Why Agricultural Technological Transfers to Developing Countries Should be Deregulated*

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Abstract

This paper analyzes the institutional arrangements governing the international transfer of input-embodied new technologies in agriculture. While developed countries characteristically allow "multiple channel" private and public technological transfer, developing countries often force technology transfer through a "single channel" controlled by government agencies, with an emphasis on official performance tests. On the basis of case studies, it is shown that allowing private technology transfer and refocusing input regulations on externalities can lead to significant productivity and income gains in developing countries.

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Non technical abstract

In many developing countries, private technological transfer in agriculture through imported inputs remains impeded by regulations based on performance tests. This is worrying in a field which has experienced rapid technological advances in recent decades and where technological transfer often takes the form of imported inputs. Although the impact of import and investment barriers have now been widely documented, the empirical evidence regarding performance-based regulations is scant. Studies by Ulrich et al (1987, for wheat in Canada) and Constantine et al (1994, for cotton in California) suggest important losses in terms of forgone income. Apart from the finding by Pray and Echeverria (1988) that seed imports are significantly correlated with maize yields, evidence is still missing for developing countries. This paper contributes to the analysis in two ways.

First, it provides a stylized description of the institutional arrangements governing the international flow of input-embodied new technologies. Although regulations vary widely across countries, it is useful to identify two stylized patterns. Most developed economies rely on a "multiple channel" framework, where farmers are exposed to new technologies through the activity of domestic companies, non-governmental organizations, universities or the national agricultural research system (NARS). Because of public health or environmental concerns, domestic sales must be approved by government committees whose tests focus on externalities. In contrast, many developing and transition countries follow a "single channel" access to foreign technology, centralized through the NARS and where government committees' approval is based on performance tests.

Second, we intend to show that, contrary to the opinion that agricultural technology does not move very well without in-country adaptive research, deregulation does lead to a significant increase in technological transfer. As cross-country comparisons would be hard to interpret, we rely on two case studies. In Bangladesh, the lifting of restrictions on imported diesel engines in the late 80s led to a fall in price and an increase in their use by farmers, as consumers shifted to cheaper and smaller engines, mainly proceeding from China. In Turkey, deregulation of seed imports in 1982-84 caused a large increase in the

number of varieties allowed for sale and a rapid expansion of private company participation. In the case of maize, hybrid seeds were mainly imported at first, but were soon obtained by local production and even exported after a few years. Moreover, estimates based on a yield response function (Gisselquist and Pray,1997) suggest that private maize hybrids boosted yields by more than 50 percent.

On the basis of these findings, it is recommendable for countries with single channel systems to revise regulations and move towards multiple channels for technology transfer. Although performance should be kept in consideration for inputs with significant externalities, such as medium and high-risk pesticides, existing regulations for other imported inputs can be redesigned to focus on externalities rather than performance. To promote competitive markets, small countries should adopt policies favoring regional input markets. Finally, to maintain the degree of local technological mastery, deregulation should by no means imply a dismantling of public sector research agencies, but a reorientation of their effort towards market-oriented research.

1 Introduction

Over the last several decades, many developing countries have implemented trade and investment liberalization, removing barriers to import and introduction of new foreign technology. Some recent models suggest that efficiency gains from relaxing trade restrictions on production inputs could be substantial (e.g., Romer, 1994). Unfortunately, agriculture often remains an exception in this reform process. Regulatory obstacles continue to restrain technology transfer through private trade in seeds and other inputs. With limited access to new private technology, many third world farmers continue to rely on traditional or old crop varieties, inefficient livestock breeds and feeding technologies, and older and more dangerous pesticides. Barriers to introduction of agricultural technology are particularly worrisome for low income countries that are heavily dependent on agriculture. On the other hand, removing existing barriers may lead to substantial productivity and income gains. For example, in OECD countries, plant breeding boosts potential maize yields about 0.7 percent a year, whereas in developing countries, where breeding effort has been less intense to date, the potential impact of new maize hybrids can be much larger.

What are the institutional obstacles to market-mediated technology transfer for third world agriculture, and are they based on convincing arguments? This paper addresses both questions. Apart from import and investment barriers, whose consequences have been widely documented, governments often impede private technology transfer with regulations that block inputs sales except for technologies that governments have tested and approved after a multi-year process that includes official performance tests.

The impact of performance-based input regulations on productivity and income has not previously been tested for developing countries. If performance-based regulations were benign or beneficial, countries that deregulate would not show any increase in technology flows or productivity growth. However, in two case studies presented in this paper the reverse was true: regulatory reforms brought dramatic gains in technology imports and productivity. This does not mean that markets should be totally liberalized, as any policy reform must explicitly consider safeguards to limit externalities. Specifically, this paper does not challenge performance-based tests for conventional pesticides and other inputs with substantial public health or environmental externalities.

Section 2 introduces features of technology generation and transfer in agriculture. Section 3 characterizes and compares systems for technology transfer in developed and developing countries. The impact of regulatory reforms in Bangladesh (agricultural machinery) and Turkey (seeds) is analyzed in section 4. Section 5 presents results and policy implications.

2 Technology generation and transfer in agriculture

In recent decades, agriculture has become a high-tech field, with rapid advances in crop and livestock genetics, pest and livestock management, and machinery. For many field crops, the average market life for a variety is no more than 5-7 years, and for vegetables it can be as short as two years. The use of conventional pesticides -- broad spectrum poisons -- is giving way to an increasing range of relatively low-risk pest-management techniques (e.g., insect growth regulators, pheromones, microbial pesticides, and innoculants).

Concurrently, while public research traditionally produced the larger share of agricultural technology, private research has become more important. The private share of agricultural research expenditures in the United States in the mid-1980's was 49 percent (47 percent in the United Kingdom and 39 percent in France), and reached an estimated 56 percent in 1992 (see Clive, 1996). Public research has been moving upstream, into basic research that private companies develop for market applications. Also, universities and other public research organizations have been applying for intellectual property rights and then selling or licensing new technology to private companies.

As in other high-tech fields, agricultural technology is international. Leading countries continuously borrow and build on research results from other countries. Technology moves between people, organizations, and countries through publications, discussions, licensing agreements, and international sales. With no master plan for research and dissemination, coordination is achieved through communication and marketing.

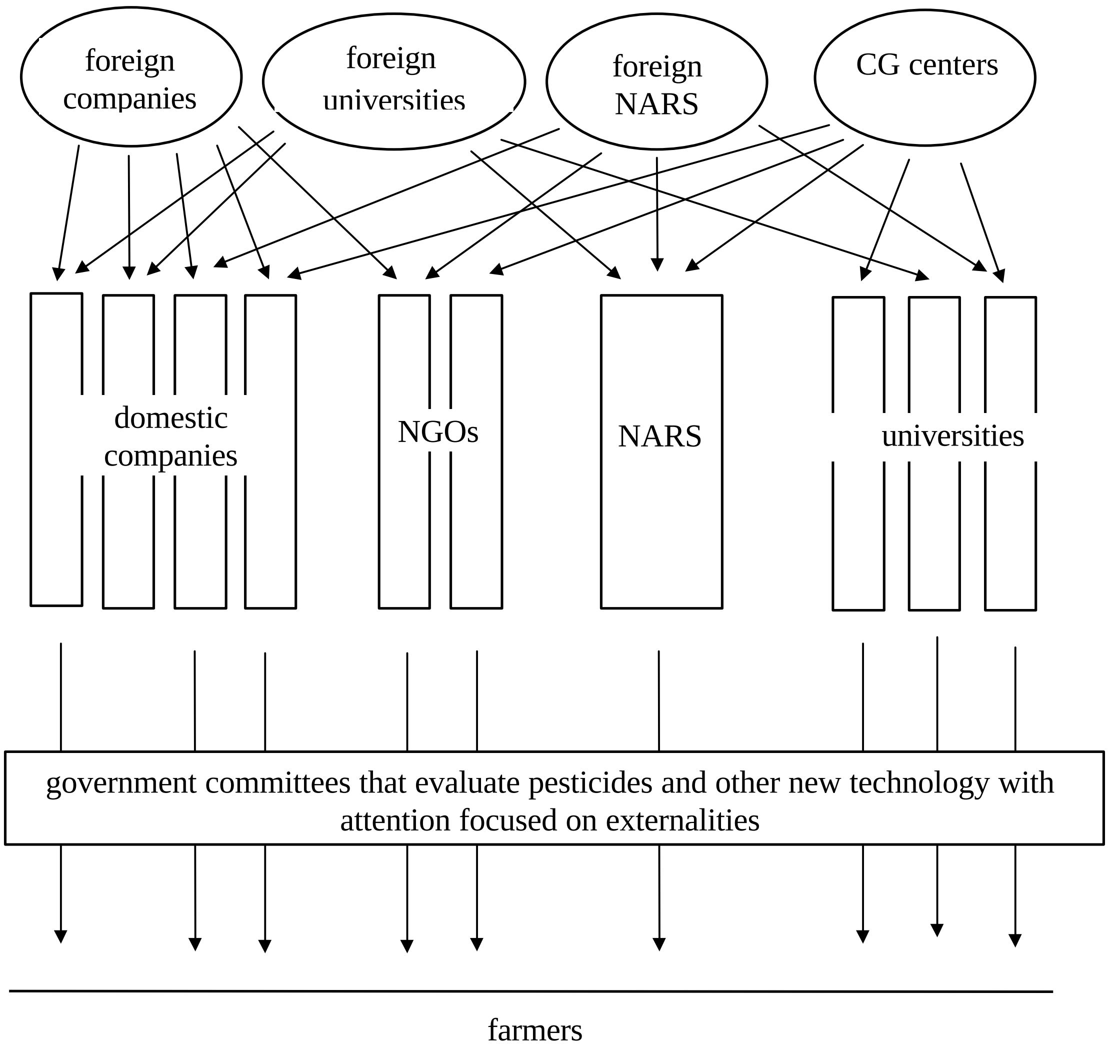
The mode of international technology transfer differs somewhat according to the type of inputs. Direct transfers through imports are common for high-value seeds such as hybrid vegetables, new proprietary pesticides, and engine-powered machinery. In-country production after import of a design from foreign research is also common, particularly in large countries, for field crops (e.g., a company imports breeders' seed to multiply in-country), out-of-patent pesticides, vaccines, or simple livestock feed additives. Finally, local research may adapt foreign technology (e.g., germplasm or machinery) to local conditions; this can be particularly important for some categories of technology, such as integrated pest management, that depend on local crop management practices.

Whatever the source of new technology, most of it reaches farmers through marketed inputs. New varieties are embodied into seeds, new pest management technology into pesticides or spraying equipment, new feed technology into pre-mixes, etc. Companies extend technology to farmers through tests plots, demonstrations, and dealers. However, technology diffusion has been uneven, with many developing countries lagging behind due in part to self-imposed barriers to introduction of private agricultural technology.

3 Institutional framework: two archetypes

Although regulations governing agricultural technology transfer and inputs trade vary widely across countries, it is useful to identify two stylized patterns. In developed countries (and some developing countries), governments generally maintain liberal trade regimes for foreign and domestic inputs, allowing multiple channels for introduction of new technology. For example, as illustrated by figure 1, companies, universities, NGOs, or government research institutes may breed new varieties from domestic or foreign lines, multiply seeds from own or imported parent seeds, or even import commercial seeds for sale. Governments regulate import of seed (including breeding material) to ensure that plant pests or diseases do not come in with the seed, but otherwise allow companies to market a wide range of varieties, trusting that farmers and companies interacting through markets will be able to chose those which are most efficient.

Figure 1: Multiple channels to new agricultural technologies



Notes:

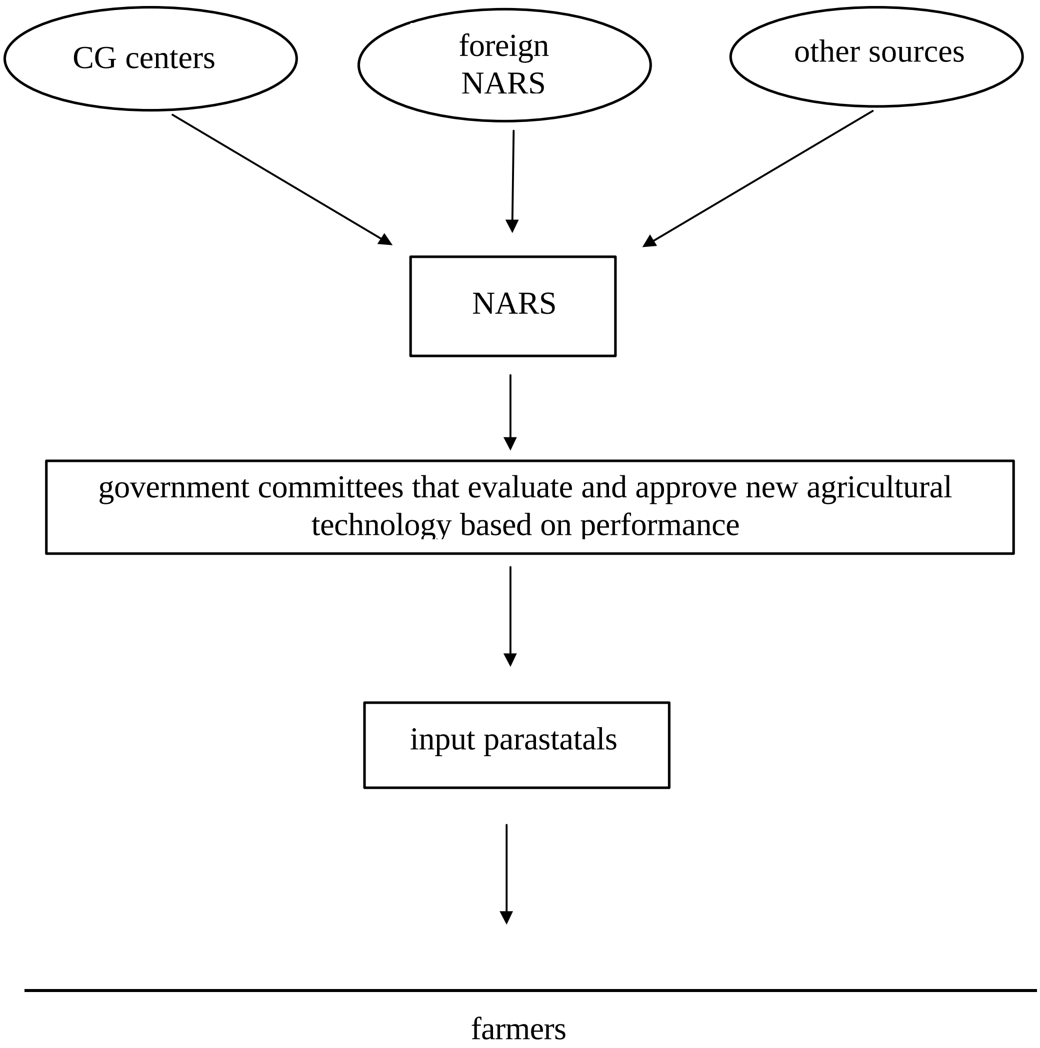
NARS: national agricultural research system.
CG centers: International Rice Research Institute (IRRI) and other international agricultural research centers associated with the Consultative Group for International Agricultural Research.

While developed countries liberally allow multiple companies to introduce new agricultural technology as shown in figure 1, there are some differences in regulatory systems. In the European Union (EU), for example, each member government tests varieties for performance, but also automatically accepts varieties approved by any other EU government without further tests. On the other hand, the US, India, and other countries allow seed sale without variety registration or official performance tests; official variety registration is available, but it is optional. Approval processes for transgenic seeds also vary among countries, due primarily to a lack of consensus on public health and environmental risks. However, by and large, regulatory systems in developed countries share the same underlying logic, allowing markets to evaluate performance, while focusing regulations on externalities. This liberal approach to technology transfer is appropriate for agriculture, a field with rapid technical change, and for which local conditions are critical in shaping the impact of new technologies.

In contrast to the liberal regulatory regime that characterizes developed countries, many developing and transition countries strictly limit market access for new agricultural technology. Restrictions are most common and problematic for seeds, but may also interfere with technology transfer for new models of machinery, new fertilizer compositions, new feed components or mixes, etc. For example, governments often require multi-year in-country performance tests before approving seeds of a new variety for sale. These regulatory processes produce positive lists of allowed inputs. Positive lists, which are common in the QR-ridden foreign-trade regimes described in Bhagwati (1978) and Krueger (1978), are far more restrictive than alternate negative lists, which allow anything not listed to be imported.

With regulations and policies that make it difficult for companies to operate, governments of many developing countries effectively block almost all private agricultural technology transfer for seeds and other major categories of agricultural inputs, so that government agencies are left as the dominant or single channel for technology transfer (see figure 2). In this pattern, a centralized government research establishment identifies new varieties and other new technology, parastatals produce and sell inputs, and extension agents encourage farmers to take what is offered.

Figure 2: Single channel to new agricultural technologies



A single channel pattern for technology transfer severely constrains the flow of new technology. Even where private companies are able to operate, regulatory costs limit private technology transfer. In many developing countries, farmers are offered an average of less than one new seed variety each year for each major crop, and many of these varieties are useless, while farmers in countries with multiple channels may see dozens or even hundreds of new varieties each year for a single major or minor crop or vegetable. Regulatory costs are particularly troublesome in small markets -- small countries or minor crops -- where companies may judge that registration of a new technology is just not worth the effort, leaving farmers with no access.

In spite of these limitations, many foreign experts and donor institutions continue to promote or endorse single channel systems and performance-based regulations. A persistent and influential argument sustaining this position is that deregulation may lead to the diffusion of unsatisfactory inputs because farmers either lack the necessary information or would fall prey to false marketing. Thus, farmers should be protected from those who "might try to market an unsatisfactory variety simply to recoup breeding costs" (Kelly,1989).

Apart from the fact that this argument underestimates the capacity of farmers to learn at low cost, it is debatable on several counts. If lack of information is the issue, there are certainly more efficient ways to address it than through a registration process that precisely limits the range of available inputs. Moreover, fears that giving farmers more choice will lead to spread of inferior varieties are not supported by experience in India and other countries that allow seed sale for untested varieties. On the other hand, many instances can be found where governments -- not farmers -- buy and distribute seed for varieties that are not appropriate and that leave farmers with losses.

In some cases, such as with low risk pesticides, excessive reliance on performance tests may even exacerbate externalities. Conventional broad spectrum poisons, which kill a wide range of pests outright, but which also threaten public health and environmental damage, are easy to manage in efficacy tests and have large markets for multiple pests. On the other hand, non-toxic biopesticides that interfere with insect mating or maturation can be more difficult to manage, so that results from efficacy tests are misleading, and at the same time markets may be limited to specific insects and crops. Forcing low risk pesticides through expensive efficacy tests can leave farmers with limited access to low risk products (see Benbrook and Gisselquist, 1996).

A second influential argument against de-regulation deserves mention. Many experts argue that agricultural technology does not move very well without in-country adaptative research. For example, Evenson and Westphal (1995) assert that "important forms of adaptative agricultural R&D require a substantial commitment of resources dedicated to developing techniques for a particular set of agronomic conditions." Such an argument does not directly support performance tests, but nevertheless undermines and discourages efforts to deregulate by asserting that nothing would happen, since even without regulatory obstacles companies would not bring in and introduce available foreign technology. The next section tests this argument against evidence from Bangladesh and Turkey.

4 Assessing the impact of deregulation: two case studies

Although the effects of trade liberalization are now widely documented, evidence on the impact of performance-based regulations is scant. For developed countries, two studies suggest that losses in terms of foregone income may be huge for cotton in California (Constantine et al, 1994) and wheat in Canada (Ulrich et al, 1987). To our knowledge, no similar estimates exist for developing countries. However, based on a sample of 50 countries, Pray and Echeverría (1988) found that seed imports and private research were significantly correlated with maize yields.

One research strategy to measure the impact of inputs deregulation is to work with aggregate data, comparing levels or rates of growth of agricultural production or total factor productivity across countries or over time. The most convincing cross-country argument is trivial: no research is required to establish that OECD countries as a group have more open and competitive inputs industries and higher levels of agricultural technology and production than low income developing countries. On the other hand, cross-country comparisons looking at rates of growth would be hard to interpret, since countries with restrictive systems can show fast growth from a low and constrained base (due in part to many years of obstructed technology transfer). Also, regulatory systems are varied and complex, so that it takes time to understand what is going on in any one country, and the result may be hard to express numerically for econometric analysis. Another set of problems undermines inter-temporal models with aggregate data: Changes in inputs regulation often occur in conjunction with other macro and micro-economic reforms. It can be difficult to disentangle the impacts of these other reforms along with climate and other factors from the impact of regulatory reforms.

The two case studies below examine impacts of regulatory changes in Bangladesh and Turkey on selected agricultural activities. These studies are not designed to measure the aggregate impact of regulatory reforms but rather to show that reforms have a positive and not insignificant impact. This is sufficient to answer two common arguments against deregulation: if production increases with deregulation, then (a) regulations, on balance, do not protect farmers from inferior technology but rather maintain inferior technology, and (b) regulations are not irrelevant.

Case 1: Diesel engines for agricultural use in Bangladesh

In this case, the pre-reform situation constitutes an almost ideal illustration of the single channel system described in the previous section. Prior to late-1980s reforms, the Ministry of Agriculture in Bangladesh maintained lists of "standardized" (tested and approved) models of diesel engines for irrigation and power tillers. Models not on the list could not be imported. The Bangladesh Agricultural Development Corporation, a parastatal, imported engines and sold them with subsidies.

Reforms arrived in 1988-89. Along with tariff cuts, the Ministry of Agriculture did away with lists of standardized engines, allowing private import of any and all models. Subsidized parastatal sales continued for several more years, but farmers increasingly shifted to private traders, who offered convenience along with a wide range of low cost models. By end-1991 private traders clearly dominated the market. As illustrated by table 1, regulatory reform -- allowing private import and sale of new and less costly models of diesel engines and power tillers from China -- was followed by a sharp increase in sales and use of imported machinery.

Table 1: Deregulation of agricultural machinery imports in Bangladesh

type of input	fall in retail price	impact on farm use, 1988-1996
diesel engines for minor irrigation	more than 50%	170% over 8 years in number of small pumps operating (extending new irrigation to an estimated 16% of gross cropped area)
power tillers	more than 40%	machinery cultivation extended from 0% in 1988 to 15-40% of cultivated area, depending on the season

Note: Regulatory reforms (1988-89) included trade liberalization of agricultural machinery and the suppression of compulsory registration.

Source: National Minor Irrigation Census and authors' calculations.

With regulatory reforms allowing farmers to choose cheaper equipment, the retail cost for the most common minor irrigation investment (12 horsepower engine and 100 mm diameter tubewell for lifting groundwater) fell below $ 500 at the end of the 1980s, less than half what it had been with subsidies in 1981/82. After reforms, minor irrigation expanded at record rates. From 1988 to 1996, the number of small power pumps lifting ground or surface water for irrigation increased by 170 percent or 390,000 units, delivering new irrigation to roughly 16 percent of gross cropped area (assuming that each new pump irrigates an average of four hectares). Markets also moved toward smaller equipment (4-8 horsepower engines and 75-100 mm diameter tubewells).

For power tillers, the 1988 pre-reform list of standardized models included only one low-cost model from China (cost, insurance, and freight [CIF] import price about $ 1000), one from South Korea (CIF about $ 1700), and about ten others from high cost sources (CIF well over $ 2000). Dealers for the two low-cost models dominated trade but took advantage of limited competition to sell at well over $ 2000. With reforms, multiple additional models from China with CIF near $ 1000 entered the market, and competition soon cut the retail price to about $ 1300. Before reforms, power tillers were so rare that one normally did not see any during a multi-day tour of rural areas. By 1996, power tillers prepared an estimated 15-40 percent of land for cultivation, depending on the season (based on power tiller imports and assuming each power tiller lasts five years and cultivates 25 hectares in a season).

Case 2: Seed varieties in Turkey

A 1963 Turkish seed law gave Ministry of Agriculture authority over seed production and trade, domestic as well as international. Through regulations based on the law, the Ministry made variety registration and in-country performance tests compulsory for most crops, set seed prices annually, and extended import and export controls well beyond phytosanitary concerns. In practice, the Ministry limited variety approvals for most field crops to those sponsored by government research agencies and for vegetables allowed only a limited range of private varieties.

At the beginning of the 1980s, difficulties with Turkey's single channel system for seed technology included widespread smuggling of vegetables seeds, failure to popularize hybrid maize, and expensive government agencies serving no more than 10 percent of planted area. Addressing these problems, government revised seed policies in the early 1980s to encourage private participation in seed production and trade. Between 1982 and 1984, government removed seed price controls, relaxed foreign investment controls, and eased (but did not entirely dismantle) compulsory variety registration by reducing testing requirements and allowing private companies to do their own tests.

Reforms brought large increases in the number of varieties allowed for sale, as well as a rapid expansion of private company participation (see table 2). From 1982 to 1994, the number of allowed varieties for hybrid maize increased 670 percent, for hybrid sunflower 2400 percent, and for soy beans 3400 percent. Most of these new varieties have been direct transfers, often from parts of Western Europe and the US sharing the same latitudes. Most have been proprietary varieties, although some have come from foreign or international public research. As a result, the share of commercial seed sales through private companies soared, exceeding 90 percent in 1993 for maize and sunflower hybrids, soy beans, and potatoes. The number of private companies rose from about five to 80 from 1980 to 1994. During this period, most major seed multinationals established a presence in Turkey through subsidiaries, joint ventures or licensing agreements.

Table 2: Impact of deregulation of seed trade in Turkey (1982-1994)

Crop	Harvested area in 1990 (hectares)	Varieties available 1982	New Varieties introduced 1982-1994	Private share of commercial seed production (%)	
				1985	1994
wheat	9,400,000	21	62	0.5	8.8
hybrid sunflower	715,000	3	74	88.9	98.9
cotton	841,000	9	19	0	0.1
hybrid maize	155,000	24	185	85.7	97.3
potatoes	192,000	31	51	11.3	91.7
soy beans	74,000	2	70	42.1	94.7

Sources: SIS, 1990 Agricultural Structure and Production and Resmi Gazete (various issues).

The case of hybrid maize, covering a third of the maize planted area in 1993, is particularly interesting. On the one hand, as could be expected, trade reforms led to an increase in seed imports, which exceeded domestic production in 1985. Soon, however, local seed production expanded to take care of local demand and then pushed into export markets as well. From 1988, hybrid maize seed exports exceeded imports, and reached a quarter of total production in 1992. Similar trade shifts occurred for hybrid sunflower seed. Once reforms allowed seed technology to enter, Turkey has been able to exploit its comparative advantage in terms of good climate, scientific skills, and low labor cost.

Available data on maize yields allow for a rough estimate of the gains from private hybrids following reforms. Gisselquist and Pray (1977) estimated a yield response function over the 1961-1991 period (see table 3). Regressors include the percent of maize area sown to private hybrids, annual fertilizer use, national annual rainfall, and a trend variable to control for other factors (transport improvements, extension, etc.). Data on maize irrigated area were not available.

Table 3: Maize yield response function, 1961-1991

explained variable	share of hybrid planted area	fertilizers per hectare	national rainfall	trend	Adjusted R^2
maize yield (ton/hectare)	2.89 (0.52)	1.4E-03 (5.3E-03)	4.58E-04 (7.14E-04)	5.34E-02 (2.73E-02)	0.924

Note: numbers in parentheses are standard deviations

Source: Gisselquist and Pray (1997)

The explanatory power of the model is satisfactory, and all coefficients exhibit the expected sign, but neither fertilizers nor rainfall are significant at the 95 percent level. Gisselquist and Pray used these regressions results to simulate projected maize yields in the absence of reform, using estimated coefficients but with zeros for post-reform hybrids. A comparison of actual yields with projected non-reform yields (see figure 3) suggests that private maize hybrids boosted maize yields by more than 50 percent.

Finally, this result is used to estimate the magnitude of the income benefit from post-reform hybrid maize in Turkey. Table 4 calculates the impact of post-reform private maize hybrids on average net economic returns per hectare of maize during 1990-92 at $ 153, equivalent to 25 percent of the gross economic value. With a total maize area of 515,000 hectares, this implies an annual net economic gain of $ 79 million for Turkey's maize farmers.

Figure 3: Turkey Maize yields: actual and projected, 1961-91 (tons/hectare)

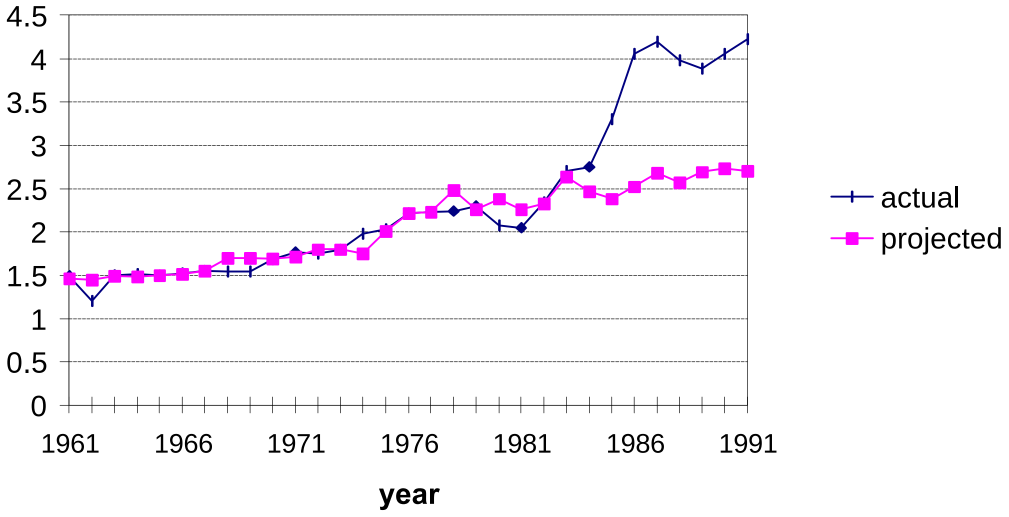


Table 4: Estimated net economic benefits from hybrid maize in Turkey (1990-92 average figures)

	volume	change in volume due to hybrids	unit price	change in value due to hybrids ($/ha)
average yield	actual: 4.13 ton/ha projected[a)]: 2.7 ton/ha	1.43 ton/ha	148 $/ton	211
costs				
local seed	37 kg/ha	-11.1[b)] kg/ha	0.148 $/kg	-2
hybrid seed	28 kg/ha	8.4[b)] kg/ha	2.97 $/kg	25
harvesting and drying [c)]				35
net gain				153

Notes:

[a)] on the basis of the yield response function described in the text.
[b)] assuming 30% of maize area planted to hybrids
[c)] estimated as 1/6 of the value of production

Source: Gisselquist and Pray (1997)

5 Conclusions and policy implications

The evidence presented in this paper suggests that deregulation of agricultural input trade leads to significant increases in the range and quality of inputs available to farmers, leading in turn to increases in productivity and incomes. From these two case studies, we recommend that countries with single channel systems revise regulations, including especially performance-based regulations for approving new technologies, and move toward multiple channels for technology transfer. Evidence for large gains with a greater range of technical options agrees with similar results from trade models. Of course results would be more robust if supported by more studies of similar reforms. Preliminary results from ongoing World Bank studies of input reforms in Zimbabwe and India corroborate conclusions and recommendations in this paper.

This recommendation to reduce and revise regulations governing inputs trade should not be confused with total liberalization. Regulations to control negative externalities in terms of public health and environmental damage should be maintained, and even reinforced in a number of countries. For example, in the case of new pesticides, governments might consider not only to maintain a positive list of allowed products, but also to levy taxes on allowed pesticides, with rates determined according to externalities. More generally, existing regulations based on performance can be redesigned to focus on externalities (see table 5), except that for inputs with significant externalities, such as medium and high-risk pesticides, performance may be taken into consideration in deciding whether or not the gains are worth the risks.

Market power, another potential source of market failure, may be a concern in the reform process. The risk of monopolies and oligopolies dominating inputs markets is more serious for small and low-income countries. For example, a minimum of 20-30 seed companies may be required to ensure that farmers in a country have access to world technology for all crops through competitive seed markets (5-6 seed companies ensure a competitive market for a single crop, but companies specialize, so several times that number are required to cover all crops). National seed markets in most Sub-Saharan

Table 5: Reforming regulation on agricultural technology transfer

input	common regulatory barrier	proposed reforms to focus regulation on externalities
seeds	* many governments prohibit seed sale except for registered (approved) varieties based in part on performance tests * many governments block seed imports to protect domestic seed production (using unreasonable phytosanitary arguments or other NT barriers) * some governments demand that companies submit samples of in-bred lines before allowing sales of hybrid seed	* allow sales of seed without variety registration * focus phytosanitary controls on diseases that are present in the exporting country but the importing country, and that threaten real economic damage * allow import and sale without deposit of a seed sample; this regulation has nothing to do with externalities
pesticides	most countries require in-country efficacy tests for new products before allowing them for sale	for no risk or low risk products, allow (provisional) sale without in-country efficacy tests
fertilizers	some governments limit types of fertilizers allowed for sale based on expert opinions about soil nutrient deficiencies	allow companies to sell fertilizers with any combination of nutrients; enforce truth-in-labeling and ban dangerous impurities
agricultural machinery	some countries limit imports to lists of approved models, basing approvals on performance tests	allow import of any model, leaving farmers to assess performance against cost and other factors
livestock feed	some countries set minimum standards for various nutrients or components or require prior registration and approval for all feed mixes based on expert opinions	allow companies to sell any combination of feed components without registration; enforce truth-in-labeling and ban or regulate feed additives with negative externalities (hormones and antibiotics)
veterinary medicines	some countries do not allow (private) vaccine import, arguing that government production is adequate, diseases do not exist, or quality is not secure	allow private import but regulate to ensure quality (impurities in vaccines can spread other diseases)

African countries are not large enough to support competitive, modern seed markets. Deregulation allows national markets to merge into regional markets that are large enough to attract enough companies to ensure competitive seed supply for minor as well as major crops. Policies favoring regional seed markets in Africa include voluntary variety registration and limiting seed import controls to realistic phytosanitary concerns, allowing varieties and seeds to move more easily across borders; seed trade reforms could begin with minor crops and small seed volumes, without challenging national self-reliance for seeds of major food crops. In small markets, foreign companies may enter through licensing agreements with local companies. Also, small and medium local companies with low overheads are required to extend competitive markets to relatively low value seeds of vegetatively propagated crops (eg, cassava and potatoes) and self and open-pollinated crops (eg, wheat, some maize).

Finally, deregulation should not jeopardize efforts to maintain and increase the local degree of technological mastery, including skills developed and deployed through public sector research. Local research capacity strengthens the bargaining power of the country if prices for technology transfer are not competitive (Pack and Westphal,1986) and avoids a widening of the technological gap when R&D spillovers are national rather than international (Grossman and Helpman,1991). Thus, deregulation should by no means imply a dismantling of public sector research agencies. On the other hand, a post-reform increase in private technology transfer may lead to a market-mediated reorientation of public sector research. Regulatory reforms may be more successful with concommitant commitment to boost funds for public sector research, which not only maintains one important channel for technology transfer, but can also blunt opposition to reform from government scientists who may otherwise fight the loss of their monopoly control over the process of technology transfer.

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