

Tilling the Earth: Improved Seed Use in Ethiopia and Brazil

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Abstract

This article looks at the use of improved seeds in Ethiopia and Brazil, two countries for whom agriculture is an important force but who are at dramatically different levels of development. Brazil has undergone a productivity revolution in agriculture since the 1970s, transforming from a net importer of food to the world's largest net exporter. Ethiopia is heavily reliant on agriculture for its GDP, yet faces high food insecurity and rural poverty. This article examines how and why gaps exist in the adoption of improved seeds between the two countries. It concludes that Brazil has mounted many of the obstacles Ethiopia now faces, and thus suggests Ethiopia follow Brazil by example.

I. Introduction

Agriculture has been fundamental to the economies of both Brazil and Ethiopia. However, even though both countries are developing countries reliant on agriculture, they are quite different places, and a large part of their divergence can be explained by divergences in agriculture. Brazil is much larger and richer than Ethiopia, and its agriculture has powered its large economic growth in recent decades, while Ethiopia faces widespread poverty, and needs to dramatically improve its agriculture to escape it.

This article explores the idea that Ethiopia today faces many of the same obstacles that Brazil did in the 1970s and has since overcome, and thus suggests Ethiopia follow Brazil by example. It begins by comparing how dependent each country is on agriculture and how that affects the lives of its people. Then, it will narrow its focus onto one facilitator of agricultural intensification, the use of improved seeds, and examine how both countries have met and implemented this opportunity for growth. This is a multifaceted issue, and it is therefore examined in three categories that explain whether or not farmers have ended up planting improved seeds in their land: the seed market structure, production capacity, and policy.

As this article will show, the use of improved seeds, and agricultural technology altogether, has great consequence on the performance of a country's agricultural sector as well as the daily lives

and food security of its people. Thus, this is an issue of great import and it is intriguing to know why some countries differ on this issue.

II. Literature Review

Most of the research currently conducted on Brazil's agriculture tends to analyze how the country accomplished the feat of a productivity revolution starting in the 1970s, and often it moves on to addressing Brazil's current issue of environmental stability, which might be concomitant to such a productivity revolution. For Ethiopia, the literature is generally diagnostic of the various food-insecurity issues the country has faced. As a point of interest, the literatures converge in that many researchers compare progress in Brazil to potential progress in Sub-Saharan Africa, suggesting Brazil can be a model for the region.

The Economist (2010) traces Brazil's agricultural revolution of the 1970s and its relevance today. The article explains that, in the midst of a global panic about food shortage, Brazil shifted from being a large net importer of food to the first "tropical agricultural giant." The author lauds the model laid forth by Brazil, which focuses on agricultural research, capital-intensive large farms, and openness to trade and new farming techniques. It also argues that the struggling countries of Africa and Asia would more effectively develop by following this example (which includes giant farms, genetically modified (GM) crops, and science instead of subsidy) than by following the contemporary "small and organic" advice. Regarding sustainability, the author argues that Brazil's intensification in the *cerrado* (its savanna region), is an example of how to divert activity in the more-precious rainforest.

Ferreira et al. (2012) places more concern on the sustainability of Brazil's agriculture, citing academic discussions about Brazil's deforestation, destruction of biomes, and increases in the use of harmful pesticides and fertilizers. The authors present disturbing data in this vein: three of Brazil's six biomes have lost at least 50 percent of their natural habitats, and the coastal Atlantic Forest has lost 88 percent of its native vegetation. The authors also trace the large gaps in knowledge about the effects of an ecologically changing Brazil, and claim such gaps leave the country open to policy decisions deleterious to its ecology. The authors discuss the Forest Act, an example of a policy aimed at protecting Brazil's ecology, but one that has been controversial and uninformed by scientific research. Ultimately, they assert, with a stronger channel between scientists and politicians in Brazil, both economic growth and ecological preservation can be harmoniously reached.

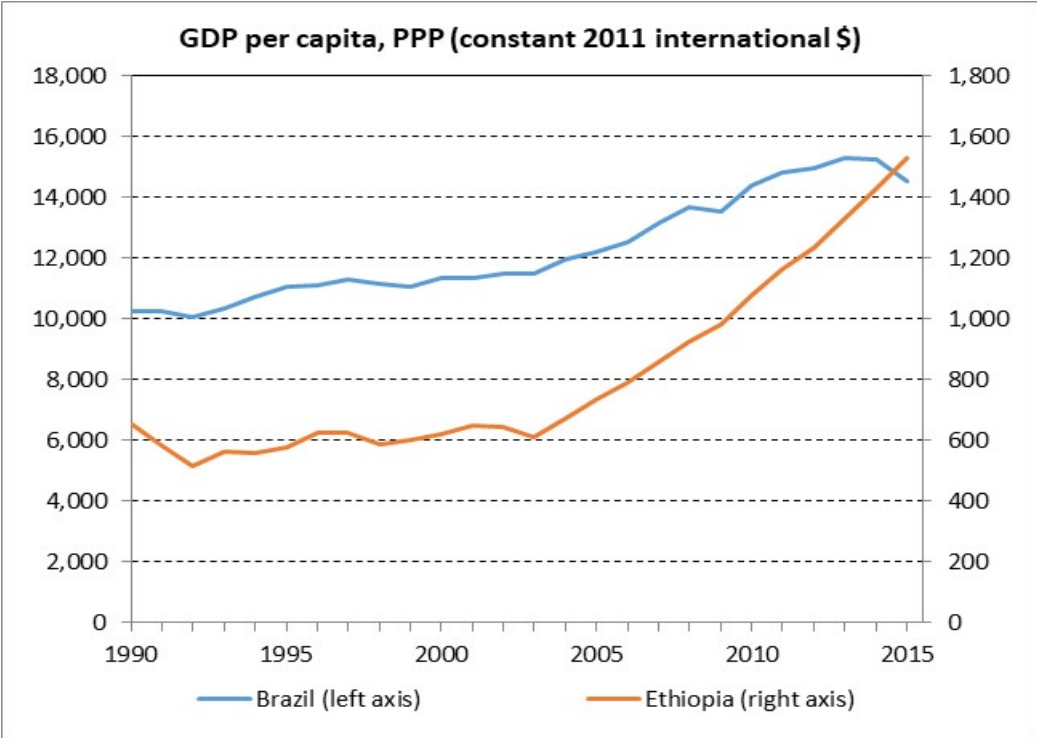
Dorosh and Rashid (2012) outlines Ethiopia's agricultural system. The authors describe the state of food in Ethiopia as a "complex reality," because of Ethiopia's great geographic diversity at an extremely local level, and its dramatic fluctuations in governance, policy, and weather shocks. They assert that food security crises owe as much to policy as natural disaster, and explain the ways that better Ethiopian policy can mean better food security by tracing the history of Ethiopia's government, which was once socialist and has since liberated to a democracy that has privatized and opened up trade. They then describe the current focus of the Ethiopian economy, an initiative called the Agricultural Development-Led Industrialization strategy (ADLI). It has "dramatically" shifted the focus of government investments away from industry and large farms and toward broad-based growth of smallholder agriculture. They maintain this has been very successful, and are optimistic for its continued success, since Ethiopia's recent improvement in agricultural production and markets has, among other things, markedly increased household consumption and almost halved poverty.

Baye (2017) points to the Ethiopian cultural fabric surrounding farming. She explains that Ethiopian peasants have continually been content with subsistence farming, and that traditionally, Ethiopians have practiced polyculture farming, meaning the regular rotation of various crops and livestock to meet the nutritional needs and security of one’s family and community. Traditionally, peasant farmers have dedicated only a small portion of their efforts to growing cash crops to bring to the markets. Above this backdrop, Baye claims, as Ethiopia reached the 20th century, several problems arose. First, governmental efforts to control and divide portions of land disconnected farmers and stripped their power to subsistence farm. Second, under these new divisions, Ethiopia’s regular low productivity became a bigger problem. Under the free polyculture system, diversity of crops made up for low yields; under the fragmented system, emphasis on production highlighted Ethiopian deficiencies in seed selection, fertilization, and land fertility. Hence, Baye (2017) highlights the shortcomings of the government before its 1974 reforms and traces their implications today.

III. Empirical Background

This empirical background section provides an overview of the stages of development Brazil and Ethiopia have reached, which has implications on the importance of agriculture and the stakes for agricultural growth in both countries. As Figure 1 shows, Ethiopia is a much poorer and far less developed country than Brazil. Throughout the period of 1990 to 2015, Brazil’s GDP per capita has dwarfed Ethiopia’s: Until 2015, the average Ethiopian person had never reached even 1/10th of the GDP per capita of an average Brazilian person.

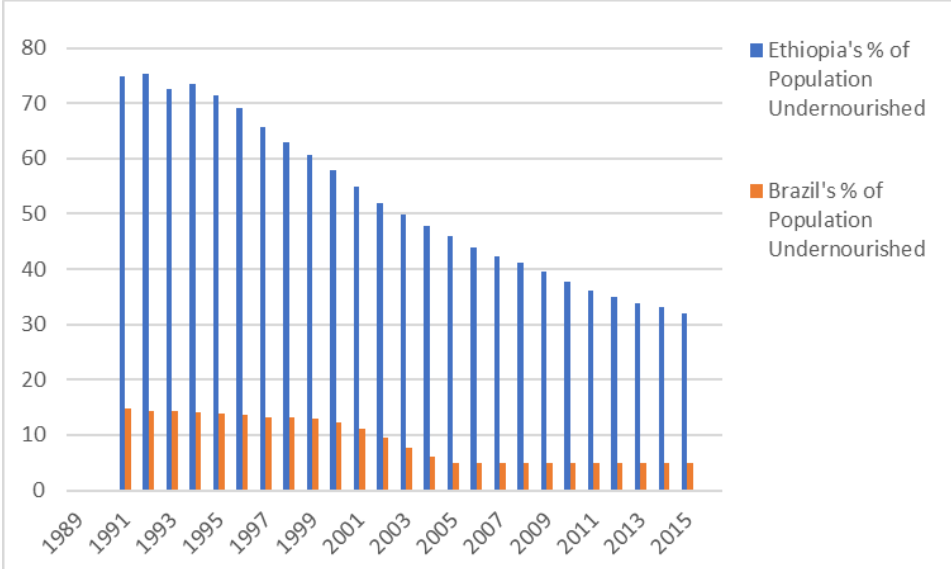
Figure 1: Brazil's and Ethiopia's PPP-adjusted GDP per capita, 1990-2015



Source: Created by author based on World Bank (2017).

Food insecurity is regularly high in Ethiopia, even in years when the country is free from natural disasters like droughts. Examining some poverty and health indicators, it is clear that Ethiopia has far greater strides to make in ensuring the wellbeing of its people. The World Bank (2017) data show sobering concerns for Ethiopia: For instance, as of 2015, 32 percent of the Ethiopian people are undernourished based on a measure of adequate dietary energy. Comparatively, Brazil is currently in a much better position. Based on World Bank (2017) data, Brazil's undernourished population has been below the 5-percent threshold since 2005, though still a distressing issue, recognized to be statistically nominal. A comparison of the evolution of this measure in both Ethiopia and Brazil can be seen in Figure 2.

Figure 2: Percentage of Total Population Undernourished in Brazil and Ethiopia



Source: Created by author based on World Bank (2017).

Given the lack of food, many Ethiopian children are stunted, underweight, and experience wasting. Based on World Bank (2017), as of 2014, in children under 5 years of age, the prevalence of stunting stood at 40.4 percent in Ethiopia (compared to 7.1 percent in Brazil), the prevalence of underweight children was 25.2 percent in Ethiopia (compared to 2.2 percent in Brazil), and the prevalence of wasting (which is defined as the proportion of children under age 5 whose weight for height is more than two standard deviations below the median for the international reference population ages 0-59) was 8.7 percent in Ethiopia (compared to 1.6 percent in Brazil).

Ethiopia's economy is also currently much more reliant on agriculture than Brazil's. As of 2015, Ethiopia's agricultural industry accounted for 40.9 percent of its GDP, while Brazil's agriculture accounted for 4.9 percent of its GDP. In 1973 and 1984, Ethiopia experienced two major famines. This was at a time when agriculture made up closer to 60 percent of the Ethiopian economy, and hence, these disasters had devastating effects not only on the country's food security and citizens but also on its GDP, manifest in 1984 and 1985 when Ethiopia's GDP fell 2.8 and 11.1 percent, respectively (World Bank, 2017).

Brazil, meanwhile, has transformed economically since the 1970s. Though agriculture hasn't historically been nearly as instrumental to the Brazilian economy as the Ethiopian— only comprising 12.4 percent of the GDP as far back as 1970— Brazil still more transformed to its current rate of 4.9 percent. Brazil has recently become a Newly Industrialized Country (NIC), which, somewhat ironically, has hidden the exceptional growth and revolution of its agricultural sector beneath the meager performance of its industrial and service sectors in the last 40 years (Chaddad 2016). Brazil and Ethiopia's annual GDP growth in percent and annual value-added agricultural growth can be seen beside each other in Figure 3, clearly demonstrating a stronger link between the movement of the two in Ethiopia. (Data for Ethiopia did not begin being collected until 1982, while Brazil's began in 1970.)

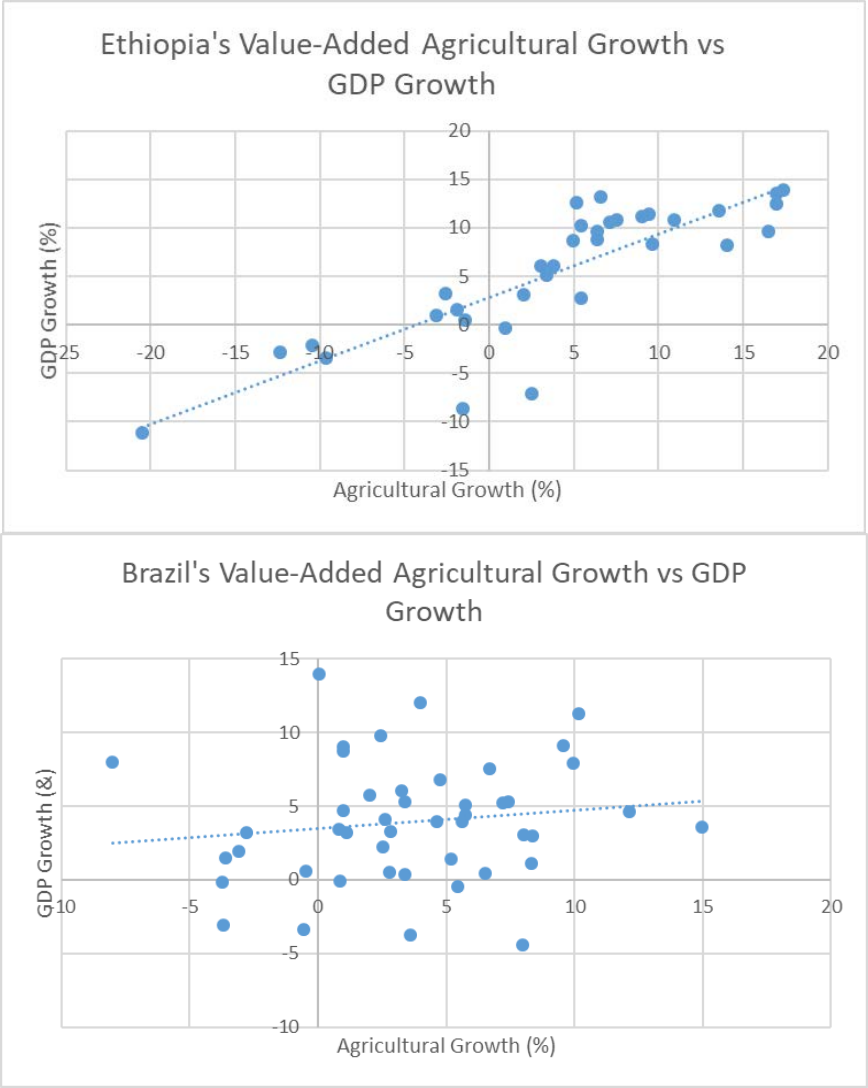
Figure 3: Ethiopia's and Brazil's Growth in GDP and Value-added Agriculture



Source: Created by author based on World Bank (2017).

Correlation analysis further shows the respective links of agricultural growth to total GDP growth in these two countries. Figure 4 shows the scatterplots of Brazil and Ethiopia’s annual GDP growth as explained by annual value-added agricultural growth: In Ethiopia, there is an extremely strong correlation between the two, with a correlation coefficient of 0.835. In Brazil, there is a weak correlation of 0.137.

Figure 4: Ethiopia's and Brazil’s Correlation between GDP Growth and Value-added Agricultural Growth



Source: Created by author based on World Bank (2017).

Brazil’s agriculture is now commonly seen as a model for African countries like Ethiopia. Nonetheless, Brazil’s agricultural productivity revolution is an exception to the rest of the country’s economic performance: it occurred *despite* the country’s productivity on the whole being relatively low and stagnating since the 1980s. One useful indicator to review is growth rate of total factor productivity (TFP), which is a ratio of output to input showing production efficiency. As

shown in Table 1, there is a large discrepancy between Brazil’s TFP in agriculture and Brazil’s TFP of the whole economy. The data here point to the fact that, while Brazil’s agricultural sector has largely been a success story, the country faces several other economic obstacles that continue to qualify it as a developing country.

Table 1: Total Factor Productivity (TFP) Growth in the Brazilian Economy (1971–2012)

| | TFP growth (percent) [Source: Bonelli (2013)] | TFP growth (percent) in agriculture [Source: Gasques et al. (2014)] |
|-----------|---|---|
| 1971–1980 | 2.0 | N/A |
| 1981–1990 | -1.2 | 2.22 |
| 1991–2000 | 0.3 | 3.47 |
| 2001–2012 | 0.8 | 4.06 |

Source: Chaddad (2016), Table 1.5, p. 10.

Finally, the stakes are higher for Ethiopia’s agriculture because far more of Ethiopia’s population, and impoverished population, lives in rural areas, with limited city and market access. As of 2015, 80.5 percent of Ethiopians lived in a rural area, and that number is growing— it grew 1.9 percent in the same year. Meanwhile, only 14.3 percent of Brazilians lived in a rural area in 2015, at a growth rate of -0.9 percent that year. Further, agriculture accounts for the employment of three-fourths of Ethiopians, and 90 percent of the poor live in rural areas (Dorosh and Rashid, 2012).

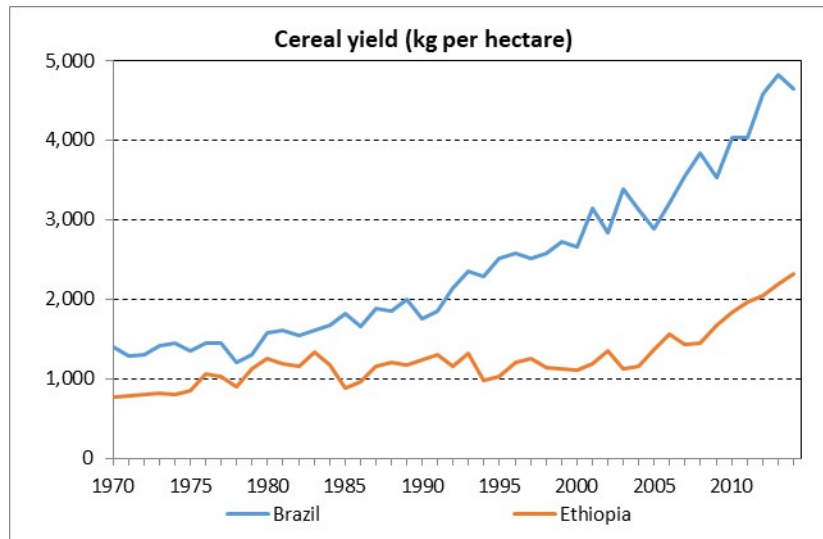
Ethiopia is uniquely un-urbanized: in 2015, the country was 19.5 percent urban while its surrounding region, Sub-Saharan Africa on the whole, was 38 percent urban. Though Ethiopia continues to make strides in its market access, as of 2009, 45 percent of Ethiopians still lived more than 5 hours from a city of 50,000 people (Schmidt and Kedir, 2009). Hence, Ethiopia is an agriculture-based country and the best and most immediate way to reach the country’s many impoverished people (33.5 percent of the country living below \$1.90 a day in 2010) is through agriculture. As the World Bank (2008) *World Development Report 2008: Agriculture for Development* outlines, a productivity revolution for Ethiopia’s many smallholding farmers is in order.

IV. Ethiopia’s and Brazil’s Use of Improved Seeds

IV.1. Agriculture and Productivity: Cereal Yield

While Ethiopia is strongly dependent on its grain production for the survival of its people, the country faces low cereal yields. As shown in Figure 5, as of 2014, Ethiopia’s cereal yield per hectare of harvested land was almost exactly half that of Brazil. While Ethiopia’s yield lags, the rate *has* grown markedly since the 2000s, and is ahead of the average rate of its Sub-Saharan African neighbors, so there is reason to be optimistic about the future. Interestingly, Brazil’s yield has skyrocketed even more in recent years, almost doubling since 2000. This can be accounted for by the technological advancements Brazil’s agricultural system has made.

Figure 5: Average Cereal Yield (in kg per hectare of harvested land), 1970-2014



Source: Created by author based on World Bank (2017).

IV.2. Agricultural Technology: Improved Seeds

One of the main drivers of increased crop yields is the use of improved seeds. These are seeds that are developed, through organic or chemical methods, to have desirable qualities, especially higher yields and the ability to survive in adverse conditions like unfamiliar climates. There are three types of improved seeds: “open-pollinated seeds,” which are created by selecting and saving desirable naturally reproduced seeds; “hybrid seeds,” which are created by cross-breeding two desirable plants, and which lose their effectiveness and cannot be replanted after one season; and “genetically modified seeds,” which are created by inserting any desirable gene from an organism into a plant’s genome (Cho, 2013).

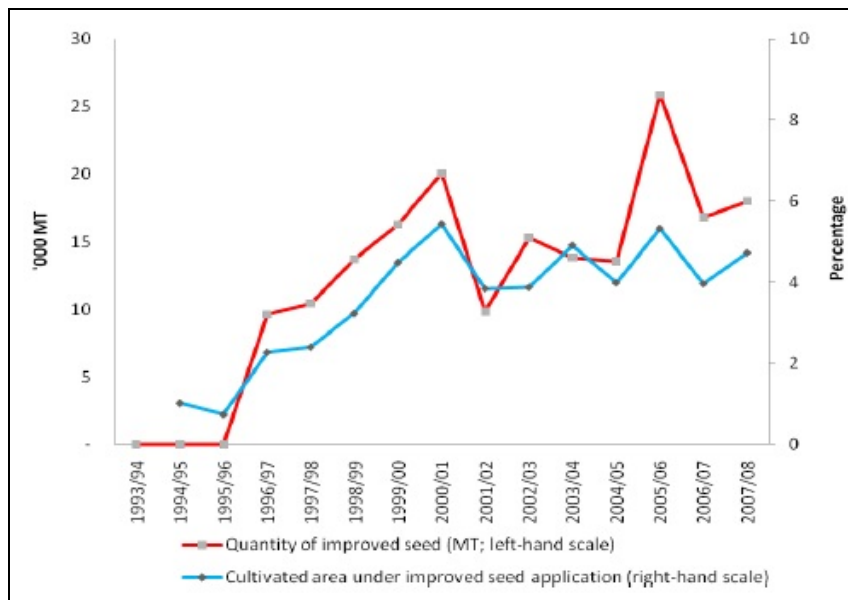
IV.3. Ethiopia’s Improved Seed Use

As Spielman et al. (2011) point out, the use of improved seeds has been historically sparse in Ethiopia, and though use has risen in recent years, the gains have been inconsistent and volatile. The dissemination of improved seeds through market forces is a tricky situation. Since there are extensive research and development (R&D) costs, and farmers can replant open-pollinated and genetically modified seeds effectively for many seasons without needing to buy new seeds, it is hard to have a profitable improved seed business.

Thus, in Ethiopia, widespread adoption of improved seeds has been difficult, and as of 2007–2008, improved seeds covered an average of only 4.7 percent of Ethiopian cropland, as shown in Figure 6. Even Ethiopian wheat, which diverges from this figure in being predominantly improved — 71 percent of Ethiopian wheat was in 2002 — points to a larger issue; a 2005 study showed that only 43 percent of the area under improved wheat varieties was sown with varieties released since 1995 (Spielman et al., 2011). That is, the rest of those seeds have been continually replanted, free of charge, since then. As this is undoubtedly a disincentive for a capitalistic seed market, the production and distribution of improved seeds has been largely left into the hands of a state-owned

entity, the Ethiopian Seed Enterprise (ESE), and the endeavor has been largely stagnant since around 2000.

Figure 6: Area Under Improved Seed Application and Quantity of Improved Seed Distributed (Cereals Only), 1993/94 to 2007/08



Source: Spielman et al. (2011), Figure 3.1, p. 11 (referring to Ethiopia, CSA (various years) as source).

IV.4. Issues with Ethiopia's Improved Seed Market

Still, Ethiopian farmers want new improved seeds and recognize their transformative ability. The issue, however, is that the public improved seed system in Ethiopia consistently fails to supply the amount of seed demanded by farmers. In 2008, the supply of improved seeds in Ethiopia's five major cereals fell short of demand by 72 percent.

One of the main reasons this figure consistently falls short is the insufficient provision of improved seeds by Ethiopia's research system to be multiplied and produced. In charge of R&D and the following provision of seeds are federal and regional research centers and universities, and inefficiencies at these institutions have often resulted in major issues for seed production. Mainly, government officials recognize that the public funds allocated to universities for agricultural research are inadequate, and that universities themselves lack valid infrastructure and qualified researchers (Belete, 2014). Indeed, formal academia is rather nascent in Ethiopia: from 2000 to 2011, the number of Ethiopian universities quickly grew from 2 to 32. Undergrad and postgrad enrollment both more than doubled in this short period. However, research in Ethiopian universities did not see a commensurate growth, and is today clustered in only a handful of universities, likely because of the obstacles cited above. Hence, Ethiopia's research activities do not meet the demands for growth by the country's industry. A private company cannot expect to stay in business with a meager and sporadic supply of input: Without a sense of stability, private companies are not incentivized to enter the seed business.

With the R&D wing of the seed market remaining a public endeavor, along with the above disincentives for private seed companies, those who *do* choose to enter the seed market often end

up serving as subcontractors for the public Ethiopian Seed Enterprise. Thus, the ESE’s pricing dominates the market. This discourages private enterprise because the ESE sets a rigid 5 percent profit margin pricing on its seeds, which is not enough for private companies to recoup their investments in production. While to some degree, the nature of improved seed development requires public help, since there is a long and often-expensive R&D period and farmers’ replanting can fizzle out investments, there nonetheless is a strong market for private production and retail distribution even in other Sub-Saharan African countries, yet Ethiopia remains dominantly public in this realm.

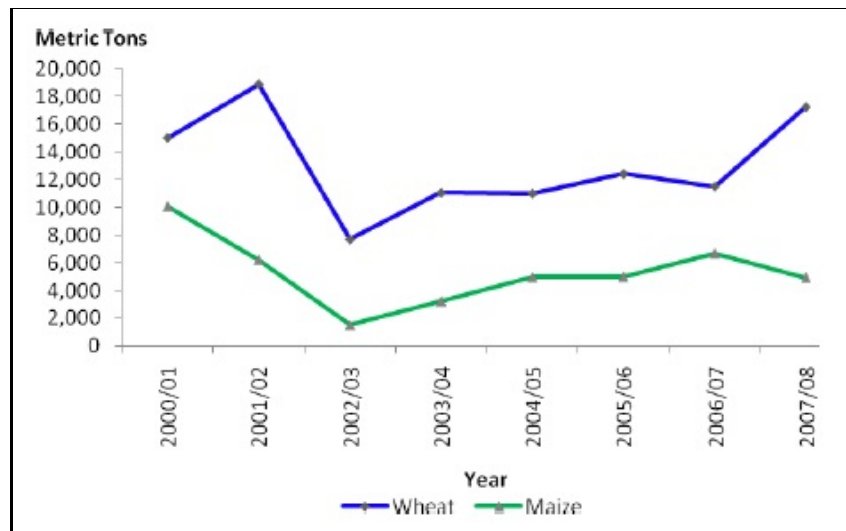
IV.5. Issues with Ethiopia’s Improved Seed Production

While Ethiopia’s public seed market’s structure presents many challenges for the dissemination of improved seeds to farmers and thus for agricultural intensification, there are also closely related issues in the production of improved seeds that contribute to the supply and demand gap (as mentioned, supply was short 72 percent for the five major cereals in 2008).

Of the seeds they have received, Ethiopian farmers have long reported two issues. The first is receiving defective seeds, which may be dirty, broken, and/or not germinating. The second is of not receiving seeds in a timely manner. If not received promptly, farmers can either have on their hands seeds past their optimal planting time or seeds rendered ineffective after changes in weather conditions. As Dorosh and Rashid (2012) highlight as a central complexity to Ethiopian agriculture, Ethiopia is both regionally and climactically diverse on an extremely local level, so environmental conditions hinder the potential for sweeping agricultural initiatives.

The volatile Ethiopian environment also explains the inadequacy of the production itself of improved seeds. When there are droughts in Ethiopia, seed production falls just as crop production does. The ESE’s precipitous drop in seed production during the severe 2002–03 drought in Ethiopia can be seen in Figure 7. A remedy for this is to grow seeds on irrigated land, and since irrigated land is sparse in Ethiopia, the expansion of which is an urgent endeavor (Spielman et al., 2011).

Figure 7: The Ethiopian Seed Enterprise's Raw Seed Production from 2000 to 2008



Source: Spielman et al. (2011), Fig. 3.6., p. 16 (referring to Ethiopia, ESE (various years) as source).

Furthermore, Ethiopian smallholding farmers themselves are often used as contract growers of improved seeds for the ESE. All the diverse issues of market, policy, and environment impinge on farmers' production here. For one, poor weather translates to poor production. For another, the ESE pays its contract farmers a 15 percent premium over grain market prices for good seeds, but the volatile grain market incentivizes smallholders to default on these contracts (Spielman et al., 2011): Since grain prices rise at planting time and fall at harvesting time, farmers are tempted to sell the seeds when they get them (perhaps after receiving them late or rendered suddenly inappropriate for local weather changes, anyway) on the market instead of working to grow them only to receive a lower price from the ESE. In effect, this hinders the ESE's ability to bulk up on the improved seeds they want, which, in the long game, would help the private market and smallholders themselves, making it a vicious cycle.

IV.6. Issues with Ethiopia's Improved Seed Policies

One of the largest hindrances to an active private improved seed market in Ethiopia is the country's failure to secure intellectual property rights (IPRs). IPRs would grant the innovator of new seeds better ability to recoup investment costs after demanding payment from farmers who choose to use their seeds, which is currently not a reality in Ethiopia. In fact, IPRs are a relatively new concept in Ethiopia; the country's first patent law was established in 1995 and it was not implemented until 1997. A national system for intellectual property did not begin until 2003, with the establishment of the Ethiopian Intellectual Property Office (EIPO) (Belete 2014). Still today, Ethiopia is not a member of the World Trade Organization (WTO), the organization through which other countries sign treaties honoring international IPRs. A widespread culture of disregard for international IPRs thus exists in Ethiopia; in two examples, Ethiopian shopping malls commonly have pirated movie kiosks, and Ethiopian companies frequently copy the branding of international companies (*The Economist* 2017). Local officials generally show little care for violations of international IP like these, and this translates to attitudes toward domestic IPRs.

The Ethiopian government has recently begun advocating for more IPR laws and stronger enforcement in hopes of attracting foreign investors and becoming more competitive in the global market. As well, Ethiopian officials have debated heavily about whether the country's universities should claim IPRs on innovations (including agricultural ones) made by their researchers as a way to commercialize their findings and transfer them into real industry. Officials in government, higher education, and industry alike cite that there is an issue with the connection between university research and industry application in Ethiopia.

But research done by Belete (2014) concludes that up and down the system in Ethiopia, gaps in knowledge about IPRs and the ability to implement them seriously inhibit IPRs' potential to advance the country's agriculture and industry on the whole. Belete (2014) finds that Ethiopian academics often don't know about intellectual property and rarely consider IPRs as a tool for transferring research outputs to industry. As well, they stress that industry application is not their primary goal. Moreover, Ethiopian industries are overwhelmingly ill-equipped to incorporate new research from universities, often lacking the skills, technology, and training to, and the capacity to take the risks this entails. Governmental organizations, such as the EIPO, lack the training, experience, and knowledge to seriously handle patent applications and draft beneficial policies.

IV.7. Brazil's Improved Seed Use

Brazil, meanwhile, has overcome many of the obstacles Ethiopia now faces. Researchers widely believe that without Brazil's major advances in agricultural technology— particularly, the development of seeds viable to grow in its *cerrado* region (a tropical savanna once thought infertile)— its agricultural revolution would not have happened. Today, Brazil has a robust improved seed industry. In 2009, more than 2.17 million tons of seeds were produced in Brazil (Morin, 2010). Brazilian farmers use improved seeds at a very high rate in absolute as well as relative numbers, partially because Brazil is home to many large agribusinesses oriented toward production and export. Even still, rates of improved seed use are high for crops sold predominantly domestically as well. In fact, as shown in Table 2, as of 2010, domestic sorghum seeds were 90 percent improved and domestic corn seeds were 84 percent improved.

Table 2: Brazilian use of improved seed for selected crops (in tons of hectares)

| Crop | Production 07/08 (t) | Production 08/09 (t) | Area Planted 08/09 (ha) | Area Planted 09/10 (ha) | Effective Demand for Improved Seed | Potential Demand for Improved Seed 1/ | Level of Utilization to Seed (%) |
|----------------|-------------------------|-------------------------|-------------------------------|-------------------------------|---|--|---|
| Soybeans | 1,242,839 | 1,290,788 | 20,831,900 | 23,239,000 | 892,378 | 1,394,341 | 64 |
| Corn | 292,867 | 232,595 | 14,409,810 | 13,030,200 | 218,907 | 260,604 | 84 |
| Wheat | 275,621 | 337,703 | 2,403,000 | 2,428,000 | 244,742 | 339,920 | 72 |
| Irrigated Rice | 81,210 | 83,932 | 2,026,100 | 1,982,400 | 130,838 | 237,888 | 55 |
| Dry Beans | 14,789 | 48,115 | 4,183,200 | 3,789,600 | 25,011 | 227,376 | 11 |
| Sorghum | 8,137 | 8,665 | 798,000 | 780,600 | 7,025 | 7,806 | 90 |
| Cotton | 6,945 | 10,291 | 747,100 | 836,000 | 5,518 | 12,540 | 44 |
| TOTAL | 2,072,614 | 2,174,872 | 46,713,829 | 47,207,200 | 1,569,442 | 2,583,251 | |

Note: 1/ Potential seed demand is total seed use in Brazil and effective seed demand is current improved seed use.

Source: Morin (2010), p. 3 (referring to ABRASEM as the source).¹

3.8: Brazil's Improved Seed Market

Brazil's improved seed market begins with a strong research system. A crucial factor in Brazil's development of this system was the country's establishment of various graduate education programs in the agrarian sciences in the mid-20th century (Ramalho et al., 2012). The first Brazilian course in Plant Genetics and Breeding was established at ESALQ (The Luiz de Queiroz College of Agriculture) in 1969. Interest in studying the agrarian sciences was small and concentrated in Brazil until the creation of EMBRAPA (The Brazilian Corporation for Agricultural Research) in 1973, which was spearheaded by the Brazilian Ministry of Agriculture, Livestock, and Food Supply. Hence, by largely a federal effort, EMBRAPA created agricultural research jobs in Brazil that sought candidates educated in agrarian sciences at a graduate level. This created a pragmatic and covetable position in Brazilian society to research agricultural technology.

¹ The author recreated the table and corrected the numbers for potential demand for improved seed for soybeans and cotton based on the level of utilization to seed (last column).

Still, strong research alone is not sufficient to power a seed market; crucial is the connection between R&D and production, as we have seen as a shortfall in Ethiopia. Hence, for Brazil's seed market to have grown in this early period, it required attracting private businesses. As I will explore more below, this was largely accomplished by Brazil's securing of IPRs for improved seed innovations. As a result of IPRs, starting in the 1990s, large corporations began acquiring domestic seed companies and negotiating licensing agreements with research institutions like EMBRAPA, linking innovation to production after finding profit in the seed industry.

Two companies that played a seminal role in Brazil's developing improved seeds and making them available to farmers were Fundação Mato Grosso (FMT) and Coodetec (Chaddad 2012). Coodetec began as a research wing for a state-level farming cooperative in 1974. The cooperative funded this first project through the combination of public funds from the Wheat Research Fund and the Soybean Research Fund and local investments from farming cooperatives who were desperate for higher yields. When Coodetec developed its first improved seeds in the early 1980s, before IPRs were established, it was able to survive without royalties because of the regular contributions cooperatives made during the research stage in lieu. It was not until Brazil began protecting IPRs that Coodetec was emboldened to convert its research wing into a commercial seed company, seeing the new opportunity for profit from R&D. This was a correct estimation, as Coodetec's revenues eventually increased from about US\$1 million in 1995 to more than US\$100 million in 2013, and its wheat seeds comprised 26 percent of Brazil's national market share in 2003, showing the importance securing IPRs had in Brazil for the growth of improved seed research and the agricultural industry.

Fundação Mato Grosso (FMT) is an important case because it evinces the power state–industry cooperation had in developing the Brazilian improved seed market. FMT was founded in 1993 in response to shortcomings by Brazilian state research. Frustrated with EMPRABA's funding obstacles, FMT was born deciding to, again, as with Coodetec, receive its funding from farming cooperatives. For the success of its research, FMT was dependent on the agreement it then signed with EMBRAPA to use its germplasm for soybeans and to test seeds in various regions throughout Brazil. Without the agreement, FMT would not have had the wherewithal to produce the rapid innovations it then did in improved seeds, including soybean seeds finally able to flourish in the *cerrado*. By 1998, 77 percent of all soybean seeds produced in the state of Mato Grosso were developed by the EMBRAPA–FMT partnership (Chaddad, 2012). FMT was able to flourish by having the autonomy and financial incentive to innovate in addition to EMBRAPA's resources, namely germplasm. Such a model should be compared to the situation in Ethiopia, where private entities have difficulty breaking away from being mere subcontractors of the ESE.

IV.9. Brazil's Improved Seed Policy: Intellectual Property Rights

As we see a pressing systemic issue today in Ethiopia, until the mid-1990s, R&D efforts in plant genetics and breeding in Brazil were chiefly carried out by public institutions. Similar to Ethiopia, Brazil did not strongly protect researchers' control over their improved seeds with IPRs. Producers given newly developed seeds for trial-runs were capable of saving them and replanting them without having to compensate the researchers (Chaddad, 2012).

However, in 1994, Brazil signed the WTO agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) and then began legislation to protect private intellectual property, a move which, as stated above, Ethiopia has yet to make. As a result, Brazil has since enacted several laws protecting the intellectual property of plant breeders, including the Plant Variety Protection Law

of 1997 and the Seed Law of 2003. Thus, a framework was set up in Brazil that assured private companies they'd be protected in their investments in R&D and that economically incentivized innovation by granting companies the ability to collect royalties and technological fees. As of April 2015, Brazil had 2,629 different plant cultivars protected (Campello Afonso, 2015), while, in Ethiopia, formal protection continues to be lacking. Brazil's success of the seed industry since introducing IPRs suggests Ethiopia should similarly embrace IPRs.

IV.10. Effects of Improved Seeds on Brazil's Agriculture

Brazil's enabling factors of an incentivized class of agricultural researchers and protected intellectual property have had enormous consequence on its agricultural development. Even before intellectual property was secured, Brazilian innovations through research created long-unthinkable agricultural realities. In an instance, up until the late 1970s, barely any Brazilians ate apples: they were a "special-occasion" food, reserved for Christmas or a sick child; they were expensive and almost always imported. Since that time, with the introduction of clones and with artificial selection under south Brazil's conditions, Brazil has not only met domestic demand for apples but has also become an exporter of them (Ramalho et al., 2012). Across the board, Brazil has made large advances in crop yield since 1974, a year when graduate study in agrarian science began in earnest and EMBRAPA was recently created.

Further, looking at the data for Brazil's growth in cereal yield may lend insight into the role of intellectual property rights on intensification. The data from 1975 to 2014 show an average annual growth in cereal yield of 3.6 percent. However, up until 1994, when Brazil signed the WTO agreement on TRIPS, growth in yield averaged 3.2 percent; from 1995 to 2014, the average rate grew to 3.98 percent. After 1997, when Brazil enacted the Plant Variety Protection Law, the average rate until 2014 grew to 4.07 percent. Of course, this is not to imply direct causation. Still, as can be seen in Figure 5 above, Brazil's cereal yield saw large spikes in growth in the period from 1995 onward that were not present beforehand. As well, the largest absolute growth in cereal yield came at +593.3 kg per hectare in 2003, the year the Seed Law was enacted.

V. Conclusion

As this article discussed, Brazil's agriculture has transformed in the last forty years. Brazil has gone from a net importer that relied on food aid to the world's largest net exporter. Ethiopia is currently facing many of the agricultural obstacles Brazil has recently mounted, and today, the survival of Ethiopia's economy and its people is dependent on large gains in agricultural productivity. As Ethiopia is overwhelmingly rural and the majority of its citizens work in agriculture, a productivity revolution is now crucial to eradicating the country's poverty. While the country has recently made bounds, it continues to struggle with this, especially with the widespread adoption of improved seeds.

However, Ethiopia's obstacles in adopting widespread improved seeds are surmountable, as we have seen in Brazil. First, the country needs to begin securing intellectual property rights. This is the main reason private companies entered the Brazilian seed market; without IPRs, they saw the market as unstable and unprofitable. However, securing IPRs is not a hit-and-run deal. Many Ethiopians need comprehensive knowledge and training in IPRs, and the culture needs to change to see the value in protecting IPRs. Furthermore, the adoption of IPRs must be part of a bigger holistic strategy to improve Ethiopian life. As stated in *The Economist* (2017), one Ethiopian lawyer asked, referring to Ethiopia's mass poverty: *How would we pay for intellectual property?*

As poverty remains widespread and devastating in Ethiopia, the country must secure IPRs in concurrence with several other human development programs that focus on uplifting impoverished Ethiopians. Efforts to increase education and household-income are essential.

In sum, for the growth of the Ethiopian seed industry, a steady federal hand needs to guide an economic matrix that incentivizes rigorous research and industrial profit while at the same time prioritizing improving the lives of poor Ethiopian farmers. This is no small feat, but Ethiopia's recent progress in development affords confidence.

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