Korea Rep	0.41	0.68	-0.07	-4.64	-4.87	-4.37	-2.22
Malaysia	2.21	4.14	0.57	-1.13	-1.22	-1.03	-0.23
Myanmar	0.97	0.60	1.93	1.76	1.84	1.66	1.85
Nepal	0.36	0.32	1.82	2.34	2.16	2.56	2.06
Pakistan	1.32	0.88	2.41	1.72	1.46	2.02	2.09
Philippines	0.86	0.80	1.90	1.23	1.24	1.21	1.59
Sri Lanka	0.79	0.53	1.69	1.44	1.58	1.28	1.57
Thailand	1.00	0.99	2.17	1.10	1.61	0.51	1.67
Vietnam	0.39	0.26	1.58	2.19	2.56	1.77	1.86
AVERAGE	0.57	0.45	1.76	1.36	1.66	1.02	1.57

Note: Growth rates are 3-year centered moving averages.
Source: Rosegrant and Hazell, 2000.

In contrast to land expansion, irrigation has played a major role in agriculture in Asia. While the average area under irrigation is around 30% for seven Asian countries, Pakistan and Korea had very high shares of 80 percent and 61 percent, respectively, in 1995. The average annual rate of growth in irrigated area in Asia was 1.8 percent from 1967 to 1995. However, growth has varied between countries, with very high growth in South Asia, compared to Indonesia and Malaysia (Table 5).

Table 5. Irrigated Area as a Percentage of Agricultural Area and Growth in Irrigated Area

Year/Period	1970	1995	1967-82	1982-95	1982-89	1989-95	1967-95
	(percent)		*(percent per year)*				
Bangladesh	11.63	37.56	4.95	5.39	6.35	4.29	5.16
China	37.18	37.02	1.59	0.79	0.36	1.28	1.22
India	18.44	31.82	2.64	2.42	1.55	3.44	2.54
Indonesia	15.00	15.18	0.65	0.49	0.22	0.80	0.58
Korea, Rep.	51.52	60.76	0.73	-0.65	0.43	-1.89	0.09
Malaysia	5.91	4.47	2.34	0.22	0.19	0.26	1.35
Myanmar	8.04	15.38	1.87	3.37	-0.50	8.08	2.56
Nepal	5.91	29.82	12.55	2.67	5.51	-0.54	7.85
Pakistan	66.99	79.63	1.39	0.89	0.97	0.79	1.16
Philippines	11.88	16.60	3.80	1.33	2.08	0.46	2.65
Sri Lanka	24.55	29.16	1.91	0.21	0.01	0.45	1.12
Thailand	14.19	22.70	4.23	2.78	3.31	2.17	3.55
Vietnam	15.95	29.60	3.71	1.29	1.11	1.49	2.58
TOTAL	25.17	33.24	2.05	1.56	1.10	2.10	1.82

Note: Growth rates are 3-year centered moving averages.
Source: Rosegrant and Hazell, 2000.

The most striking trend in input use in this period, however, is the dramatic increase in the use of both chemical fertilizers and agricultural machinery, leading to significant increases in productivity. In 1970, the average farm applied 24 kg of fertilizer per hectare, less than half of the world average. In 1995, the application rate was 171 kg per hectare comparable to that of the United States (Table 6). There is considerable variation among countries, some exhibiting exceedingly high application rates, such as Korea (with five times the rate of industrialized countries) and China, with 346 kg per hectare in 1995. Growth in fertilizer application was highest in the 1960s and 1970s at the onset and takeoff of the Green Revolution (Rosegrant and Hazell, 2000). Growth rates were highest in Viet Nam, with 16% annual growth. In this period, national policies to promote fertilize use by farmers were particularly important.

Table 6. Fertilizer Application per Unit of Land, and Growth in Application

Year/Period	1970	1995	1967-82	1982-95	1982-89	1989-95	1967-95
	(kg/hectare)		*(percent per year)*				
Bangladesh	15.7	135.5	11.41	7.46	8.30	6.48	9.56
China	43	346.1	11.93	7.37	6.70	8.16	9.79
India	13.7	81.9	10.49	5.70	8.19	2.86	8.24
Indonesia	9.2	84.7	15.14	2.92	3.89	1.79	9.29
Korea Rep	251.7	486.7	3.16	3.12	4.30	1.76	3.14
Malaysia	43.6	148.6	8.51	3.82	4.40	3.15	6.30
Myanmar	2.1	16.9	14.69	0.19	-7.59	10.09	7.71
Nepal	2.7	31.6	14.90	7.26	11.23	2.81	11.29
Pakistan	14.6	116.1	12.84	4.98	5.98	3.83	9.12
Philippines	28.9	63.4	5.17	4.10	6.40	1.47	4.67
Sri Lanka	55.5	106	2.32	2.01	3.01	0.86	2.18
Thailand	5.9	76.5	7.43	10.41	11.23	9.46	8.80
Vietnam	50.7	214.3	7.28	12.95	10.52	15.85	9.87
AVERAGE	23.9	171.1	10.75	5.92	5.75	6.11	8.48
World	59.7	102.2	4.29	0.47	1.47	-0.69	2.50

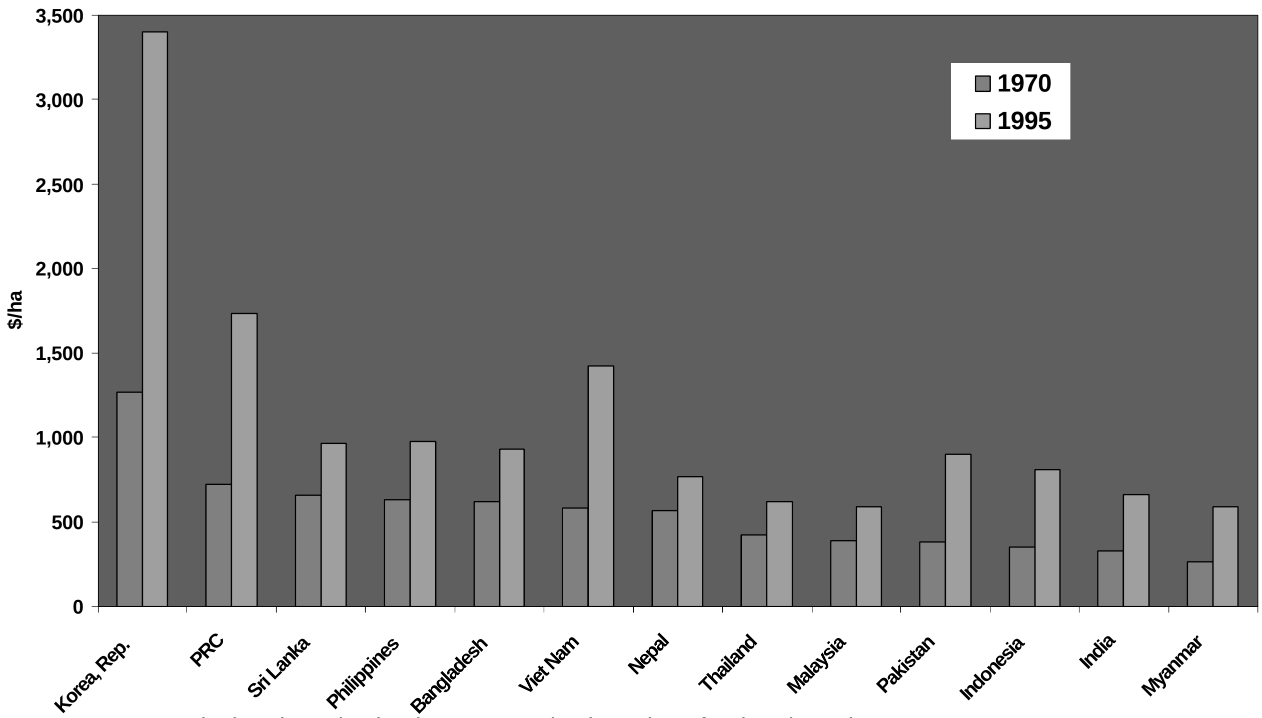
Note: Fertilizer includes Nitrogenous, Phosphate, and Potash fertilizers. Land is measured as arable land plus permanent crops. Growth rates are 3-year centered moving averages.
Source: Rosegrant and Hazell, 2000.

Agricultural mechanization also played a key role in the agricultural transformation of Asia. Over the period from 1967 to 1995, the growth rate in the number of tractors per agricultural worker was 7.5 percent, with the most rapid growth at 11.1 percent during the height of the Green Revolution.

Land and Labor Productivity Growth

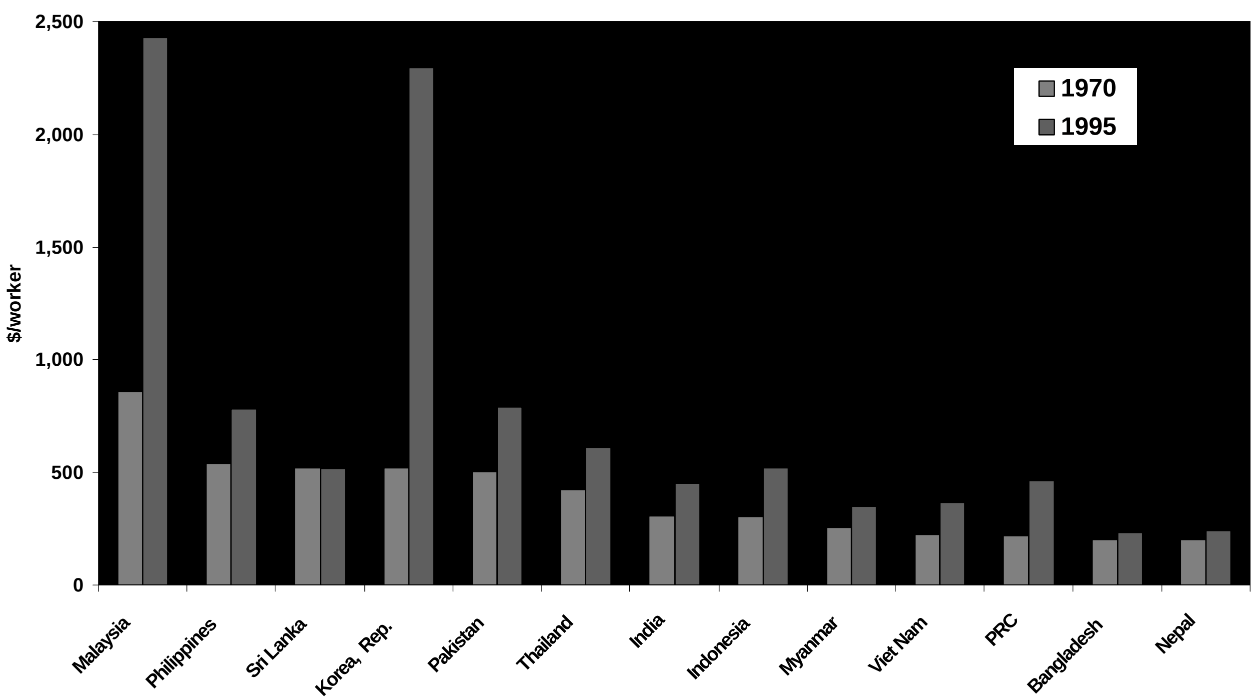
Two partial productivity measures, output per unit of labor and output per unit of land, are used to illustrate the variation in the relationship between factor endowments and output. There is a close association between land productivity and use of biological technology and labor abundance relative to land and the use of mechanical technology (Hayami and Ruttan, 1985). Land productivity, measured as the value of aggregate output per hectare, increased by 3.3 percent per year from 1967 to 1995, although there were large variations among countries (Figure 6). During the same period, labor productivity, defined as the value of aggregate worker per worker, increased by 2.2 percent annually. Slower growth of labor productivity is an indication that Asian economies adopted land-saving, labor-using, technologies (Rosegrant and Hazell, 2000; Hayami and Ruttan, 1985; Timmer, 1988). There is also a significant difference in labor productivity growth between East Asia and South Asia, with a clear trend of higher growth in East Asia over the past thirty years (Figure 7).

Figure 6. Land Productivity in Asian Agriculture (International 89-91 $/Hectare)



Note: Net Agricultural Production is gross production minus feed and seed.
Source: Rosegrant and Hazell, 2000.

Figure 7. Labor Productivity in Asian Agriculture (International 89-91 $/Worker)



Source: Rosegrant and Hazell, 2000.

Labor productivity can be partitioned into the land-labor ratio (A/L) and land productivity (Y/A), according to the following identity:

$$Y/L \quad ? \quad (A/L) \times (Y/A) \qquad (1)$$

In the case of Taiwan, the annual rate of increase in agricultural labor productivity of 3.3% between 1952 and 1966 was nearly three times higher than the 1.2% rate during the period 1901-50 (Table 6). Thus, during the half-century ending in 1950, yield increases were twice as important as increases in area cultivated per worker. Between 1952 and 1966, extraordinary yield increases made possible a substantial increase in labor productivity despite a decline of more than 25% in the cultivated area available per worker.

Table 7. Annual Rates of Change in Agricultural Labor Productivity in Taiwan

Period	Output per Male Worker *Y/L*	Area cultivated per worker *A/L*	Yield per hectare cultivated *Y/A*
1901-50	1.2	0.4	0.8
1952-66	3.3	-0.8	4.1

Source: Tomich, Kilby, Johnston,1995

In T. H. Lee's classic analysis of the components of Taiwan's agricultural progress between 1911-15 and 1956-60, he notes that underemployment in agriculture was substantially reduced in spite of the fact that the 49% increase in the size of the farm labor force was nearly twice as large as the 27% increase in the cultivated land area over that 45-year period. The expansion and improvements in irrigation enabled a 96% increase in the cropped area, as a result of increased multiple cropping. This increase was much larger than the 27% increase in cultivated land area. Similarly, an increase of labor inputs of 98% in working days was almost identical to the 96% increase in cropped area. Thus, Taiwan's impressive increases in farm labor productivity were made possible by fuller as well as more efficient utilization of the available farm workforce. Total farm output increased 3.4 times between 1911-15 and 1956-60, reflecting increases in output per cropped acre as well as the increases in cropping intensity. A five-fold increase in use of divisible current inputs, including a 13-fold increase in fertilizer consumption, accounted for almost all the increase in purchased inputs associated with the 3.4-fold expansion of farm output (Lee, 1971).

What has driven factor productivity growth? Public investment, particularly for agricultural research, has been a key driving force. Public expenditures on agriculture increased by 4.6 percent per year on average, with wide variations among countries (Table 8). Viewing the share of public expenditure in agricultural GDP as a sign of public commitment to agriculture, this ratio rose from 7 percent in 1972 to a peak of 9 percent in 1993, declining to 8 percent in 1993 (Fan and Pardey, 1998). Decomposition analysis of total factor productivity (TFP) growth reveals that in India, research and extension and private innovations have been the most important sources of productivity growth. Investment in roads and irrigation have likely had a significant and positive impact (Fan, Hazell, and Thorat, 1998). In Pakistan, the highest impact on productivity growth has come from research, share of modern varieties, rural literacy, and the share of irrigation (Rosegrant and Evenson, 1993).

Significant public expenditures have been spent on subsidies as well as on research and infrastructure investments. Input subsidies account for 20 to 60 percent of total spending on agriculture in Asia. In Indonesia, the total fiscal costs of subsidies both for farmers as well as domestic fertilizer industry amounted to nearly one-sixth of government spending on agriculture and irrigation in 1986-87. Similarly, fertilizer subsidies in Bangladesh in 1983-84 accounted for 14 percent of agricultural spending (Rosegrant and Hazell, 2000).

Table 8: Government Expenditures on Agriculture in Asian Countries, 1985 US $ (purchasing power parity)

Year	1972	1975	1980	1985	1990	1993	1972-79	1980-89	1990-93	1972-93
	(million dollar)						*(percent per year)*			
Bangladesh	2,358	528	1,187	1,749	1,269	1,773	-3.56	-1.30	11.81	1.29
China	11,595	17,843	24,542	21,113	28,229	31,061	14.20	1.16	3.24	4.80
India	15,491	13,680	22,877	30,549	39,109	35,918	6.18	5.46	-2.80	4.09
Indonesia	1,436	3,020	5,026	4,351	6,157	5,958	15.68	1.36	-1.09	7.01
Korea Rep	537	993	1,129	2,244	4,332	4,160	21.48	15.03	-1.34	10.24
Malaysia	348	458	1,264	1,851	1,830	1,693	11.43	3.00	-2.57	7.83
Myanmar	272	219	655	874	296	181	8.53	-8.13	-15.22	-1.93
Nepal	107	136	257	541	254	359	15.15	1.79	12.24	5.96
Pakistan	740	1,031	1,168	971	1,312	1,669	2.96	1.97	8.36	3.95
Philippines	416	1,145	729	604	1,409	1,694	12.68	7.19	6.32	6.92
Sri Lanka	627	449	589	2,124	614	596	-2.83	4.02	-0.97	-0.24
Thailand	902	767	1,850	3,181	3,190	4,513	8.26	3.54	12.26	7.97
AVERAGE	34,828	40,269	61,273	70,151	88,001	89,574	9.46	3.46	0.59	4.60

Note: Government expenditures in PPP US dollars was calculated in two steps: Government expenditures in constant (1985) local currency for each year was calculated, and then 1985 PPP exchange rates were used to convert local currency to PPP US dollars.

Source: Fan and Pardey 1998

Lessons from the Asian rural development experience

The Chinese Rural Development Miracle: 1979-84

Starting in 1979, the People's Republic of China instituted major reforms of its agricultural sector: dismantling the commune system, granting farmer decision-making power, introducing the contract responsibility system, and raising producer prices. In the period from 1979 to 1984, the value of agricultural output rose by 9 percent annually, per capita grain production rose from 319 kg to 395 kg and the supply of farm products rose by 24 percent (Du, 1987). At the same time, opening up previously restricted labor markets allowed the surplus labor in agriculture created by productivity increases to enter the rural non-farm labor force and thus support the expansion of rural industry in China. Thus, over this period, an increasing number of farmers transferred out of agriculture into secondary and tertiary industries. These newly emerging township enterprises accounted for 32 percent of the national industrial output in 1986 and employed 70 million farmers, equaling 62% of urban employees.

A key lesson is that with technological change increasing output per worker, rural incomes were raised through changing the employment structure and encouraging the outflow of workers from agriculture into the rural non-farm economy. In turn, the demand linkages of increased rural incomes supported urban industrial development.

The Taiwanese Transformation: 1952-1987

The earlier experience of structural transformation in Taiwan is perhaps one of the most dramatic and illustrative examples of rapid rural development (Mellor, 1986). In the period from 1952 to 1980, Taiwan made very impressive gains in transforming its economy from a primarily agrarian-based to a diversified economy. As shown in Table 9, the relative share of agriculture in domestic output declined from 38% in 1953 to 6% in 1987. Similarly, the share of agricultural labor declined from 56% in 1953 to 15% in 1987 and per capita income increased almost eight-fold in constant prices.

The real net domestic product of agriculture increased by about 80% during the 1952-64 period, at an average annual rate of 5%, even as the share of agriculture in net domestic product declined from 36% to 28% (Kuo et al, 1981). Because the agricultural population only increased by one-third over the whole period, the 5% annual growth in agricultural output assured a net agricultural surplus and enabled structural transformation to proceed rapidly.

Table 9. Changes in the Economic Structure of Taiwan, 1953-1987

	1953	1970	1987
Production Structure (NDP) (%)			
Agriculture	38.4	18.0	6.3
Industry	17.7	34.5	47.5
Services	43.9	47.5	48.2
Labor Structure (%)			
Agriculture	55.6	36.7	15.3
Industry	17.6	28.0	42.7
Services	26.8	35.3	42.0
Per capita national income			
NT$ at 1981 prices	17,863	45,081	142,733
US$ at current prices	159	360	4,630

Source: Taiwan Statistical Data Book 1988 in Mao, 1992

How did Taiwan achieve these gains? The transformation of agriculture into a source of economic surplus was achieved primarily through the result of increased yields of traditional crops and the introduction of new crops. Fixed capital expanded by 34%, mainly irrigation and flood control facilities, working capital increased by 140%, and fertilizer use grew by 91% (Table 10).

In the same period, Taiwan's industrial sector grew at an average annual rate of 11%, relative to the 7% growth of net domestic product. By 1964, the net domestic product was 250% higher than in 1952, and the share of industry in total NDP increased from 18% to 28% (Kuo et al, 1981). This industrial growth is attributed to the emergence of a manufacturing subsector, which was highly concentrated in food processing and textiles, and other light manufactures. Taiwan's rapid structural transformation is due to the combination of increased agricultural productivity, rapid growth of rural non-farm employment in small and medium enterprises, and increased agricultural commercialization primarily to Japan, alongside its dramatic decline in fertility in the same period (Gabre-Madhin and Johnston, 2002).

Table 10. Agricultural Employment, Production, and Development in Taiwan, 1952-1964

	1952	1956	1960	1964
Indices:				
Agricultural population	100.0	110.4	126.2	132.7
Agricultural employment	100.0	100.1	104.7	112.2
Total agricultural production	100.0	121.0	142.8	178.7
Agricultural crop production per worker	100.0	115.4	126.1	142.4
Fixed capital	100.0	107.5	116.6	133.6
Working capital	100.0	151.5	169.7	240.2
Multiple cropping	171.9	175.5	183.6	188.0
Diversification	3.54	4.07	4.01	5.75

Source: Kuo, Ranis, and Fei, 1981.

Government-led Agricultural Modernization in Korea: 1961-1986

Over the 1961 to 1986 period, the agricultural sector at an average rate of 3.3 percent per year while real GNP grew by 8.4 percent, thus reducing the share of agriculture in GNP from 40 percent to 13 percent. In this period, the agricultural labor force decreased by 6 million and the number of farm households has declined by 18 percent while average farm income rose from US $ 466 in 1961 to US $6,813 in 1986 (Kim, 1987). Korean agriculture has become more diversified, shifting from cereals to fruits and vegetable and livestock. Korea's integrated strategy for the Green Revolution involved establishing a nationwide campaign to disseminate high yield varieties among rice farmers in 1972, dramatically increasing the acreage of the new variety (IR-667 or Tongil) from 2,750 hectares in 1971 to 929,000 hectares in 1978. The widespread adoption of new varieties and heavy fertilizer use came about as a result of pervasive government intervention in the form of technical assistance as well as economic incentives such as favorable purchase prices, national yield contests, and guaranteed income arrangements.

Korea's agricultural price policy in the earlier period from the 1950s consisted of maintaining low prices to avoid inflation. However, this policy discouraged agricultural production and, in view of this, the government raised its purchase price by 17% in 1968. In this period, producers could sell to the private market as well as through government channels. In addition, in 1966, the government established a price stabilization fund to smooth price fluctuations, particularly for cash crops.

From Famine to Food Self-Sufficiency in India: 1967-1986

Indian agricultural production nearly doubled in a period of two decades, achieved through impressive gains in yields per hectare. At the same time, there was no remarkable improvement in the living standards of the rural poor and its agricultural transformation has not resulted in the reduction of poverty (Vyas, 1986). In the period from 1967 to 1986, agricultural output grew annually by 2.7 percent, outpacing the population growth rate of 2.24 percent. During this period, land area increased by only 0.4 percent per year, while yields per hectare increased by 2.0 percent, leading to significant impact of productivity gains. The strategy of grain production was centered on modern, high-yielding, varieties of wheat and rice, released on a large scale in 1967. By 1981/82, nearly 75 percent of area planted of wheat and 50 percent of rice planted was modern varieties. In order to achieve and maintain the momentum of the significant yield gains brought about in this period, the government managed the difficult task of delivering modern inputs to millions of small farmers, establishing massive extension services, and strengthening credit and marketing institutions (Vyas, 1987). Three factors were critical in maintaining the momentum of the Green Revolution: (1) expansion of area under irrigation; (2) continuous adaptation and release of new varieties; and (3) provision of fertilizers and other inputs.

Price policy played a major role in spreading the Green Revolution through ensuring stable and remunerative prices for crops with the potential for yield gains through technological advances. The Food Corporation of India (FCI), established in 1964, operated a public food distribution system. An autonomous entity called the Agricultural Price Commission was established in 1965 to establish minimum support prices and procurement prices in order to support the spread of new technology. Thus, the price policy was closely coordinated with the India's technology policy. Remunerative prices for crops for which new technologies were available were announced prior to the sowing season in order to encourage adoption of technology without fear of falling prices. From the mid-1960s to the mid-1970s, wheat production more than doubled as minimum support prices were increased at 3 percent per year to offset rising input costs. Similarly, with the introduction of a superior technology of rice in the mid-1970s, minimum support prices for rice were boosted by 7 percent per year, a rate much higher than the increase in input prices (Vyas, 1987). Second, price policies were aimed at softening, while not entirely eliminating, market price volatility. Finally, price policies evolved in latter years to ensuring consumer benefits through reducing the margin between minimum support prices and farmers costs.

However, steady increases in producer prices, combined with good weather, have resulted in continued production increases and a massive stock build-up. Government procurement of rice and wheat rose from an average of 17.2 million tons per year from 1980 to 1992 to an average of 26.6 million tons per year from 1993 to 2000. Domestic distribution remained at approximately the same levels as earlier (16.5 and 16.2 million tons per year in the two periods), so that average net procurement rose from 0.7 million tons per year to 10.4 million tons per year. As stocks increased, the Government of India took increasingly aggressive measures to promote exports, both through sales of government stocks for exports and promotion of private sector exports. In spite of these measures, public foodgrain stocks grew rapidly, from 11.8 million tons at the start of 1993 to 45.7 million tons at the start of 2001.

VII. POLICY IMPLICATIONS FOR AFRICA'S AGRICULTURAL TRANSFORMATION

In countries such as Ethiopia, which has recently proved very successful in increasing on-farm maize yields and expanding production, negative price effects can lead to smallholders becoming trapped in Cochrane's famous "agricultural treadmill," ultimately undermining a potential Ethiopian maize revolution. This paper has highlighted that who adopts a new technology and how quickly drives the movement of the aggregate supply curve and dictates the distribution of the gains from the new technology. The paper has also reviewed the Asian experience of agricultural transformation. The key lessons that emerge are the active engagement of the public sector in both technology and price policy, while, at the same time, a close reliance on the operations of a competitive private sector in a mutually trusting environment.

What is the appropriate pricing policy vis-à-vis price stabilization and support in the face of inherently inelastic demand for agricultural goods? Defining an appropriate and feasible role for the public sector in the post-reform era is a critical challenge. A major lesson learned from two decades of market reform is that, while getting *prices* right is necessary, it is not sufficient for realizing the potential of markets to transform rural economies and improve the livelihoods of the poor, that is, to getting *markets* right. Thus fostering competitive markets requires supporting market institutions and the adequate provision of public goods and services that are essential for markets to develop (Fafchamps and Gabre-Madhin, 2001).

In considering appropriate policy to address the price effects of technological change, emphasis must be given to the following. First, it is critical to foster production increases brought about through technological change that reduces per unit costs. In Asia, the Green Revolution led to cost-reducing technological change (and hence growth in total factor productivity) and farm incomes did not fall with consumer prices until after imports had been displaced (Hazell and Ramasamy, 1991).

Second, it is necessary to improve domestic market functioning so that excess supply transmits more quickly and at lower cost to other parts of the country. The Asian model demonstrates the importance of rural infrastructure and institutions. How well integrated markets are, intra- and inter-nationally, determines the slope of the aggregate demand curve facing local producers. The more segmented the market, the more price inelastic the demand and the lesser a share of the gains accrue to the producers (Barrett, 1997). If the marketing system is competitive, then aggregate supply changes are met with changes in aggregate demand, as predicted by theory. But if there is market power or market failure of any sort, in inter-seasonal storage, transport, wholesaling, processing, etc., especially if this is due to minimum efficient scales of investment and operation coupled with fixed capacity limits, then market failure can have especially negative effects on grain prices.

Third, recent experience in countries such as Indonesia and India illustrate the use of export markets as a means of absorbing excess domestic supply, thus providing a market-based means of domestic price stabilization. Succesful implementation of this policy requires establishment of trading contacts and a thorough understanding of the relevant import and export parity prices.

A fourth critical dimension of this issue is the need to ensure that food aid imports are not providing disincentives to domestic production. Increasing demand for food aid commodities through well-targeted direct distribution programs can mitigate these disincentive effects. Nonetheless, these positive demand effects are unlikely to completely offset the impacts of the food aid in increasing supply. The net effect is thus to reduce prices and discourage domestic production, except in the case where food aid inflows are small and are only replacing private imports (Dorosh, 2002). With the exception of Bangladesh, food aid flows to Asian countries fell sharply prior to their agricultural transformation.

Finally, policy must focus on stimulating domestic demand through income growth, based on employment creation, particularly in the non-farm sector (Haggblade and Hazell, 1989). General economic growth helps drive demand, which keeps food prices up in the face of expanding supply from technological change. This is a crucial part of East Asia's structural transformation (Gabre-Madhin and Johnston, 2002).

Together, these five elements represent key areas in which policy can have a critical impact on fostering and sustaining an agricultural revolution.

Taken as a whole, these elements reveal the interactions between technology, domestic and external markets, food aid, and the non-farm economy. Pursued separately, each represents a "blind policy alley," resulting in unsustainable outcomes. Thus, technology pursued without consideration of markets chokes off its own source of momentum. Stimulating long-term demand depends on income growth, and thus, employment creation. Similarly, the effectiveness of food aid policy to overall food security is closely tied to domestic supply and trade considerations. The interactions among these five elements pinpoint the need for an integrated agricultural growth strategy.

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