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TECHNOLOGICAL CHANGE AND PRICE EFFECTS IN AGRICULTURE: CONCEPTUAL AND COMPARATIVE PERSPECTIVES

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ABSTRACT

This paper addresses the conceptual issues around the negative price effects of technological change on agricultural producers, explores price policy options vis-à-vis this problem, and reviews and compares experiences across Asian countries as they transformed their rural economies. It then draws implications for the challenge of achieving a smallholder-led agricultural revolution in Africa in the context of market liberalization.

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TECHNOLOGICAL CHANGE AND PRICE EFFECTS IN AGRICULTURE: CONCEPTUAL AND COMPARATIVE PERSPECTIVES

Eleni Gabre-Madhin[1], Christopher B. Barrett[2], and Paul Dorosh[3]

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.

The distributional consequences of technological change on technology adopters resulting from changes in relative output prices are an important dimension of this evolving debate. As output expands through technological change, in the face of relatively inelastic demand, the significant drop in output prices that results not only adversely affects the incomes of technology adopters but also threatens the very process

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of a sustained technological advance itself. The key issue is that, although technological change may reduce unit costs, prices may fall faster. In recognition of these adverse price and income effects, different schools of thought have emerged. Among these are those who advocate 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).

These 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 contrast to Asia, Africa is facing these questions in a context of market liberalization, implying that the issue of the negative price effects of technological change on producers is particularly relevant to African countries as they attempt to increase agricultural productivity and to foster a smallholder-led agricultural revolution. It should be recognized, however, that African countries are, in the short-term, net food importers on average. In the post-market reform era, evidence in numerous cases across the continent points to the increased volatility of African markets and the difficulty of ensuring remunerative prices for producers in bumper crop years.[4]

Market liberalization implies a greater reliance on market mechanisms to ensure the efficient distribution of agricultural output. Thus, the extent of market integration

[4] In the Ethiopian case, over the 1995-2001 period, increased fertilizer and modern seed use have resulted in significant gains in maize yields. In 2000-01, average production increased by 130 percent over the previous five-year average while producer prices fell to record lows, by as much as 80 percent in rural producer markets (Bonger, Gabre-Madhin, Babu, 2002).

determines the demand for agricultural output. With market liberalization, 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. The more segmented the market, the less responsive demand is to changes in price and the lower the producers' share of the gains from increased production. Even if markets were to function perfectly, the expectation that an agricultural transformation can occur without government intervention at some level in markets is contrary to the history of economic transformation in either the industrialized countries of Europe and North America or more recently in Asia.

To begin, such an expectation would require that markets work. In sub-Saharan Africa, a major lesson learned from two decades of market reforms is that, while removing policy distortions in order to "get prices right" is necessary, it is not sufficient for "getting markets right." That is, in order to ensure that markets work effectively, appropriate investments in institutions and infrastructure are required. Thus, the evidence 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).

This paper addresses the conceptual issues around this fundamental problem of the negative price effects of technological change on agricultural producers, explores price policy options vis-à-vis this problem, and reviews and compares experiences across Asian countries as they transformed their rural economies. It then draws implications for

the challenge of achieving a smallholder-led agricultural revolution in Africa in the context of market liberalization.

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.

CAUSES AND CONSEQUENCES OF PRICE VARIABILITY

Why do agricultural prices exhibit such wide and irregular fluctuations, especially in low-income countries? 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. 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.

Similarly, on the supply side, the short-run supply of agricultural output is highly inelastic, implying 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 unresponsive supply likewise contributes to the wide fluctuations in producer prices.

Intra- and inter-annual 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 following year's price, which can lead to the 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 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).

III. THE AGRICULTURAL TECHNOLOGY TREADMILL

Technological change results in increased total factor productivity, 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.[5] A cost-reducing technological innovation, by contrast, reduces optimal variable costs per fixed factor but does not increase yields per fixed factor, thus saving variable inputs.[6] Yield-increasing innovations reduce average fixed costs while cost-reducing innovations reduce average variable costs. In sum, 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.

Cochrane's (1958) classic theory of the "agricultural technology treadmill" is an apt representation of farmers in a fully commercialized economy. Hayami and Herdt (1977) later applied this theory 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. 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.

The idea of the "agricultural technology treadmill" is simple but powerful. In an economy where all producers are price takers and where a technological advance reduces

[5] Modern seed varieties best employed with a package of chemical fertilizers and pesticides or irrigation that stimulate increased use of labor and fertilizer are classic examples.
[6] Genetic selection for pest-resistant crop traits and the development of more efficient forages for livestock are good examples of cost-reducing technologies.

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 undertake 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 for producers. 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."[7]

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 can capture this cost through royalties and revenues from consumers. Because research has a public good nature and intellectual property rights are weak, financing research fro technology development can be a challenge for low-income countries with a thin domestic tax base and declining levels of international aid.

[7] Cochrane, p.100.

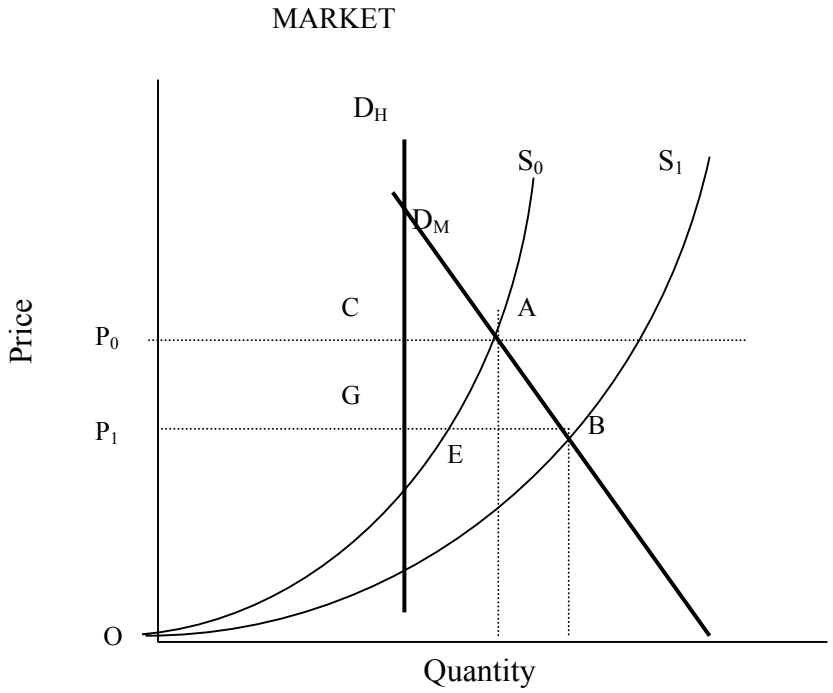
TECHNOLOGICAL CHANGE WITH SEMI-SUBSISTENCE AGRICULTURE

The above discussion implies that technological progress benefits mainly urban consumers at the expense of producers. However, the situation is significantly different when producers themselves consume a significant portion of the commodity (Hayami and Ruttan, 1985). In this case, in a closed economy, 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 1, 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, the larger the quantity of home consumption, the higher the consumer surplus is that accrues 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 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 1—The impact of technological change on a subsistence crop



Source: Hayami and Herdt, 1977.

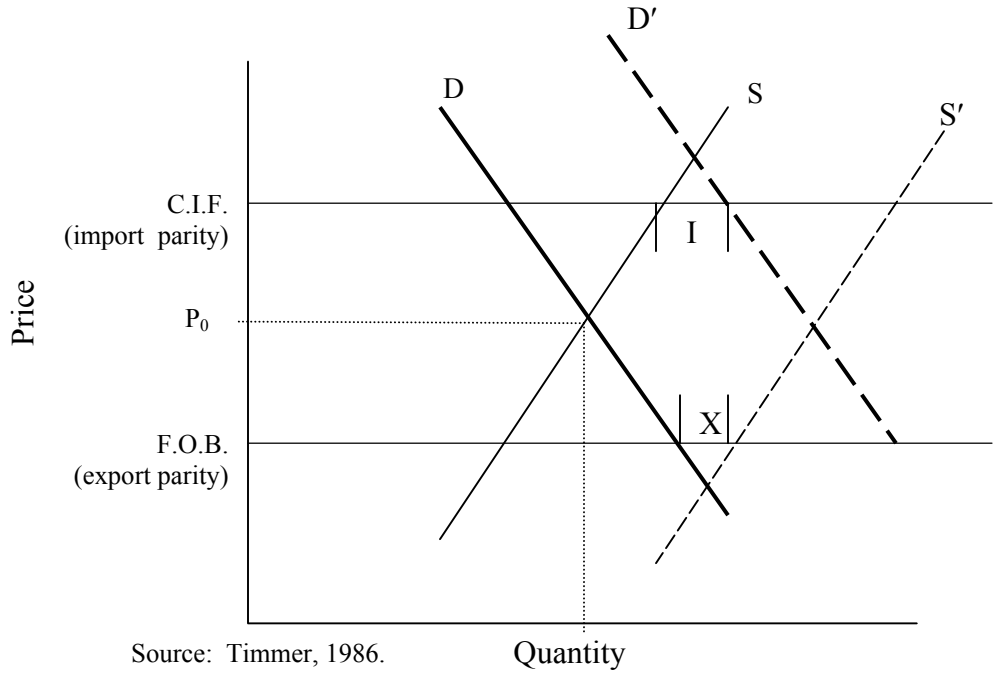
IV. PRICE POLICY OPTIONS

In the long run, aggregate supply increases are unsustainable with the effects of the agricultural treadmill. How can policy address the problem of the adverse price effects of technological change? In the context of a small open economy with the conditions that characterize 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 favor by 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 supply in wealthy countries). This school, promoted by T.W. Schultz and others at the University of Chicago, argues this pricing strategy, which relies on the border price, results in the optimal efficiency of resource allocation and minimal rent-seeking activity (Schultz, 1978; Timmer, 1986; Little and Mirrlees, 1969). Distinguishing between price instability and the treadmill effect is important. The challenge is for price policy to address both. The border price paradigm addresses the treadmill effect but may exacerbate the instability problem. The converse is true of the structuralist approach. The stabilization approach appears to address both the treadmill and the instability problem.

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. The reality is more considerably more complex in 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 a 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 to be 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 2) or in the parity band itself, as by exchange rate devaluation (Barrett 1999b).

Figure 2—Switching from non-tradable to tradable commodities



Source: Timmer, 1986.

THE STRUCTURALIST APPROACH

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 for 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 approach, embraced by many countries in East and Southeast Asia, openly rejects the free market approach for primary staples and favors 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 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.

PRICE STABILIZATION IN ASIA

Indonesian experience with BULOG

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 sold 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 late 1980s, BULOG exported rice, as domestic supply, spurred by investments in irrigation, spread of green revolution technology and appropriate price incentives, 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.

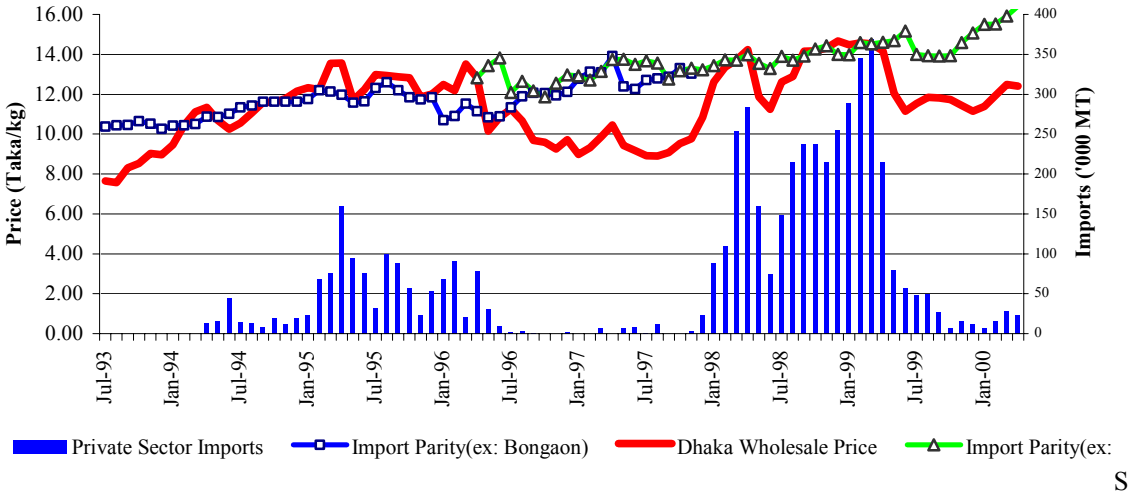
Bangladesh's experience with trade for stabilization

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 the 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, with public sector distribution almost exclusively targeting poor households, and private imports of wheat and rice were also liberalized.

As a result of the liberalization of Bangladesh's imports, as well as of India's export trade in 1994, 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 3). 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).

Figure 3—Rice prices and quantity of private rice imports in Bangladesh, 1993-2000



Source: Dorosh, 2001

FOOD AID AND PRICE EFFECTS

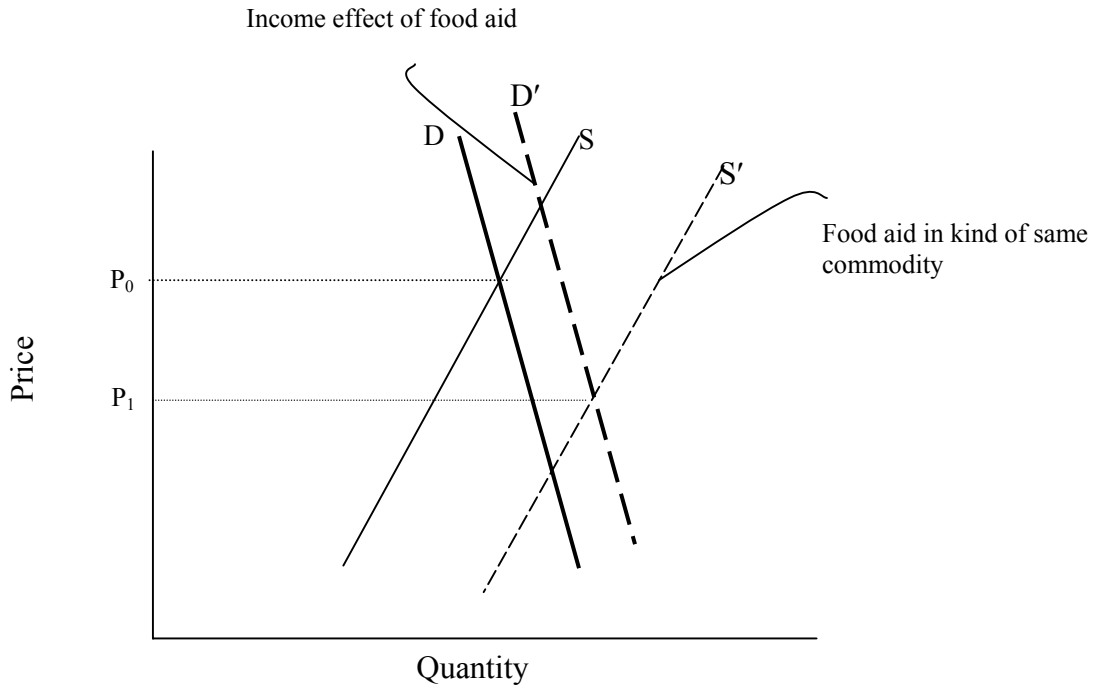
Food aid has been an important component of food policy in many low-income, food-deficit countries for the past five decades. The impact of food aid on domestic prices depends fundamentally on how extensive the need for food is within a recipient country, how effectively food aid reaches those in need, and the substitutability between major domestic food staples and the commodities imported as food aid. 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, food aid begins to have adverse incentive effects of producers and traders in recipient country markets by expanding supply faster than demand.

In the case of the impact of food aid on the domestic market for the same commodity, such as the impact of wheat food aid on the domestic wheat market, the distributed food aid adds to the total supply of wheat in the economy, shifting the supply curve from S to S' (Figure 4). At the same time, the transfer of food aid 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). In general, the increase in demand is less than the size of the food aid transfer,[8] so even well-targeted food aid distributions tend to shift the demand curve to the right from

[8] 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).

D to D' by less than the amount of the food aid, resulting in a fall in prices (Dorosh and Haggblade, 1997).[9] The more poorly food aid is targeted, the more severe the adverse price effects of food aid distribution (Barrett and Clay 2002, Barrett, Holden and Clay, forthcoming).

Figure 4—Price Effects of Food Aid in Kind of Same Commodity



In the case of the impact of food aid on the domestic market for a substitute commodity, such as the impact of wheat food aid on the domestic maize market, there are

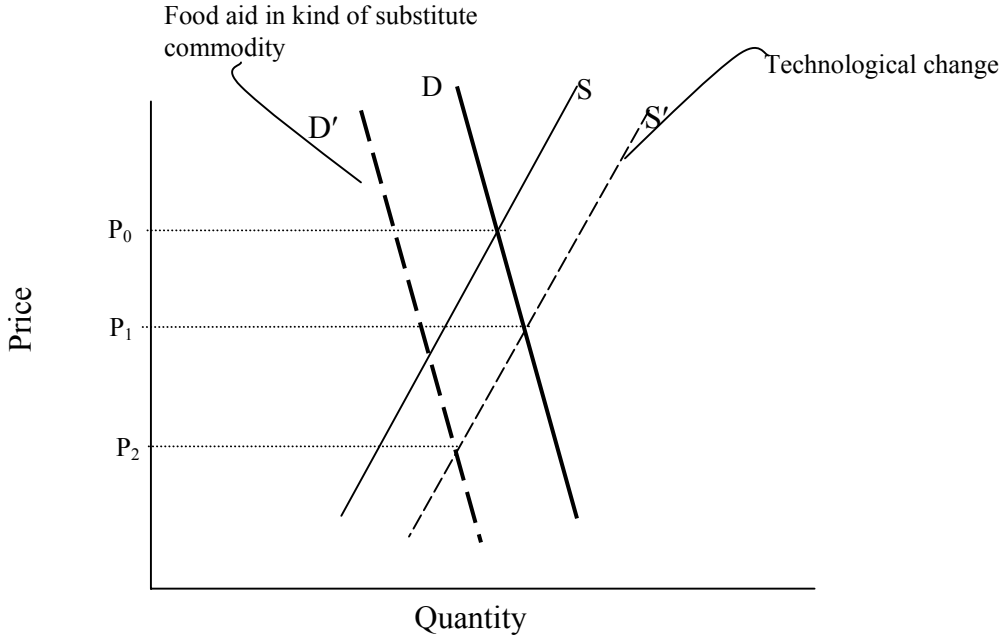
[9] Note that these results are for a closed economy or a situation where the food aid commodity is not traded internationally by the private sector because the import parity price is higher and the export parity price is lower than domestic prices.

no direct supply effects, just demand-side effects. The cross-price effects of food aid are more ambiguous than the own-price effects. Food aid transfers (or cash transfers financed by the monetization of food aid), tend to decrease the demand for substitute commodities, such as for rice 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, domestic maize production rises due to technical change results in a fall in maize prices from P_0 to P_1 as the supply curve shifts from S to S' (Figure 6). With wheat food aid, this fall in maize prices is exacerbated by reduced demand for maize (shifting the demand curve from D to D'), resulting in a lowering of the maize price even further to P_2 (Figure 5).

In sum, food aid usually exerts downward pressure on food prices, with that pressure greatest in places where targeting is poor. The South Asian experience in Bangladesh, Pakistan, and India nonetheless demonstrates that, with appropriate government policies, 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. These policies are investments in rural infrastructure, assuring input supply to farmers, and maintaining remunerative producer prices (Shaw and Clay, 1993). In Bangladesh, which reached record levels of grain production in 1999/2000 and 2000/2001, green revolution technology in the form of small-scale irrigation, expansion of improved seed and fertilizer use has contributed to

the doubling of rice output and increases of wheat production multiple-fold over the past two decades. In this period, the uses of food aid have evolved from the use of monetized food aid funds for public expenditures in the 1970s and early 1980s to reforms in the late 1980s and 1990s to improve targeting and reduce leakages (Dorosh et al., 2002).

Figure 5—Price effects of food aid in kind of substitute commodity



V. AGRICULTURAL GROWTH AND PRICE POLICY IN ASIA

From a relatively desperate situation in the early 1960s, Asian economies have undergone a dramatic transformation over the past 30 years. Famine was averted in South Asia as 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. Real per capita income increased multiple-fold in China and Indonesia and doubled elsewhere and the incidence of poverty in Asia fell from 60 percent to 20 percent in the period from 1975 to 1995 (Rosegrant and Hazell, 2000).

How did countries in Asia achieve this tremendous agricultural transformation without succumbing to the adverse price effects described in earlier sections? What price policy options did they exercise? A closer investigation of the growth experiences in China, Taiwan, South Korea, and India reveals that, while there is no single blueprint, a clearly emerging commonality is the importance of providing remunerative prices to producers, of investing in rural infrastructure, and of developing the rural non-farm economy to increase rural incomes.

THE CHINESE RURAL DEVELOPMENT MIRACLE IN A MIXED ECONOMY: 1979-97

Starting in 1979, the People's Republic of China instituted major reforms of its agricultural sector that created a mixed economy in which central planning and markets co-exist. These market-oriented reforms contributed to the extraordinary growth of GDP

of nearly 10 percent annually over the period from 1979 to 1984 (USDA-ERS, 2002). The reforms consisted of dismantling the commune system, granting farmers decision-making power, introducing the contract responsibility system, and raising producer prices (Du, 1987). Prior to and during the initial stage of reforms, the state set mandatory minimum delivery quotas for grain at fixed prices that remained well below international parity prices as well as a price bonus for above quota deliveries (Sicular, 1988). In the first stage of reforms, between 1977 and 1982, the state maintained this planned apparatus, but reduced quota levels by 20 percent and increased quota prices by 20 percent. It also increased the percentage price bonus of above quota deliveries from 30 percent to 50 percent. In this reform period, the state also encouraged private local and long-distance exchange, although producers could only sell to the private sector after fulfilling quota deliveries.

In response to this liberalization policy, the number of markets more than doubled from 30,000 to 61,000 between 1977 and 1985, with more than 18 percent of purchases in 1984 at market prices (Sicular, 1988). At the same time, the state established a system of negotiated purchase prices for deliveries above the quota, with prices jointly agreed between producers and local state commercial agents. One problem that arose was the increased quota evasion by farmers who found means to sell at higher market prices (Table 1). Second, as surpluses emerged and market prices fell, government stocks at above quota prices were built up because the state had no maximum delivery limit. Third, as the growth in income lead to increased selectivity of demand, the state found

itself holding stocks of undesirable commodities while consumer demand for higher quality goods was not met (Sicular, 1988).

These problems lead to the second stage of reforms. Starting in 1983, the government removed the price distinction between quota and above-quota prices for oilseeds, grains, and cotton and established a new system of pricing based on a weighted average of the old quota and non-quota prices. It also replaced the quota system with a system of negotiated purchase contracts with farmers before the sowing season, which gave farmers the choice of contracting or selling at market prices at harvest.

Table 1—Growth of Commercial Activities in China, 1977-1985

	1977	1978	1979	1980	1981	1982	1983	1984	1985
Number of markets (total)	29882	33302	38993	40809	43013	44775	48003	56500	61337
Urban	0	0	2226	2919	3298	3591	4488	6144	8013
Rural	29882	33302	36767	37890	39715	41184	43515	50356	53324
Volume of trade (billion yuan)	10.5	12.5	18.3	23.5	28.7	33.3	38.6	47.1	70.5
Percent of total purchases at market prices	n.a.	5.6	n.a	n.a.	9.4	10.2	10.5	18.1	n.a.

Source: Ministry of Commerce, 1984 in Sicular, 1988.

In attempting to boost incomes and production incentives, the government further reduced the amount procured under the contract system after 1985, from 74 million tons in 1985 to 52 million tons after 1988. It also increased the procurement price further in 1987-89 and in 1992-95 to cope with inflation. As procurement prices rose and production continued to expand, the gap between procurement and market prices narrowed. In 1997, the price relation reversed to a situation in which market prices fell

below procurement prices, following two consecutive bumper harvests, and the state began to incur heavy losses associated with what became a price support program after 1997 (USDA-ERS, 2002). Thus, in 1998, China entered a third stage of grain market reforms, in which market forces would determine quota procurement prices and the government would no longer procure low-quality grains. In sum, technological change increased output per worker, rural incomes were raised through changing the marketing system and 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. The relative share of agriculture in domestic output declined from 38% in 1953 to 6% in 1987. 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 rural labor force 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 2).

In this period, Taiwan's agricultural price policy, for rice in particular, focused on maintaining stable prices. To do so, the government procured and stocked large quantities of rice, up to 1973 (Mao and Schive, 1995). It collected rice through paddy land taxes in kind, compulsory purchases from landowners, rent in kind from government-owned land, the barter of fertilizer for rice, and the repayment in kind of production loans. All of these methods resulted in the procurement of 50 to 60 percent of the total volume of rice marketed in the period up to 1973. This policy resulted in an extended period of stable rice prices, while maintaining a narrow spread between producer and consumer prices. The government taxed farmers in this period both through the hidden tax in the compulsory purchase system as well as the farmland tax. In the case of compulsory purchases, the government taxed farmers by offering prices that were 70-80 percent of the market price. Similarly, the fertilizer barter terms and the production loans were at unfavorable terms to producers.

By 1973, the government had reduced its procurement to only 20 percent of the market volume and significantly reduced the hidden tax on compulsory purchases (Mao and Schive, 1995). In 1973, the government switched to a guaranteed rice price policy, with the objective of raising farm incomes.

Table 2—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

GOVERNMENT-LED AGRICULTURAL MODERNIZATION IN KOREA: 1961-1986

Until the mid-1960s, South Korea was one of the largest recipients of U.S. food aid and, despite the poverty of its agricultural sector, followed an agricultural policy of three lows: low grain prices, low interest rates, and low exchange rate (Diao et al., 2002). Over the 1961 to 1986 period, the agricultural sector grew 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 declined by 18 percent while average farm income rose from US $ 466 in 1961 to US $6,813 in 1986 (Kim, 1987). In this period of modernization, Korean agriculture became 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.

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, and continued to raise the real producer price of grains. Thus, as of 1969, Korea began to subsidize rather than tax agriculture and initiated a policy of direct transfers to farm households in 1975. To date, Korea has continued to provide among the highest levels of support to its agriculture in the world (USDA-ERS, 2002). In addition, in 1966, the government established a price stabilization fund to smooth price fluctuations, particularly for cash crops. A centerpiece of Korea's successful strategy to achieve self-sufficiency in rice and barley was the complete protection of these markets through import bans as well direct subsidies. Thus, consumer prices for rice and other agricultural goods have remained considerably higher than international prices, which have driven urban wages higher.

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. 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 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 using 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, in Punjab, the procurement price of wheat from 1967 to 1986 ranged from 104 to 152 percent of the production cost, and, in the case of paddy rice, from 107 to 124 percent (Bhalla, 1995).

Price policy was closely coordinated with 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. As stocks have increased, the Government of India has taken increasingly aggressive measures to promote exports, both through sales of government stocks for exports and promotion of private sector exports.

LESSONS FROM ASIAN EXPERIENCES

The review of experiences with price policy during the critical phases of the agricultural transformation in China, Taiwan, Korea, and India reveals that, in spite of the country specificities, several common factors emerge. These are: (i) the active role played by government; (ii) the emphasis on price stability as well as price support; (iii)

the co-existence of government support with market mechanisms; and (iv) the evolution of government intervention over the transformation, which moved from initially taxing agriculture to supporting it. In the next section, we address the relevance of these lessons for present-day Africa.

VI. IMPLICATIONS FOR AFRICA'S AGRICULTURAL TRANSFORMATION

Africa has yet to embark firmly on a massive Green Revolution of the scale and extent experienced in Asia. Indeed, it is projected that Africa will continue to be a net food importer on average in the short term. However, if Africa is to achieve a transformation, a critical issue is to what extent Asia's experiences matter and to what extent the different policy environment Africa finds itself in may hinder or encourage this transformation. The Asian experience points to the extensive role of government in both stabilizing and supporting prices as a means of encouraging and sustaining technology adoption. The African reality at present is that markets are expected to do the job.

If that is so, then the African experience of agricultural transformation will be very different than that of Asia. The first question then is: Is it possible to have an agricultural transformation that relies so heavily on market forces? The second question is: If so, how does this shape the agricultural transformation experience? In response to the first question, a market-based agricultural transformation will have to be based on effectively functioning markets, in which transaction costs are not prohibitively high, market access is even across the population, and neutral market intermediaries absorb

risk. The integration of markets, 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.

In response to the second question, a defining characteristic of a market-based agricultural transformation is that farmers will have to be far more commercially oriented than their Asian counterparts, thinking pro-actively of market opportunities, premia for quality and post-harvest handling, and diversification into high-value products.

To create both of the above conditions, governments will have to make significant investments and be actively engaged, in different roles than the traditional price interventionist role. Thus, to make markets work, governments must invest in infrastructure, such as transport and telecommunications; in institutions, such as quality control, grades and standards, contract dispute settlement mechanisms, information systems, among others; and in social capital, such as business networks, producer associations, and industry groups. To make farmers behave commercially, governments must invest in farmer training, new models of market-oriented extension, new types of farmer associations and cooperatives, and innovative financial instruments, among others.

Scattered throughout the continent, there are pockets of emerging agricultural transformation where yield increases have been sustained over time. In such countries, for example in the case of Ethiopia over the 1996-2001 period, maize yields increased significantly over the 1996-2000 period, due to the introduction of new maize technology and dramatic increases in fertilizer application. However, in areas not affected by drought, the increased production in the 2001-2002 harvest resulted in a 60 percent decline in producer prices in 2002, leading to a drop in fertilizer and seed use by nearly 30 percent in 2003. This situation was brought about by a very weak marketing system, characterized by high transaction costs, that was unable to absorb the surplus and distribute it to export or store it over time. The Ethiopian marketing system is not unlike many others in Africa.

Given the weak state of market systems in Africa, clearly a market-based agricultural production transformation will not happen without a significant transformation of the marketing system itself. But this takes time and may not happen fast enough for pressing objectives of hunger and poverty alleviation, even if done in parallel. The alternative to the *laissez-faire* approach is to consider what a rational price policy should be that relies on the market while not leaving it all to the market.

What is the appropriate pricing policy vis-à-vis price stabilization in the face of inherently inelastic demand for agricultural goods? 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. Successful implementation of this policy requires establishment of trading contacts and a

thorough understanding of the relevant import and export parity prices. Second, a market-based stabilization approach implies that 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).

The alternative to the free market-based transformation strategy is that of a market-based stabilization policy to support agricultural transformation. By placing the burden of ensuring stability on governments and not markets, it transfers risk away from producers, who are least able to bear it. This has the effect of sustaining the momentum of an agricultural transformation, which depends on the continued adoption of technology by farmers. To carry out this strategy, governments must be nimble, must be committed to improving markets, must be able to take risks, and must encourage and collaborate with the private sector, on whom this strategy crucially depends. This is the challenge facing Africa in the market-based agricultural transformation it seeks to achieve.

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