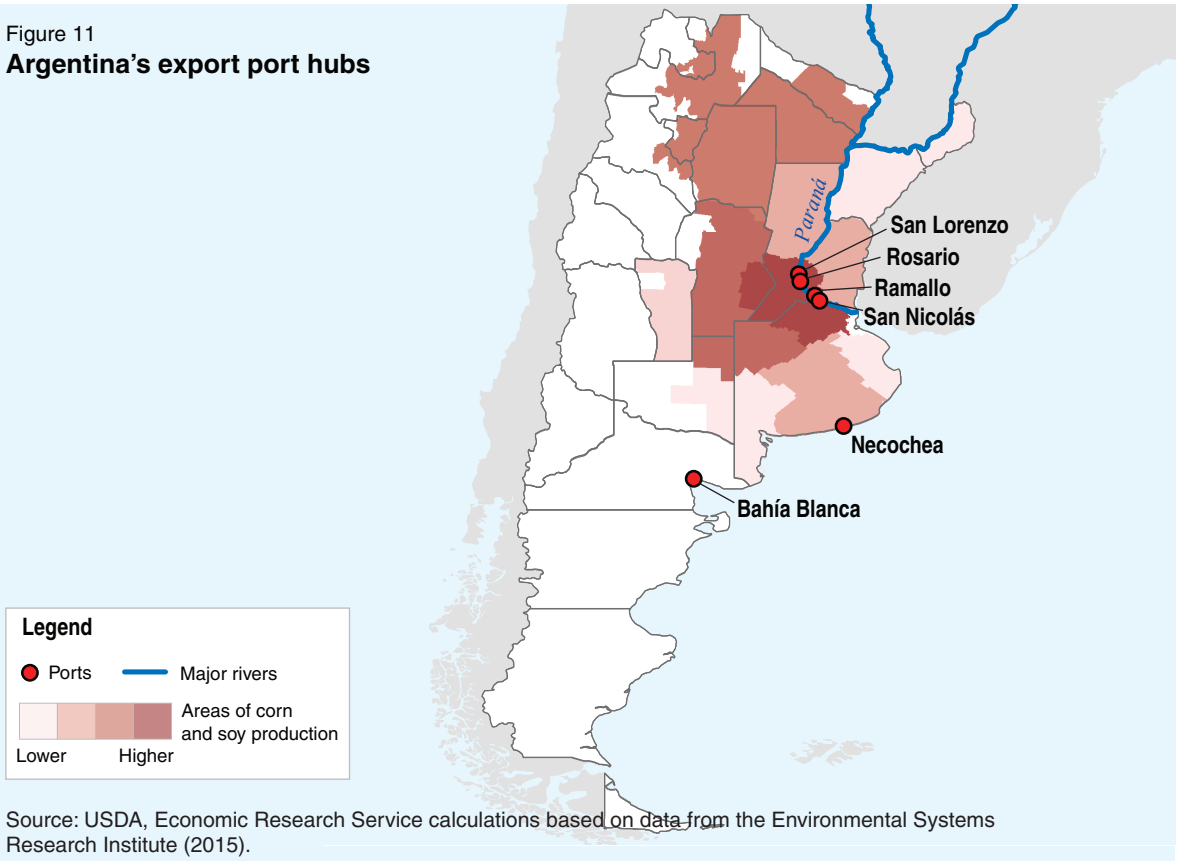
Corn is grown in most U.S. States, but production is concentrated in the Heartland region (fig. 10), which accounts for an average of 76 percent of U.S. corn grain production (an average 13 percent of all corn production is exported). U.S. soybean production is also concentrated in the Heartland—an average of 72 percent of all U.S. soybeans are grown there (and about 44 percent of U.S. soybean production is exported).[24] Much of the corn and soybeans for export is destined for the Gulf ports. Overall, U.S. corn and soybean exports rely on barge (54 percent and 49 percent, respectively) and rail (37 percent and 38 percent, respectively) for long-distance shipments (table 6). (For a detailed discussion of U.S. corn and soybean transportation, see Denicoff et al. (2014a, b).)

Drivers of transportation costs: Argentina

While **Argentina's** costs of production (table 5) are significantly below those in the United States and in Brazil (except for soybeans grown in Mato Grosso), its export price (FOB port price) is higher. The reason for this gap is the impact of fees (export taxes) and extra costs (risk of export restrictions), which lower the prices paid to producers. Inland transportation for soybeans, however, is competitive with Mato Grosso and that of the United States because the main soybean production regions in Argentina, as well as the country's main crushing complex, are near the most important (i.e., efficient) port hubs: the Paraná River (which includes the port of Rosario), Necochea Port, and Bahia Blanca Port (fig. 11) (Ordonez et al., 2001).

Figure 11
Argentina's export port hubs



Source: USDA, Economic Research Service calculations based on data from the Environmental Systems Research Institute (2015).

[24]The percentages are 5-year averages over 2008/09 to 2012/13, as reported by USDA-NASS, 2015b.

In Argentina, the largest share of crop production by far (85 percent) is transported to the ports by truck, while train transport makes up 13 percent and the Paraná river system accounts for the remaining 2 percent (López, 2012). Unlike the United States and Brazil, where the main production areas can be more than 1,000 miles from the port areas, the average distance in Argentina is less than 200 miles. Although the agricultural frontier has moved to inland Provinces such as Salta (about 600 miles from the Rosario Port), prices in the port areas remain the reference points—putting pressure on the margins of producers in inland areas who need to be even more efficient to compete with producers closer to the port.

A considerable share of the extra cost in Argentina arises due to export taxes, which were 35 percent for soybeans and 20 percent for corn during the study period. In addition, there were also export authorizations that, in the case of corn, act mostly as an export restriction, which could cause considerable extra costs (such as storage costs and low domestic prices) and lower the prices paid to domestic producers. Argentina's inland transport and handling costs amount to 10 percent of the FOB port value for soybeans, and 15 percent of the FOB port value for corn (table 5). Thus, inland transport, handling, and other costs totaled 46 percent of FOB port value for soybeans and 52 percent of FOB port value for corn. Export taxes imposed by the Government put the Argentine farmer at a competitive disadvantage, as farmers bear much of the burden for these costs.

Drivers of transportation costs: Brazil

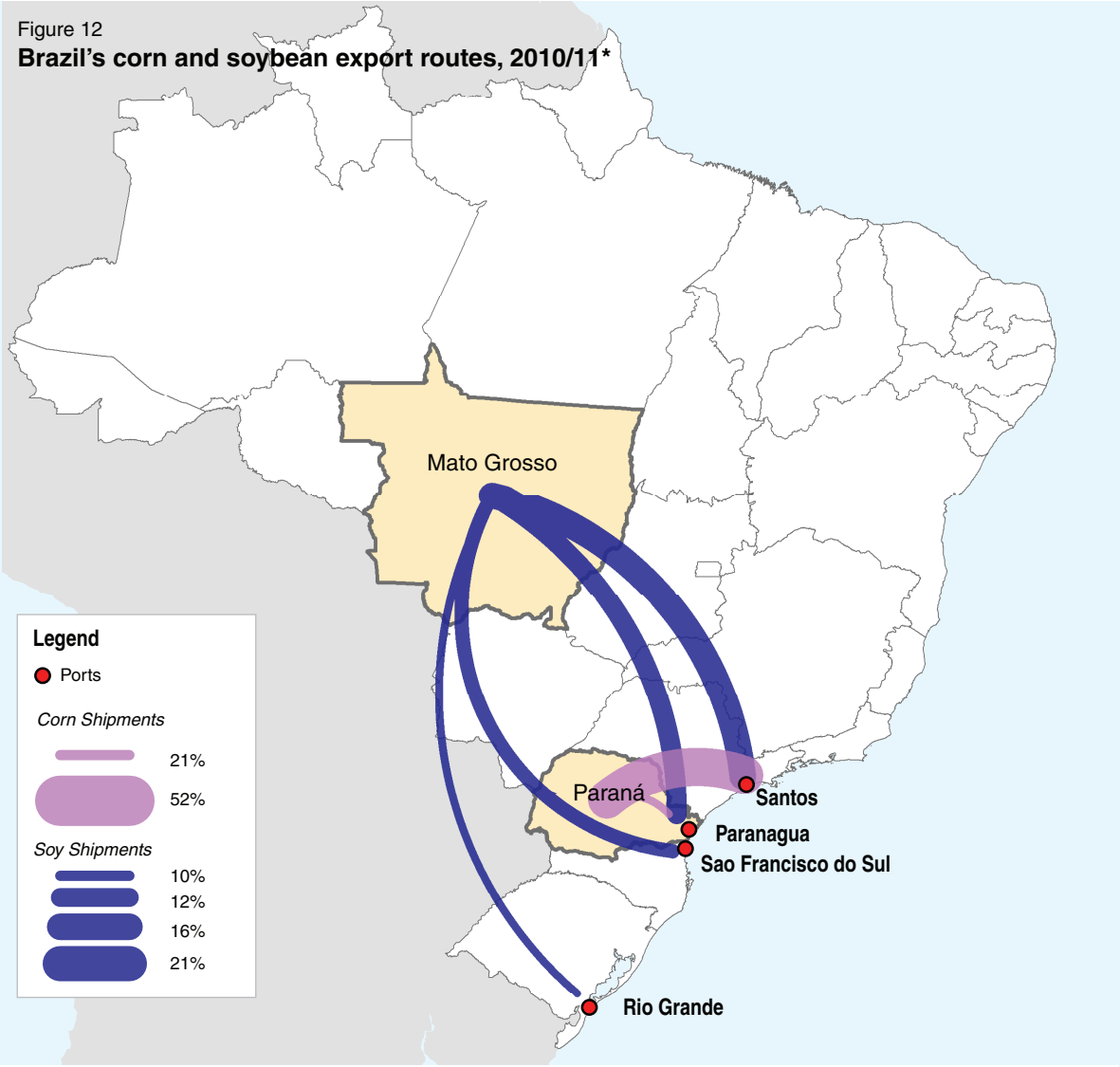
Although soybeans and corn are produced throughout **Brazil**, the States of Mato Grosso and Paraná account for a large share of Brazil's production, and these States form the basis of comparisons with transportation costs in the U.S. and Argentine Heartlands.[25] Paraná is close to the main Atlantic ports of Santos and Paranáguá (fig. 12); Mato Grosso is roughly 1,000 miles from the coastal ports. In 2010/11, 40 percent of soybean production was exported while the share for corn was 20 percent. Most transport is by road (63 percent), with rail transport making up 22 percent. About 12 percent of those shipments are at some point transferred to a barge and only 3 percent are transported entirely by river.

Similar to the main soybean and corn production regions in Argentina, Paraná's proximity to large ports keeps internal transportation/handling costs relatively low. From Paraná, these costs for corn and soybeans are $33 per ton, much below those in the United States and Argentina. Paraná accounted for 22 percent of soybean production and 19 percent of corn production during 2008-12. In contrast, the distance of Mato Grosso from ports on the Atlantic coast or alternate ports along the Amazon River, combined with the lack of a barge or well-developed rail system, put this region at a disadvantage compared with both the United States and Argentina. Internal transportation costs for soybean exports from Mato Grosso of $98 represent an average of about 20 percent of the port price, compared to 12 percent from the U.S. Heartland and 10 percent from the Argentine Northern Heartland (table 5). Transport costs are even higher ($102) and account for a larger share (36 percent) for Mato Grosso's corn exports. The region accounted for 29 percent of soybean production and 19 percent of Brazil's corn production during 2008-12. It should be noted that transportation costs are quite variable over time, and farm prices vary even more as they respond to supply and demand forces and changes in currency valuations.[26] In Brazil, the percentage of transport as a share

[25]In 2010/11, Mato Grosso accounted for 27 percent of Brazilian soybean production and 15 percent of corn production. Paraná accounted for 21 percent of soybean production and 25 percent of corn production.

[26]Brazil has also been affected by an economic crisis in the last 2 years, which has caused a depreciation of the cur-

Figure 12
Brazil's corn and soybean export routes, 2010/11*



*Since 2010/11, the second-crop corn (*safrinha*) grown in Mato Grosso has come to represent the bulk of Brazil's corn exports.
Source: USDA, Economic Research Service calculations based on data from the Brazilian Institute of Geography and Statistics (IBGE) (2014).

of landed cost has declined steadily over time in all regions. For soybean shipments originating from north Mato Grosso to Santos, that share declined from 45.4 percent in 2006 to 28.4 percent in 2012 (Salin, 2013).

The phenomenal growth in Brazil's trade, with a 65-percent increase in agricultural exports between 2005-14 and a 36-percent increase in agricultural imports during the same period, has meant that, despite intense development and modernization of highways, railroads, waterways, and ports, the country still requires huge investments in that sector to maintain competitiveness. Despite the progress achieved, Brazil's transportation infrastructure and ports face many challenges when it comes to increasing efficiency, reducing operating costs, and effectively attracting investment to sustain expansion of the agricultural sector.

rency, making the exports of corn and soybeans more attractive (USDA-FAS, 2014a).

Conclusion

Average farm-level production costs for corn and soybeans *per acre* were higher in the United States than in Argentina and Brazil in 2010, largely because of higher land and capital costs. These higher costs, however, are offset to a large extent by higher yields (over the 5-year period between marketing years 2008 and 2012), particularly for corn. National average production costs *per bushel* for soybeans were lowest in Brazil and highest in Argentina. On the other hand, the United States has the lowest farm-level production costs *per bushel* for corn at the national average level. While Argentina's Northern Heartland region has even lower costs, this production region accounted for only 25 percent of total Argentine corn production.

One variable that can distort production costs when comparing across countries is land value. Land values in the United States and Argentina are 2 ½ to 3 times those in Brazil. Given land's unique nature among inputs and the difficulty of determining comparable land values, we also compared returns over costs excluding the charge for land—in that case, the United States and Argentina are considerably more competitive in both corn and soybean production.

Transportation is also a major factor in export competitiveness. In the United States, more grain is moved to ports using lower cost barge and rail transport, while higher cost truck transport is more common in South America. In Argentina, high export policy costs due to taxes and risks of export restrictions lowered prices paid to producers, erasing their cost advantage from low cost of production and inland freight costs (due to proximity of the main production areas to ports). Brazilian producers had lower farm level production costs than the United States in soybean production in 2010. Moreover, the Paraná region of Brazil had the lowest marketing and transportation costs to the common destination (China). However, Paraná accounts for only 19 percent of soybean production in Brazil, while the U.S. Heartland, the second most competitive region, accounts for 74 percent of U.S. soybean production.

U.S. average national costs per bushel of soybeans, in turn, were lower than in Argentina, where returns were negative as a result of export policies resulting in low farm-level prices. U.S. Heartland returns were almost equal to those in Mato Grosso even though U.S. national average returns were below those in Brazil. Soybean prices paid by grain merchandizers were highest in the United States, closely followed by Brazil, and lowest in Argentina. The same patterns hold for corn, where higher U.S. per acre costs are more than offset by much higher yields, leading to considerably higher returns. The higher farm prices received by U.S. producers may reflect generally better infrastructure for marketing and transporting grain.

Long-term changes and adjustments in production, shipping, and handling costs, as well as costs associated with export policies and fluctuations in exchange rates, can have a profound impact on export competitiveness. As mentioned, Argentina's competitiveness could be greatly enhanced by reductions in export taxes and export restrictions, which depress prices paid to producers. The new Government that took power in December 2015 has already eliminated all agricultural export taxes (except for soybeans and soybean products, which have been reduced by 5 percentage points) and export restrictions. Argentina's agricultural sector is entering a new competitive environment which should be monitored and assessed further in the coming years. Brazil's costs can be reduced further if inland transportation costs can be decreased. These changes would further pressure U.S. competitiveness in world corn and soybean export markets.

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Appendix A: Methodology in Calculating Production Costs

This appendix presents information on data and cost components used in this report's comparison of cost of production of corn and soybeans. For each country, we provide background information on the surveys used, the structure of accounts, and the methods for estimating certain cost components.

The United States

The U.S. Department of Agriculture (USDA) has estimated annual production costs and returns and published accounts for major field crop and livestock enterprises since 1975. These historical accounts are based on the actual costs incurred by producers—they differ from projected accounts, which are often referred to as enterprise budgets and are reported by most U.S. land-grant universities to assist in farm planning. The costs and returns of all participants in the production process, including farm operators, landlords, contractors, and contractees, are included in the USDA accounts.

Survey/data—Data used to establish the cost and return estimates are based on producer surveys conducted every 4-8 years for each commodity and updated each year with estimates of annual price, acreage, and production changes. Commodity-specific surveys as part of the annual Agricultural Resource Management Survey (ARMS) are used to collect the data. These surveys gather detailed information about input use, field operations, and production costs of a particular commodity. Field enumerators personally interview farmers using questionnaires developed by USDA's National Agricultural Statistics Service (NASS) and the Economic Research Service (ERS).

Each farm sampled in the ARMS represents a known number of farms with similar attributes so that weighting the data for each farm by the number of farms it represents provides a basis for calculating estimates for the target population. Target populations for crop commodities include all farms producing one or more acres of the commodity. The survey data are supplemented with price and production data from other sources, mainly from USDA-NASS (2015b) to create the indices needed to develop estimates for nonsurvey years.

Structure of accounts—The commodity cost and return accounts are divided into operating costs and allocated overhead costs.[27] Operating costs are mainly cash expenditures incurred when factors of production are purchased or rented. Allocated overhead costs include many noncash costs that occur when factors are owned. For example, if a farmer fully owns the land used to produce a crop, he/she would have no expenditure for land rental or for loans to pay for the purchase of land. Yet, an economic cost arises because production resources are limited and have alternative uses. For example, by owning the land and using it to grow a crop, the farmer foregoes income from other uses of the land, such as renting it to another producer. Additionally, if a farmer uses savings to pay for operating inputs, such as seed, fertilizer, chemicals, and fuel, and thus pays no interest on operating loans, the farmer still incurs an economic cost because the savings could have earned a return in another use. Likewise, the farmer has an opportunity cost of his/her labor used in the production of the commodity because it could have been used on another farm or in off-farm employment.

[27]This format conforms to that recommended by the American Agricultural Economics Association Task Force on Commodity Costs and Returns (2000).

Estimating costs and returns—Methods recommended by the American Agricultural Economics Association Task Force on Commodity Costs and Returns (2000) are used to estimate the commodity costs and returns.[28] The following is an overview of the estimation methods.

The gross value of crop production is calculated by valuing the survey crop yields by harvest-month crop prices in each year. The crop production accounts include only costs incurred in the production of each crop commodity, excluding costs for marketing and storage. Secondary products are also valued.

Four basic approaches are used to estimate the commodity costs: direct costing, valuing input quantities, indirect costing, and allocating whole-farm expenses. The choice among approaches used to estimate particular cost items is mainly driven by the ability of farmers to report commodity-specific costs for that item. For example, most farmers can report the cost of seed purchased for a commodity, but cannot report the fuel cost for a commodity because fuel is typically used to produce several commodities on the same farm.

Argentina

Since agricultural statistics in Argentina are scarce compared to the United States, the Buenos Aires Grains Exchange developed the *Applied Agricultural Technology Survey (AATS) 2010-11*, mainly to assess the amount of inputs used at a regional and national level, and to obtain data for each crop, using 2010 as the benchmark.

The survey/data—The AATS collected data related to grain production, including information on soybeans, wheat, corn, sunflower, sorghum, and barley, through surveys carried out with the help of Qualified Informants[29] with knowledge of different aspects of the agricultural sector. The survey included variables such as input use and the adoption of various forms of crop management, such as no-till production, and covered 17 regions (figure A1).

Qualified Informants were interviewed by specially trained and experienced staff members of the Buenos Aires Grain Exchange. Consultations were conducted and structured around a nonprobabilistic sample, through deliberate and strategic sampling of each zone, to efficiently and representatively cover the entire agricultural area. Phone consultations were complemented by site visits.

Estimating costs and returns—For Argentina, the structure of accounts was modeled after the U.S. template. Input use was evaluated with respect to type of tillage, seeds or materials utilized in the planting period, amount and type of fertilizers, herbicides, insecticides, fungicides, and seed treatments. The production profile of each region is characterized by different quantities of fertilizers, seeds, and herbicides used for the production of soybeans and corn. Production practices were classified into three technological levels, and a matrix was prepared for each level for each region.

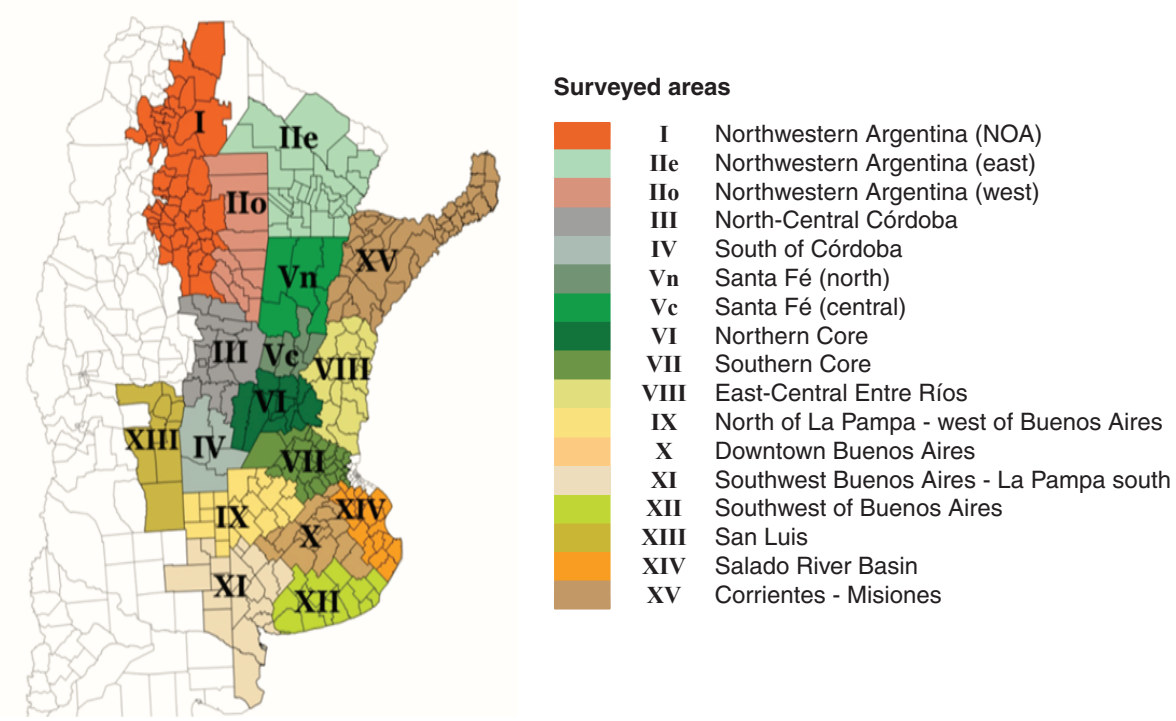
Data differences with United States—The Argentine data are similar to those of the United States with several exceptions. Irrigation expenses are not included in Argentina since that practice is

[28]Specifics of the recommendations and more details about the methodology used to construct USDA accounts can be found in the USDA-ERS Commodity Costs and Returns documentation (2015c).

[29]Qualified Informants are mostly agricultural advisors with knowledge of the production and management requirements of each crop across production regions. They might be input or custom-service providers, operating across large production areas.

Appendix figure 1

Argentina's crop production areas - 17 agro-ecological regions



Source: Applied Agricultural Technology Survey (AATS) 2010-11, Buenos Aires Grain Exchange, 2012.

uncommon, but some tax and insurance costs are included.[30] The most noteworthy difference is in calculating the costs of planting and harvesting. In Argentina, it is common to outsource planting and harvesting because of prohibitively high capital costs. For farmers, outsourcing services are less expensive than the capital investment and cost of maintenance, in addition to fuel and other related inputs. Hence, the cost of planting, fertilizing, and harvesting is reflected in the payments to custom operators. For this reason, fuel, electricity, and repairs, as well as capital recovery of machinery and equipment costs, are not calculated separately because they are captured within the custom operations cost estimate.

Data sources and methods—Direct costs were calculated based on input quantities presented in regional production matrixes. Operating costs were calculated based on quantity data from the AATS, complemented with price data from the publication *Márgenes Agropecuarios* (2008-15). The regions analyzed are those where most production is concentrated. The national average cost of production was calculated as a weighted average of regional values.

Brazil

Brazil's National Company of Food Supply (*Companhia Nacional de Abastecimento*, CONAB) has estimated annual production costs for major field crops since 1976. Cost accounts are constructed

[30]The interest rate for 2010 was calculated as 9 percent. Allocated overhead costs were based on the size of representative farms and information from the most recently available data from the Agricultural Census (INDEC, 2015) (at the time of this report, 2002 data were used because data from the 2008 Census were not fully available). The opportunity cost of land was calculated as a rental rate equal to a fixed percentage of the gross value of production (35 percent). Taxes include property, fuel, and income taxes. Insurance was not calculated.

using technical coefficient matrices to represent the resources used in the production of each commodity and the prices of the inputs used during each marketing year. The technical coefficient matrices include inputs, hand tools, and machinery for individual commodities, with the corresponding market prices. Information on area harvested, systems of production (conventional, transgenic, organic, no till), and type of technology used (manual, mechanized) are also included in the cost calculations. A representative municipality/region is selected based on the importance of that municipality's production, area, and yields for the specific crop, as reported by IBGE (2014) for several States (CONAB, 2010).

The survey/data— For Brazil, the structure of accounts was modeled after the U.S. template. Each marketing year, CONAB's field enumerators visit representatives from the selected municipalities to interview farmers and collect the cost-of-production data. For soybeans and corn, the production practice and cost data are collected in May, after harvest. The accuracy of the cost results is evaluated by a panel of representatives of all participants in the production process, including farm operators, input industry representatives, brokers, contractors, and lenders.[31]

Estimating costs and returns—Costs are updated annually for soybeans, corn, and all the field crops. Given the regional differences in the planting of the crops, cost estimates are separately estimated for the summer harvest, the winter harvest, and the dry-season harvest. The gross value of crop production is calculated by valuing CONAB's survey crop yields by State-average harvest-month crop prices in each year.

[31]Price data for inputs and services are calculated by a panel of representatives and from surveys conducted monthly by CONAB (*Companhia Nacional de Abastecimento)*. The cost of labor includes market wages for a total of 220 hours per month plus social security charges. Diesel and other energy expenses are calculated as a percentage of the machines' power, and capital is given a 6-percent annual rate of return. Maintenance/repairs and insurance are calculated as a set percent of the equipment's value or the value of the equipment being insured.

Appendix B: Costs of Production of Soybeans and Corn in the United States, Argentina, and Brazil, 2010/11

Detailed costs of production are presented by commodity and country, with estimates for each country's most important production region for each commodity, as well as an average for each country. Data for each country are presented in the original format, using 2010 production costs, and comparing costs and revenues using 2010/11 yields and harvest period prices.

Soybean costs of production

The United States—Since 74 percent of the 2010 U.S. soybean production occurred in the Heartland, we focus on soybean production costs for this region, in addition to providing a U.S. average (USDA-NASS, 2015b).

Argentina—During the 2010/11 season, soybeans covered 44.7 million acres (18.5 million hectares) (Ministry of Agroindustry, 2015). Soybean production is distributed throughout the country's agricultural regions in a variety of conditions. In addition to a national average, this study presents costs of production for the Northern Heartland,[32] where most production (21 percent) took place and the highest level of technology was used.

Brazil—In 2010/11, the States of Mato Grosso (in the frontier[33] agricultural region) and Paraná (in the traditional agricultural region) accounted for 48 percent of the 75.3 million tons of soybeans produced in Brazil in that year—27.1 percent and 20.5 percent of total soybean production, respectively. We provide soybean production costs for Mato Grosso and Paraná, as well as a national average soybean cost (IBGE, 2014).

[32]The following counties are included in this region: San Martin, San Jeronimo, Diamante, Victoria, Rosario, San Lorenzo, Caseros, Marcos Juarez, Belgrano, Iriondo, and Union.

[33]Brazil's frontier agricultural region reflects the westward expansion of agriculture into the forest frontier, which includes the Amazonia, one of the world's largest forest ecosystems, and the surrounding cerrados savannah.

Appendix table B6

Brazil corn production costs and returns per planted acre, 2010-11[1]

	Mato Grosso		Paraná		Brazil national average	
	Dollars per planted acre	Percent	Dollars per planted acre	Percent	Dollars per planted acre	Percent
Operating costs	277.35	70.0	279.01	68.5	274.85	69.2
Seed	63.81	16.1	48.28	11.9	49.82	12.5
Fertilizer	123.22	31.1	125.88	30.9	100.97	25.4
Chemicals	22.62	5.7	38.08	9.4	48.46	12.2
Custom operations	37.07	9.4	49.41	12.1	41.84	10.5
Fuel, lube, and electricity	15.38	3.9	0.84	0.2	14.83	3.7
Repairs	7.39	1.9	5.31	1.3	7.94	2.0
Purchased irrigation water	NA	NA	NA	NA	NA	NA
Interest on operating capital	7.86	2.0	11.20	2.7	10.98	2.8
Allocated overhead	118.65	30.0	128.21	31.5	122.17	30.8
Hired labor	5.31	1.3	1.73	0.4	2.64	0.7
Opportunity cost of unpaid labor	6.82	1.7	9.09	2.2	8.61	2.2
Capital recovery of machinery and equipment	65.44	16.5	31.15	7.6	44.49	11.2
Opportunity cost of land	20.06	5.1	58.57	14.4	41.66	10.5
Taxes and insurance	15.85	4.0	22.22	5.5	18.51	4.7
General farm overhead	5.18	1.3	5.45	1.3	6.25	1.6
Total costs	396.00	100.0	407.22	100.0	397.02	100.0
Supporting information						
Yield (bushels per planted acre, 2010/2011)	95.6	NA	111.5	NA	98.6	NA
Price (dollars per bushel, 2010/2011)[2]	4.10	NA	3.74	NA	4.28	NA
Costs per bushel (dollars), 2010/11	4.14	NA	3.65	NA	5.09	NA
Operating	2.90	NA	2.50	NA	3.52	NA
Allocated overhead	1.24	NA	1.15	NA	1.56	NA
Comparison with 5-year average, 2008-2012						
Yield (bushels per planted acre, 2008-2012)	103.6	NA	108.3	NA	83.7	NA
Price (dollars per bushel, 2008-2012)	4.62	NA	4.50	NA	5.11	NA
Costs per bushel (dollars), 2008-2012	3.82	NA	3.76	NA	4.74	NA
Enterprise size (planted acres per farm)[3]	898	NA	87	NA	114	NA

[1]Refers to the crop planted in 2010 and harvested in 2011.

[2]Average price during Brazilian corn harvest months January, February, March.

[3]Developed from farm census 2006.

NA = Not applicable.

Source: Brazilian National Food Supply Company (CONAB), 2015.