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Impacts on India's Farmers and Processors of Reducing Soybean Import Barriers

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Abstract

India is the world's largest importer of soybean oil, despite its high tariff. In the past decade, India's domestic consumption of soybean meal increased roughly five-fold, leading to sharp decreases in India's once significant exports of soybean meal. India's policies prevent imports of oilseeds (the raw material for producing soybean oil and meal), and domestic soybean production has not kept pace with India's growing demand for these products. This study examines the potential impacts on Indian farmers and processors of reducing barriers to soybean imports. Model-based simulations find that with imported soybeans, processors could more fully utilize their existing crush capacity, reduce their unit costs, and sharply expand their sales volumes and revenues—leading to substantial economic benefits. If India maintains its soybean oil tariff at current levels, imports of soybeans are economically attractive even when subject to a tariff that protects Indian soybean farmers—India could lower its barriers that effectively preclude soybean imports without adversely affecting farmers.

Keywords: India, oilseeds, soybeans, soybean meal, feed, vegetable oil, imports, processor, solvent extraction

Acknowledgments

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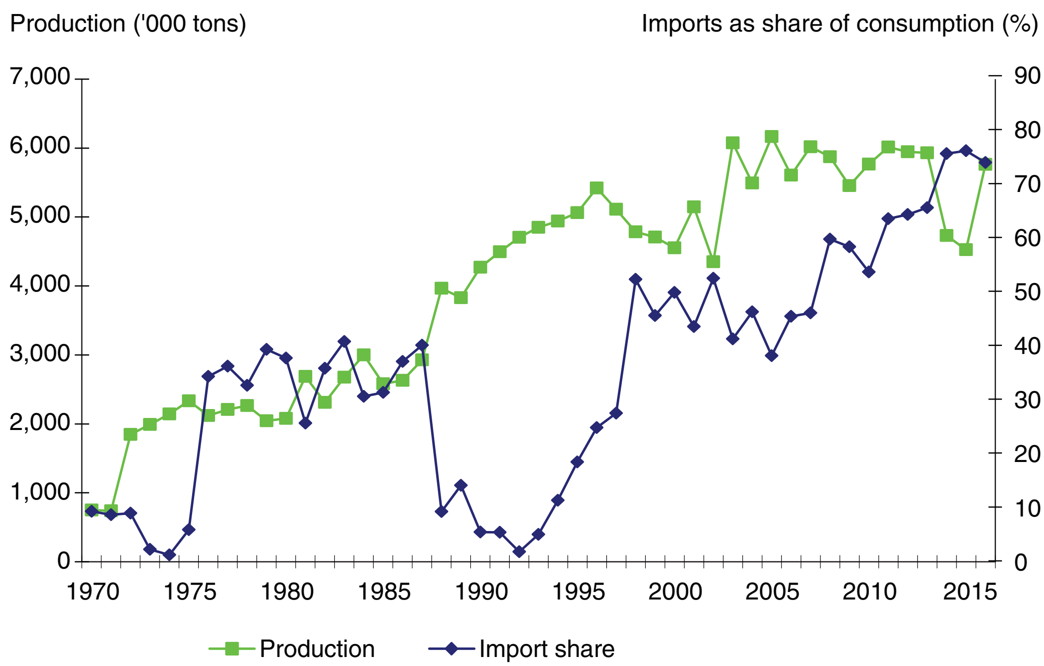
Introduction

Despite its tariffs, India accounted for over 20 percent of global vegetable oil imports in 2016, making it the world's leading importer of vegetable oils, ahead of the European Union (EU) and China. In 2016, imports supplied about 70 percent of India's vegetable oil consumption, up from about 50 percent a decade earlier (fig. 1). India's total consumption of vegetable oils has grown almost without interruption since the 1970s, propelled by rapidly expanding population (from about 550 million in 1970 to 1.2-1.3 billion in 2016) and strong real per capita income growth, which rose throughout the 1970s (1.4 percent annually), 1980s (3.1 percent), 1990s (3.7 percent), and 2000s (5.3 percent). Per capita consumption of vegetable oils in 2016 was almost three times higher than it was in 1990, in line with real per capita gross domestic product (GDP), which expanded 3.3 fold over the same period.

Figure 1
India's production of vegetable oils and import dependency



Source: USDA Production, Supply and Distribution and USDA, Economic Research Service calculations

India's domestic production of oilseeds, the raw material that is processed into oil and meal, is inadequate for meeting domestic demand for vegetable oils. Moreover, domestic production of meal, which is used primarily as a protein ingredient in livestock feed rations, has not kept pace with the demands of India's rapidly expanding poultry and egg sectors. India's once significant exports of soybean meal have diminished—in marketing year[1] (MY) 2015/16, India narrowly avoided becoming a net importer by drawing down stocks.

A distinctive feature of the Indian market is that although imports of vegetable oils are sizable and domestic soybean meal use has grown by double digits in the past decade, India's tariff and nontariff

[1]Marketing year is October-September.

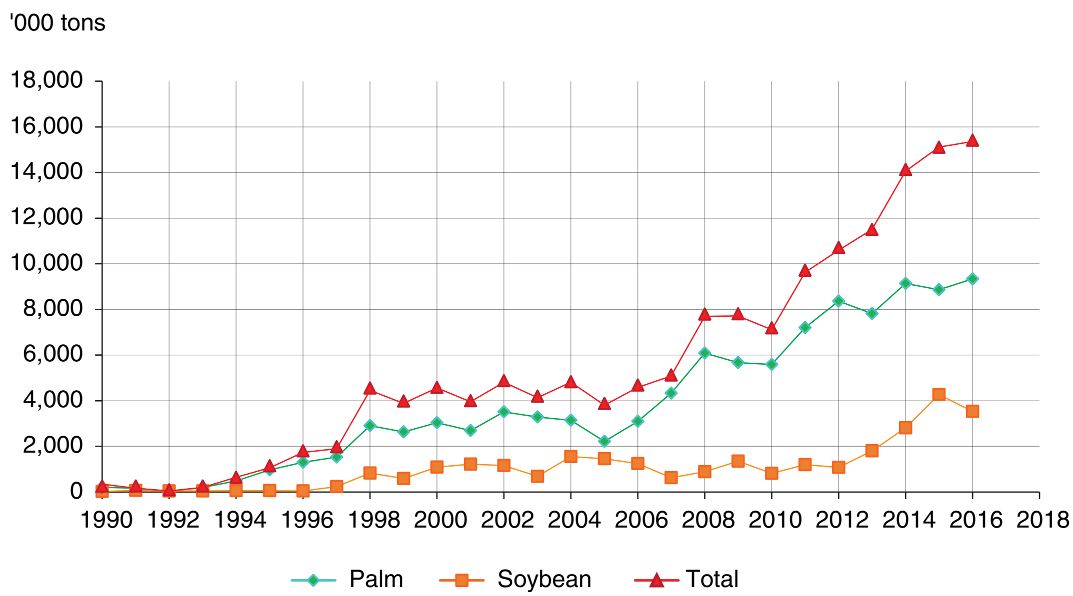
barriers effectively prevent imports of oilseeds. Despite allowing imports of vegetable oils (subject to tariffs) that are produced from genetically modified (GM) oilseeds, India does not grow or import GM soybeans (Singh, 2018). Low supplies of domestically produced oilseeds also limit capacity utilization rates among India's processors, which are generally of small scale. The result is high domestic oilseed processing costs, which are covered by domestic oil prices, which are above world prices, at the expense of consumers.

This report examines the potential impacts on Indian farmers and processors of reducing barriers to soybean imports. Soymeal has a dominant role in meeting protein feed demand in India's poultry, eggs, aquaculture, and, potentially, dairy sectors. Soybean oil is the most heavily imported oil for which India also has a substantial domestic production base. The country seeks to protect this base from foreign competition through tariff and sanitary/phytosanitary (SPS) restrictions on imports of oilseeds and tariffs on imports of oils. This report shows how trade liberalization would allow India's soybean processing sector to emerge as a high-volume, lower margin industry. With imported soybeans, processors could more fully utilize their existing crush capacity, reduce their unit costs, and sharply expand their sales volumes and revenues. Thus, processors would receive substantial economic benefits from improved access to imported raw materials. A key finding is that if India maintains its soybean oil tariff, imports of soybeans would be economically attractive even when subject to a tariff that protects Indian soybean farmers. Thus, India could permit soybean imports without adversely affecting farmers.

Trade Polices Influence Consumption of Vegetable Oils

In 2016, India consumed 20.6 million metric tons (MMT) of vegetable oils, up from around 2 MMT annually in the early 1970s, placing India behind only China and the EU in total edible oil consumption (USDA, 2018). When edible oil imports were placed under the Open General License (OGL) System in 1994, private traders were permitted to import any quantity of vegetable oils, subject only to a tariff (Sharma, 2017). During the period 1995-98, India's tariff structure was relatively simple and increasingly liberal—with a common applied ad valorem (percentage) tariff for all oils progressively lowered to a uniform rate of 16.5 percent by the middle of 1998 (Dohlman et al., 2003). In response to the more liberal trade regime and declining international prices, imports sharply increased—edible oil imports climbed from 0.6 MMT in 1994 to 4.6 MMT in 2000 (fig. 2).

Figure 2
India's imports of vegetable oils



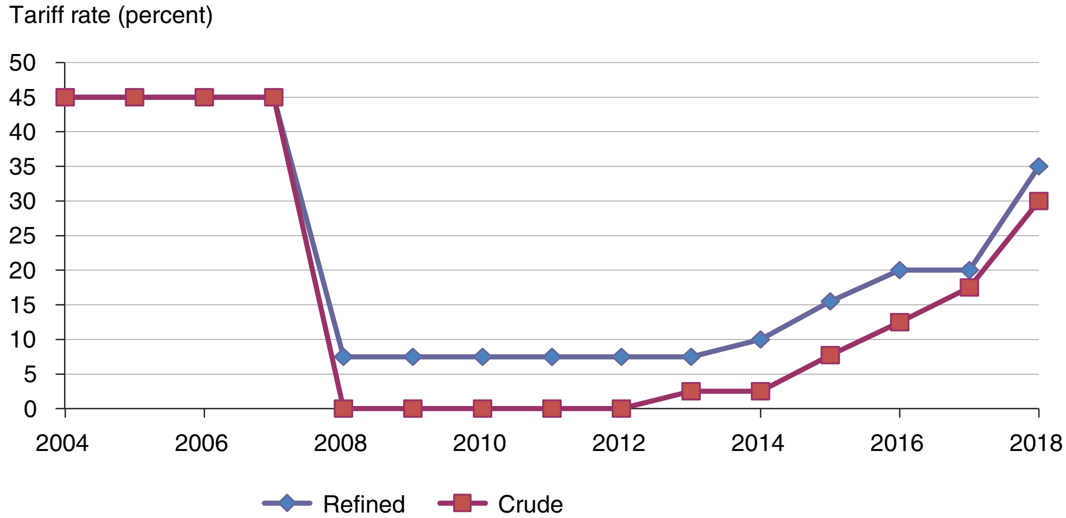
Note: Cottonseed oil is excluded.

Source: USDA Production, Supply and Distribution and USDA, Economic Research Service calculations.

Beginning in 1998, however, the Indian Government began making frequent tariff adjustments to protect domestic oilseed producers and processors from imports and to smooth the effect of fluctuating world prices on domestic consumers. Although applied tariffs fell in 1999 after an initial hike in June 1998, the trend after April 2000 was one of incremental increases to applied tariff rates for all imported oils. Moreover, adjustments were made to the relative rates on different types of oil—e.g., palm versus soybean oil and crude versus refined oil—creating a more complicated tariff structure. The main effect of these changes was to slow the growth of edible oil imports (Dohlman et al., 2003). After reaching 4.6 MMT in 2000, imports stagnated, remaining below 5.2 MMT through 2007. The year 2008 witnessed price spikes for agricultural commodities on world markets with a sudden strengthening of the U.S. dollar. In an effort to dampen increases in domestic vegetable oil prices and to expand domestic oil supplies, the Government abolished the import duty on crude soybean and palm oil, setting these rates to zero effective April 1, 2008 (fig. 3), and the import duty on refined edible oils was reduced to 7.5 percent.

Figure 3

Tariffs applied to imports of crude and refined soybean oil

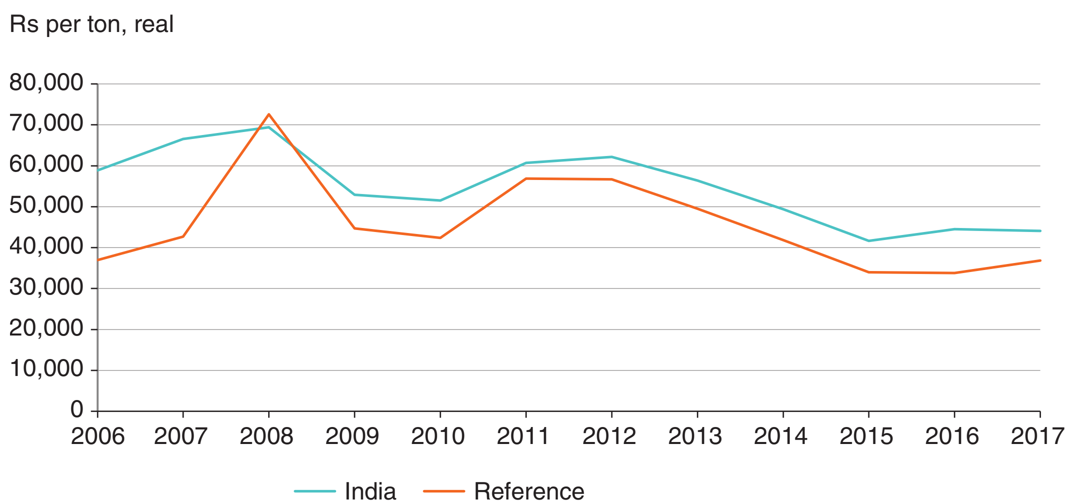


Source: USDA, Foreign Agricultural Service, Global Agricultural Information Network reports, various.

Following a period of low and stable duties, the Indian Government began to increase tariffs after 2012, starting with crude oils and continuing with refined oils. Crude soy oil tariffs climbed from about 7.5 percent in 2015 to 12.5 percent in September 2016, followed by further increases first to 17.5 percent and then to 30 percent by the end of 2017, within range of the World Trade Organization-bound rate of 45 percent. Total imports of edible oils jumped 48 percent in 2008 to 7.8 MMT and then stabilized around that level for 2 years (fig. 2). Subsequently, imports nearly doubled to 15 MMT from 2010 to 2016, although the domestic price of soybean oil has largely remained above the international reference price (fig. 4).

Figure 4

Soybean oil prices, India, reference, real



Notes: reference price for soy oil in USDA Baseline is Dutch free on board (f.o.b.), ex-mill.

Sources: Prices in India are from the Soybean Processors Association; reference prices are from USDA Baseline.

The U.S. share of the Indian soybean oil market declined sharply when U.S. exports shifted from concessional shipments to commercial sales after the mid-1990s. From 2012-17, the U.S. exported a total of 113,369 MT of soybean oil to India, for a cumulative value of about $125 million.[2] Price is a key determinant of the origin of oils purchased by Indian importers. The Indian soybean oil market is currently dominated by suppliers in Argentina and Brazil (Singh, 2018), who offer consistently lower prices than U.S. suppliers. On average during the period 2012-17, the U.S. export price of soy oil to India was about 42 percent higher than Argentina and 38 percent above Brazil. The United States accounted for less than 1 percent of India's soybean oil imports, while Argentina's market share was 77 percent (2012-2017, average) (GTIS, 2018).

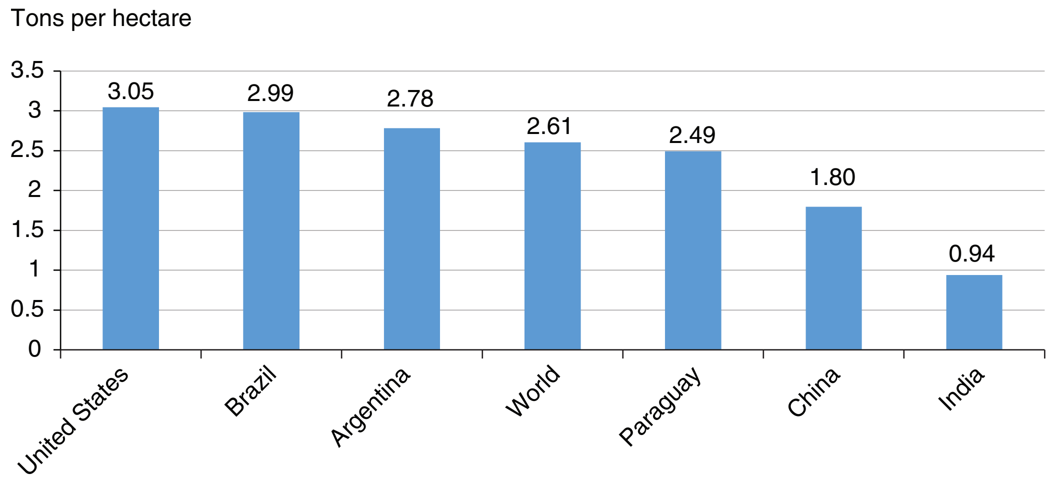
[2]This $125 million of soy oil exports accounted for the vast majority (83 percent) of total U.S. exports of oilseeds and oilseed products to India from 2012-17.

Oilseed Production

Indian production of oilseeds is highly variable and inadequate for meeting domestic demand for oil. Many oilseeds are cultivated on rainfed lands with little to no irrigation, resulting in large contractions in output when precipitation is inadequate or excessive.[3] Rainfed production also contributes to low yields in both normal and drought years. For all of India's major oilseeds (groundnut, rapeseed, soybeans, and sunflower), yields have stagnated at levels that are low by international standards. For example, India's soybean yields are roughly one-third those achieved in the United States and Brazil (fig. 5).

Figure 5

Soybean yields for top soybean-producing countries (2010/11-2016/17, average)



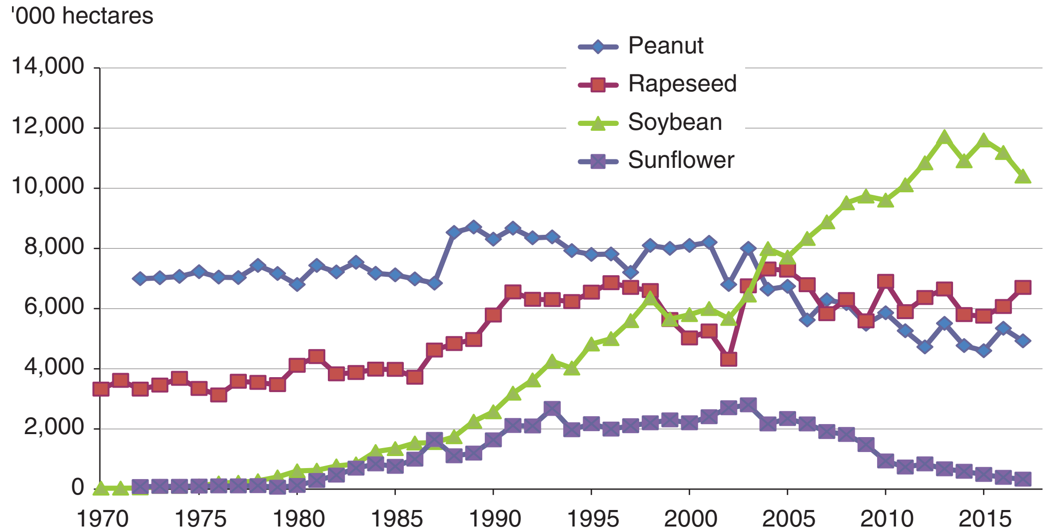
Source: USDA Production, Supply and Distribution.

Area cultivated in India has declined for all oilseeds except soybeans (fig. 6). Growth in soybean area and output (figs. 6, 7) has been supported by strong domestic and export demand for soy meal—soybeans now account for roughly 45 percent of the total production of India's major oilseeds (fig. 8).

[3]In India, soybeans are cultivated only in the kharif season (Aradhey, 2018—i.e., the period from July-October, relying on monsoon rains. This is the case for the kharif oilseed crops like soybeans, but not for rabi crops such as rapeseed, where three-fourths of the crop area is irrigated. Also, about one-fifth of the Indian peanut area is irrigated.

Figure 6

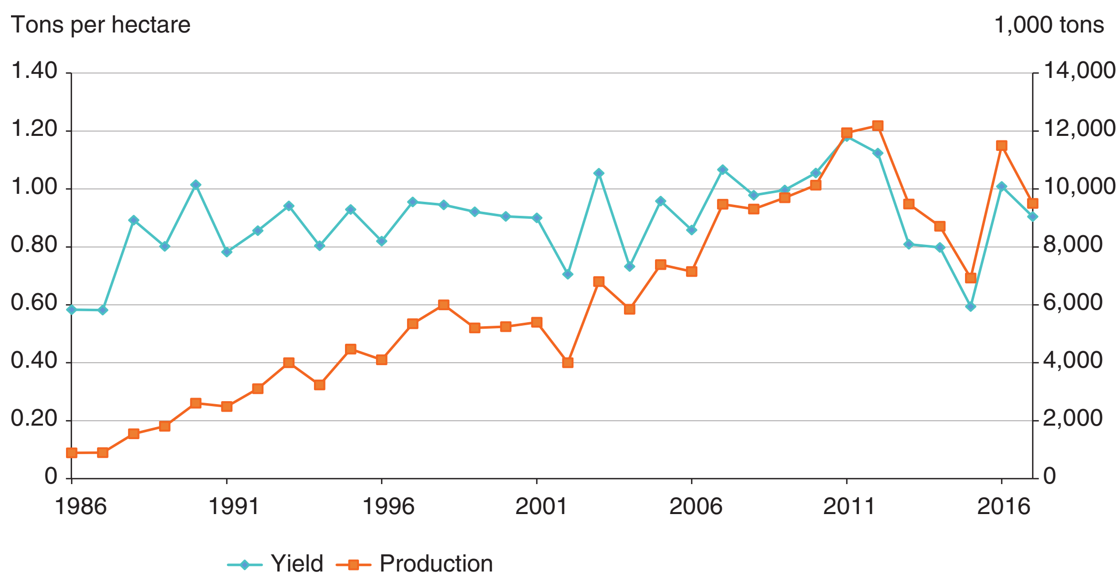
Area cultivated to oilseeds in India



Source: USDA Production, Supply and Distribution.

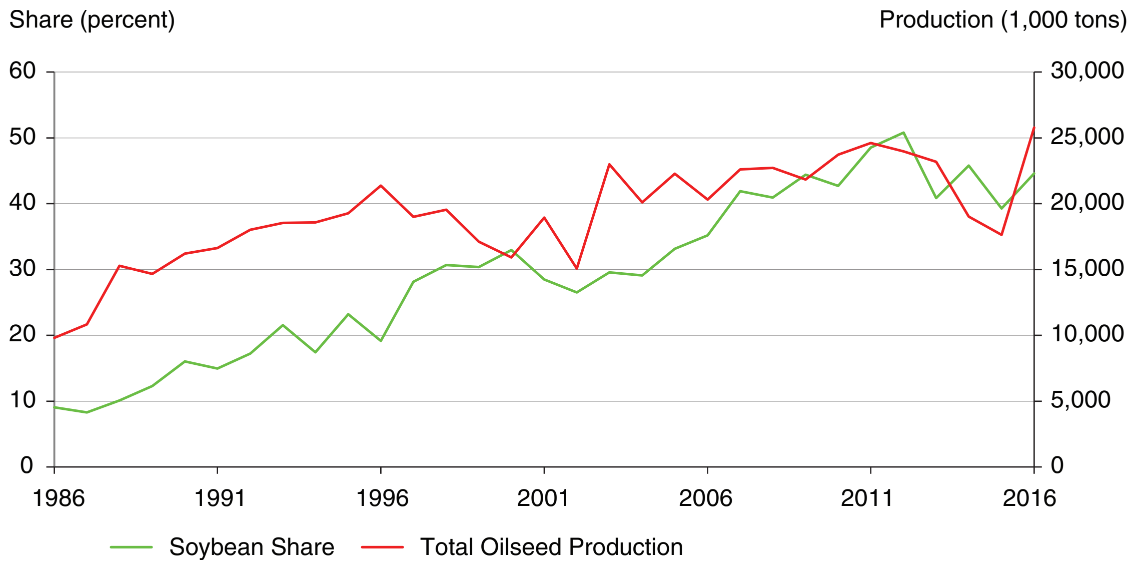
Figure 7

Soybean production and yield in India



Source: USDA Production, Supply and Distribution.

Figure 8
Soybeans now account for about 45 percent of total oilseed production in India



Source: USDA Production, Supply and Distribution and USDA, Economic Research Service calculations.

India's major soybean growing area is in the centrally located state of Madhya Pradesh, away from India's wheat and rice cultivation centers. Soybean production has the advantage of not generally competing for crop area with India's heavily subsidized food grain sector. Nevertheless, India's production of vegetable oils and soybean meal has not kept pace with demand. Although India was once a significant exporter of soybean meal, these surpluses are being absorbed by the rapidly growing domestic demand for livestock feed. With India's mostly unchanging yields, area growth is generally the primary driver of growth in soybean production. The prospects for future gains in soy production will be influenced by competition with other rainfed kharif crops, such as coarse grain (corn, millet, sorghum; the former with strong feed demand) and pulses (with strong food demand).

Trade Policies for Oilseeds

India's large imports of edible oils result in part from policies on soybean imports. Imports of genetically modified (GM) oilseeds are not permitted unless approved by the Government's Genetic Engineering Approvals Committee (GEAC). (GM soymeal is also not approved for domestic feed use, so GEAC approvals are needed for both seed and meal.) The GEAC currently has no policy that would permit such approvals. In addition, a Plant Quarantine Order issued in 2002 requires that shipments be certified free of certain pests or that seeds be "devitalized." At present, the only permissible means of "devitalization" is to split the seed mechanically, a process that adds considerable cost and, if done at the point of origin, leads to an unacceptable deterioration in quality during transit. Although non-GM soybeans can be imported without quantitative restrictions, such imports are not economically viable because they face a 30 percent tariff and additional complex phytosanitary requirements (USDA, 2018c).

India's oilseed tariffs are intended to protect the country's oilseed producers, but in fact, domestic oilseed prices are determined more by the economics of processing, including oil and meal prices, oil and meal extraction rates, and unit processing costs. Domestic soybean prices tend to track world soybean prices (correlation = 0.78), thereby limiting the effectiveness of oilseed tariffs as a tool for protecting soybean farmers. Consequently, domestic oilseed prices are not afforded protection equivalent to the 30-percent import tariff and, in some years, may even drop below international reference prices. India's soybean prices have not always exceeded the reference price, and in those years when it has, the price gap was below 30 percent (the tariff rate) (fig. 9).

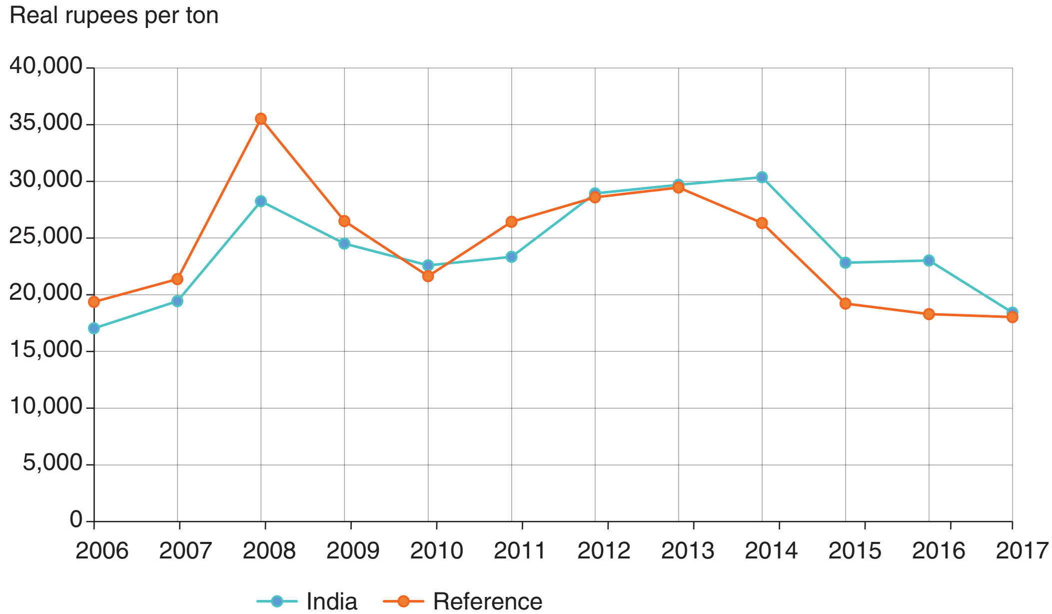
Oilseed crush yields two jointly produced outputs (meal and oil), and the prices of both outputs contribute to the price of the raw material (oilseeds). However, the derivative oil and meal do not contribute equally to the value of the oilseed—1 ton of soybean crush yields 0.18 tons of soybean oil and 0.80 tons of soybean meal (USDA, 2018a). Thus, the price of the oil (SOYOILPrice) and the price of the meal (SOYMEALPrice) must be weighted by their respective extraction rates. This weighted sum of the outputs, along with the unit crush cost, determines the soybean price, i.e.

SOYBEANPrice = 0.18*SOYOILPrice + 0.80*SOYMEALPrice - CRUSHCost

The above equation is drawn from Persaud and Chern (2002); Bickerton and Glauber (1990). Since India imports soybean oil and exports soybean meal, changes in the weighted sum of their international reference prices will therefore drive changes in the domestic price of soybeans, where the weights are given by the oil and meal extraction rates. India's soybean prices have not diverged greatly from the weighted sum of the international reference prices of soy oil and soy meal (correlation = 0.84) (fig. 10). Thus far, India's soybean producers have not received the equivalent benefit of the tariff and non-tariff barriers applied to oilseeds—the derivative oil and meal are tradeables, and their respective prices shape the domestic price of the non-tradeable raw material (the oilseed). This could change in the future. Strong gains in domestic demand could deplete India's exportable surplus of soybean meal, and if India's trade restrictions remain in place, internal demand pressures would then raise India's prices of soybean meal and soybeans above their international reference prices.

Figure 9

India's restrictions on soybean imports have not protected its soybean farmers: Soybean prices, India, reference

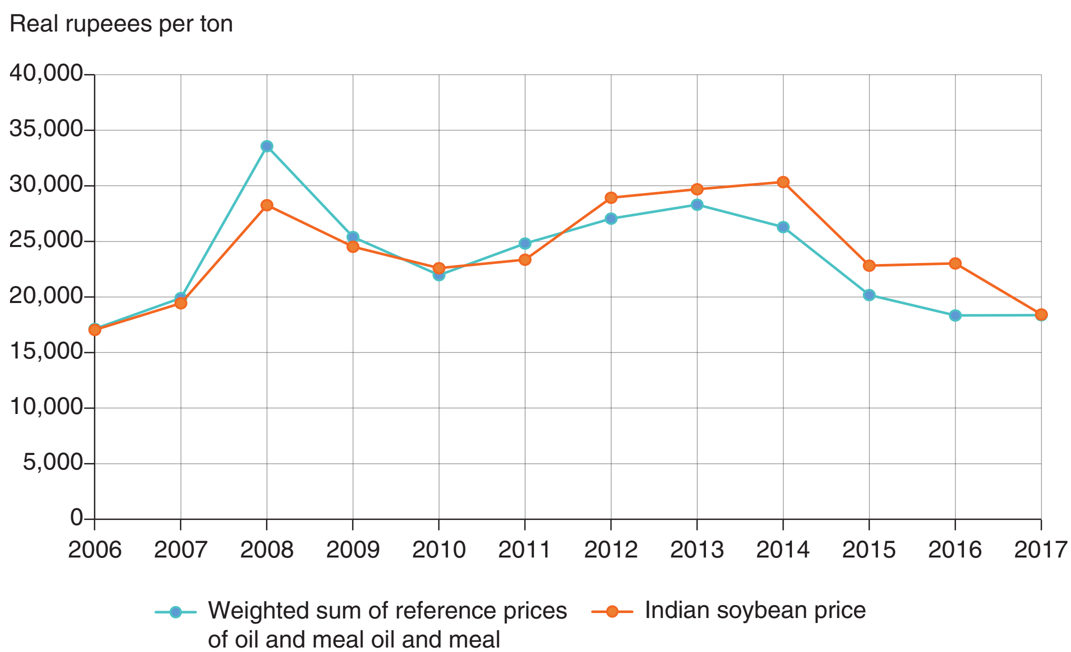


Note: Rotterdam soybean reference price used in USDA Baseline.

Sources: prices in India are from the Soybean Processors Association; reference prices are from USDA Baseline.

Figure 10

India's soybean prices track the weighted sum of international reference prices for soy oil and soy meal



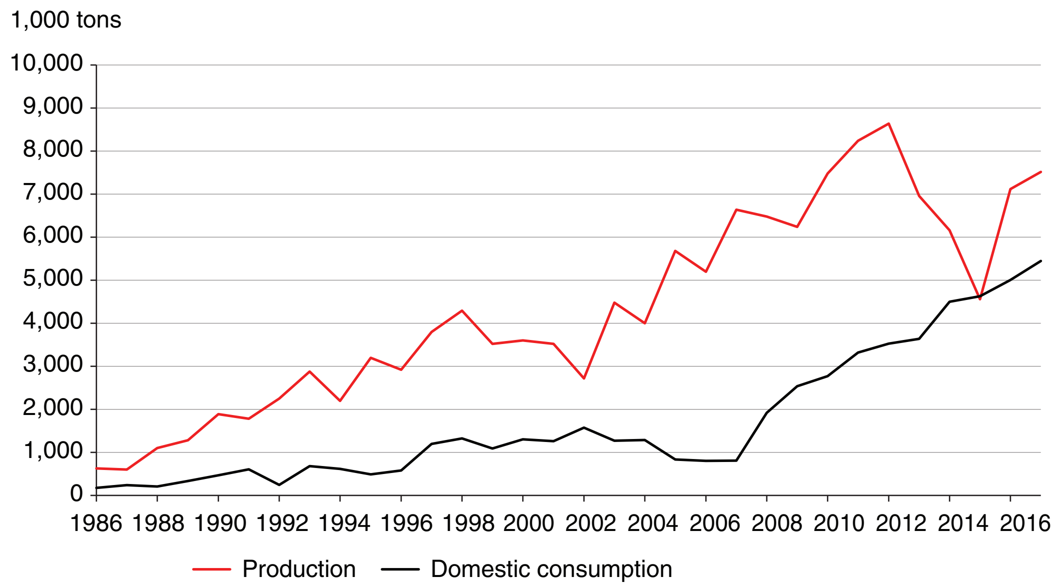
Notes: reference prices in USDA Baseline are Soy pellet 45/46 percent, Arg, cif, Rotterdam for soybean meal, and Dutch fob, ex-mill for soybean oil.

Sources: prices in India are from the Soybean Processors Association; reference prices are from USDA Baseline; weighted sum is USDA, Economic Research Service calculations.

Feed Demand

Growth in estimated consumption of soybean meal, and particularly feed use, has increased. According to USDA estimates, the annual growth rate of feed use of soybean meal was about 12 percent during the 1990s, 20 percent in the late 1990s, and 21 percent in the past decade since 2007 (fig. 11). Rapid growth in the feed use of soybean meal stems from demand from aquaculture producers, a component of India's large dairy herd, and the poultry and egg sectors. USDA does not provide estimates of feed use by animal type. In the absence of more detailed data, it is not possible to decompose soybean meal use by animal type or to calculate the relative importance of each animal sector as drivers of oilseed-based protein demand. However, the data indicating rapidly growing total feed use of soybean meal are credible.

Figure 11
Soymeal consumption slightly surpassed production in 2015/16



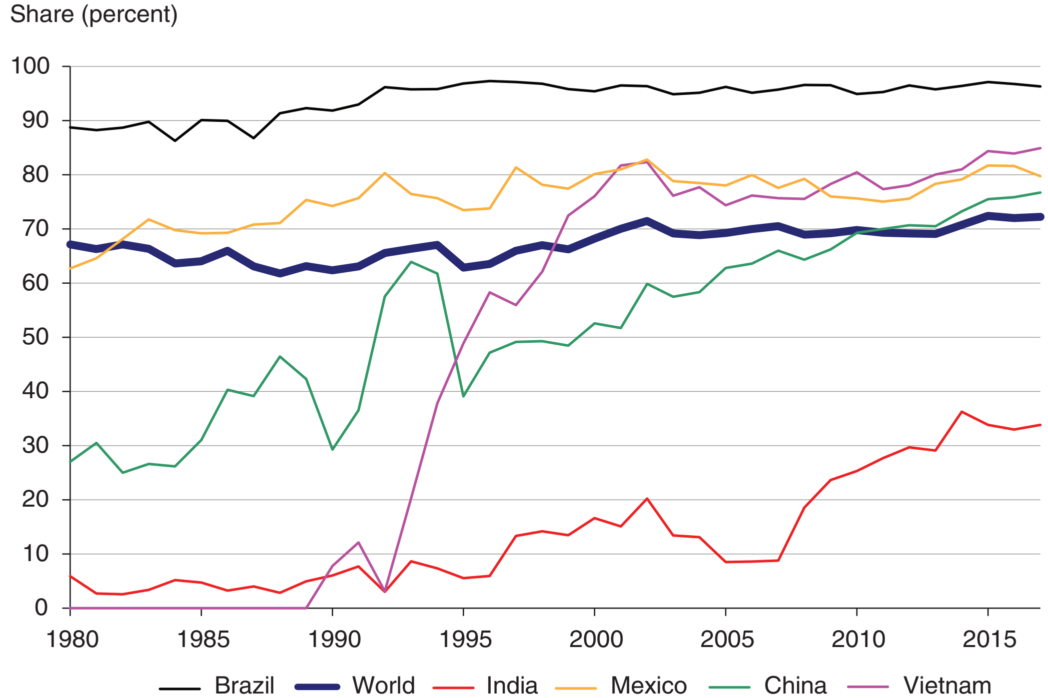
Source: USDA PS&D

As livestock production systems transition toward more efficient feeding practices, soybean meal accounts for a larger share of the total protein meal use. In 2017, India's total protein meal use was about 14.0 MMT, of which 4.8 MMT or 34 percent was soybean meal, up from about 9 percent in 2007.

Although soybean meal has become an increasingly important component of animal feed in India, its utilization rate is still far below the world average. Global protein meal demand in 2017 was about 347.5 MMT, of which 251.1 MMT or 72 percent was soybean meal. Brazil and India bracket the two extremes depicted in fig. 12. Soybean meal accounts for almost all of Brazil's livestock meal consumption. Rapidly expanding livestock sectors coupled with rising soybean meal inclusion rates in feed rations spur strong increases in demand for soybean meal. After starting with soybean meal utilization rates below those of India, Vietnam experienced sharp increases in its utilization rate starting in 1993, surpassing the world average in 2000. India's relatively low soybean meal utilization rate of 34 percent suggests substantial room for future growth in soy demand, due to the combined effects of shifting toward feed rations that contain a higher percentage of soy, as well as continuing growth in livestock numbers to meet expanding consumer demand.[4]

Figure 12

Only about one-third of India's demand for protein meal is supplied by soybean meal, substantially below the world average



Source: USDA PS&D and author's calculations.

Although India once ranked as the world's fourth largest exporter of soybean meal, the country's excess supplies of soybean meal have diminished. In 2015/16, India's consumption of soybean meal surpassed domestic production following a series of weather-induced shortfalls beginning in 2013/14 (fig. 11). India narrowly avoided becoming a net importer by drawing down stocks. Note that prior to this recent (2013/14 - 2015/16) series of poor harvests, India's soybean meal output had reached a record-high level of 8.6 MMT in 2012/13, of which 4.9 MMT was exported. Thus, India began with a substantial cushion/surplus of soybean meal that supported uninterrupted increases in domestic feed use of soybean meal, even in the face of falling production. At 1.8 MMT in 2017/18, soybean meal exports are substantially smaller than in 2012/13—India could be one bad monsoon away from experiencing a deficit in soybean meal.

[4]The composition of the fed animal sector is a consideration: compared to other countries, India would have less "red meat" (hogs, cattle) with much higher feed conversion rates in the fed herd. Thus, India's potential soymeal share may not be as high as the global norms. Nevertheless, India's low share does indicate room for growth.

Oilseed Processing

The Indian oilseed processing sector is characterized by a large number of relatively small-scale, low-technology plants and substantial excess capacity. The structure of the industry has been heavily influenced by Government policies that have regulated plant scale, capital intensity, and the marketing of oilseeds and their products; provided incentives for building new capacity; and prevented imports of oilseeds for processing. Also shaping the industry have been erratic supplies of domestic oilseeds for processing (Narayan, 2016; Jha et. al, 2012; Dhankhar, 2007; Persaud and Landes, 2006).

The Indian oilseed processing industry includes three major processing technologies: (1) traditional mechanical crushing, or expelling, used for oilseeds with relatively high oil content; (2) solvent extraction for processing raw materials, such as soybeans, cottonseed, and expeller oilcake with less than 20 percent oil content; and (3) oil refiners that process solvent-extracted oil, which must be refined before consumption. The traditional mechanical crushing industry has two segments: "ghanis" (very small-scale, low technology plants) and the small-scale expellers. The processing industry also includes an oil refining sector, which primarily refines domestic solvent-extracted oils and imported crude and solvent-extracted oils, and a "vanaspati" (hydrogenated oil) sector that refines and hydrogenates domestic and imported oils. Inefficiency arises because some processes are not well integrated. While it is common to see an oil refinery and/or vanaspati unit combined with a solvent extraction plant, expeller units are often not integrated with solvent extraction units. As a result, oil production is lost because significant amounts of expeller cake are not solvent-extracted (Narayan, 2016; Reddy and Bantilan, 2012; Persaud and Landes, 2006).

In the oilseed crushing/processing industry, reducing costs depends largely on increasing the scale of operations, with larger plants able to achieve lower unit costs at any given level of capacity utilization. Per unit operating costs are two-thirds higher for a 500 ton/day crushing plant than for a 1,500 ton/day facility (Jha et al., 2012). Despite India's status as the world's seventh largest market for soybean meal, its soybean processors are small by international standards. Although some Indian soybean crushers/processors have a capacity of about 1,500 tons per day, the average capacity is approximately 250-300 tons per day, based on data from Jha (2017). In contrast, Vietnam recently built two 5,000 ton per day crushing plants (Kasabe, 2015). Argentine soybean processing plants have capacities of 10,000-20,000 tons per day—2 plants alone (Renova Mills River and Terminal VI) are each capable of processing 20,000 MT/day (Carné, 2018).

Excess processing capacity has been a persistent problem in India's oilseed industry (Mohan 2017; Narayan, 2016; Pathak, 2016; Jha et al., 2012; Reddy and Bantilan, 2012; Ghosh, 2009; Chand, 2007; Persaud and Landes, 2006; Persaud and Dohlman, 2006; Dohlman et al., 2003; World Bank, 1997). Indian expeller and solvent extraction plants tend to operate only around the domestic raw material harvest, or at about 30-40 percent of capacity, based on an annual solvent extraction capacity of 30 MMT (Jha, 2017; Kasabe, 2015). This contrasts with capacity utilization rates of 92-96 percent for U.S. plants (Reca, 2003). Low rates of capacity utilization are compounded by relatively poor technical efficiency and further increase the average and marginal costs of processing raw materials (Narayan, 2016), because fixed costs must be recouped over fewer units of output.

Tariff and nontariff barriers to oilseed imports limit average capacity use in the processing industry to what can be achieved from low and variable domestic production. Domestic oilseed processors are typically able to cover their high costs, largely because of the high border protection afforded to vegetable oils (Persaud and Landes, 2006), except during periods of poor domestic oilseed harvests (Ghosal, 2017; Jha, 2017; Pathak, 2016; Kasabe, 2015).

In the short run—with existing processing capacity and low capacity use—India's processors operate their plants at a level where average costs are high. They can reduce unit-processing costs by increasing capacity use (Narayan, 2016; Reddy and Bantilan 2012; Persaud and Landes, 2006; World Bank, 1997). In the long run, costs can drop further if larger, more technically efficient plants are built that can operate at high levels of capacity use. In addition, because the price of oilseeds is determined by the cost of processing—together with the market value of the derived oil and meal—current high processing costs dampen oilseed prices, partially offsetting benefits to producers from India's tariffs on oilseeds and oils. Lower processing costs would create a stream of benefits to processors that could be shared with producers (in the form of higher oilseed prices).

Prospects for India's Soybean sector: Imports of Soybeans Prohibited

In addition to oilseed trade policies and structural characteristics of the crushing industry, key variables affecting the Indian oilseed complex include growth in income, crop area, farm yields, changes in world prices of oils and meals, and exchange rates. India's future imports of soybean oil and exports of soybean meal, as well as the competitiveness of the domestic oilseed processing sector, will be influenced by the availability of domestically produced and imported soybeans. We develop multi-year simulations using a structural model to examine the likely effects of these key factors on India's projected consumption, production, and trade flows of soybean oil, soybean meal, and soybeans.

We first generate a Reference Scenario that contains a 10-year projection, beginning in 2016 and ending in 2026, for India's soybean sector. This Reference Scenario provides a "business as usual" projection that is based on existing policies and assumed changes in key exogenous variables, including income growth, exchange rates, and world prices. The Reference Scenario is then compared to an alternative scenario (Scenario II) that analyzes the effects of removing non-tariff barriers to imported soybeans (Table 1).

Table 1

Major analytical assumptions for India soybean model

Variable	Reference	Scenario II
GDP growth, Local Currency Units, real (%)	5.7	5.7
Real exchange rate appreciation (%)	1.8	1.8
Soybean yield trend (growth, %)	1.9	1.9
Soybean meal demand trend (growth, %)	4.9	4.9
Soybean processing capacity (millions of tons)	30	30
Inland capacity	22.5	22.5
Coastal capacity	7.5	7.5
Soy oil tariff, base year (%)	12.5	12.5
Soy oil tariff, terminal year (%)	30	30
Soybean phyto-sanitary restrictions	maintained	eliminated
Soybean tariff, base year (%)	30	30
Soybean tariff, terminal year (%)	30	10.9

Source: ERS, USDA

The real world prices of soybean oil, soybean meal, and soybeans, as well as India's real exchange rate and real GDP per capita, are drawn from USDA's long-term productions (also known as the Baseline) through the year 2026 (USDA, 2018b). All of the scenarios presented in this report are similar in that real GDP per capita (measured in rupees) grows at same rate of 5.7 percent per year from 2016-26, and the real exchange rate follows the same pattern, appreciating 1.8 percent each year (Table 1). Soybean yield grows at a trend rate of 1.9 percent. Given this rate of growth, yield climbs to 1.18 tons per hectare by 2026, which is in line with USDA's long-term projections. Oilseed processing capacity remains fixed at current levels; and real prices for oilseed processing inputs, other than the raw material, remain constant. The growth trend of India's soybean meal consumption (4.9 percent) generates a use level in 2026 that is in line with USDA Baseline projections. Non-crush use of soybeans is a behavioral equation that is influenced by changes in soybean prices, allowing for partial adjustments.

Model Characteristics

In the absence of soybean imports, oilseed crush is simply a residual equal to the predetermined level of domestic oilseed production less the exogenous quantities of seed, feed, waste, and food uses. The stock of crush capacity remains constant throughout the projection period, implying that once the quantity of crush is known, capacity utilization can be computed. We assume nonfarm input costs of crushing, such as labor, hexane, energy, and interest expenses, are constant in real terms (they grow at the same rate as inflation). Thus, capacity utilization is the only variable that causes the real cost of crushing to vary throughout the projection period. Given the level of capacity utilization, the model computes the cost of crush. The autarchy wholesale price of soybeans is formed by subtracting the cost of crushing from a weighted sum of the oil and meal prices, where the weights are the oil and meal extraction rates. The farm price of the oilseed is then computed by subtracting a margin from the autarchy wholesale price of the oilseed. The farm price will determine the production of oilseeds in the subsequent period.

Reference Scenario

World prices of soybeans, soybean meal, and soybean oil follow decreasing trends from 2016-26 (in real Rs/MT), as per the USDA baseline projections (USDA, 2018b). The duty on soybean oil imports is initially set at 12.5 percent in the base year, rises to 17.5 percent in the first out year of the projection, and is then held at 30 percent for all subsequent years of the simulation period. These tariffs increases are based on the Government of India's recent hikes in the soybean oil duty. Although India does not import soybeans under the Reference Scenario, the domestic price of soybeans trends downward, approximately in line with world prices of meal and the tariff-adjusted world price of oil. Domestic oilseed prices track world prices because they are determined primarily by the prices of their derived products—oil and meal—which are traded. In the soybean specification, area is influenced by a trend term, as well as expected returns represented by lags of price and yield. Soybean yield grows at a trend rate of 1.9 percent per year. Soybean area expands at an annual rate of 1.2 percent through 2026—expected returns to soybean cultivation grow as yield increases offset decreasing domestic prices of soybeans. Thus, despite the absence of price incentives, soybean production grows at an annual rate of about 3.2 percent (table 2).

Table 2
Simulation results

			Reference		Scenario II	
Variable	Unit	Base year	Terminal year	Growth rate (%)	Terminal year	Growth rate (%)
Soybean production	MT	11,000,000	15,089,267	3.21%	15,221,773	3.30%
Soybean area	HA	11,300,000	12,787,328	1.24%	12,899,619	1.33%
Soybean yield	MT/HA	0.97	1.18	1.94%	1.18	1.94%
Soybean total usage	MT	11,000,000	15,089,267	3.21%	22,454,200	7.40%
Soybean crush usage	MT	9,000,000	10,893,072	1.93%	18,277,010	7.34%
Soybean non-crush usage	MT	2,000,000	4,196,195	7.69%	4,177,190	7.64%
Soybean imports	MT	0	0	--	7,232,427	--
Soy meal production	MT	7,200,000	8,714,458	1.93%	14,621,608	7.34%
Soy meal total usage	MT	5,188,999	8,650,825	5.24%	8,650,825	5.24%
Soy meal exports	MT	2,011,000	63,633	-29.20%	5,970,783	11.50%
Soy oil production	MT	1,620,000	1,960,753	1.93%	3,289,862	7.34%
Soy oil food usage (incl stock adj)	MT	5,300,000	7,047,294	2.89%	7,047,294	2.89%

continued

Table 2
Simulation results–continued

			Reference		Scenario II	
Variable	Unit	Base year	Terminal year	Growth rate (%)	Terminal year	Growth rate (%)
Soy oil imports	MT	3,534,000	4,940,541	3.41%	3,757,432	0.61%
Price of soybeans (import)	Rs/MT	28,276	23,960	-1.64%	23,960	-1.64%
Price of soybeans (inland, wholesale)	Rs/MT	27,335	22,576	-1.89%	23,163	-1.64%
Price of soybeans (farm)	Rs/MT	23,235	19,190	-1.89%	19,689	-1.64%
Price of soy meal (wholesale)	Rs/MT	23,000	16,483	-3.28%	16,483	-3.28%
Price of soy oil (wholesale)	Rs/MT	65,850	67,181	0.20%	67,181	0.20%
Price of soy oil (refined)	Rs/MT	68,850	70,181	0.19%	70,181	0.19%
Unit processing cost excluding seed	Rs/MT	2,000	1,785	-1.13%	1,226	-4.77%
Unit processing cost including seed	Rs/MT	29,335	24,361	-1.84%	24,723	-1.70%
Unit processing surplus	Rs/MT	918	918	0.00%	556	-4.89%
Total processors' surplus	mill Rs	8,265	10,003	1.93%	10,504	2.43%
Soybean processing capacity	mil MT	30	30	0.00%	30	0.00%
Capacity Utilization	%	30	36	1.93%	61	7.34%

Source: ERS model results

Notes: price changes are in real (inflation adjusted) terms; MT = metric tons.

It is to be expected that future growth in soybean production would fall short of the historical rate due to a combination of projected real appreciation of the exchange rate and real decreases in world prices of soybean oil and meal. Falling price incentives restrain future production growth.

India's soybean meal exports decrease to 64,000 tons by the end of the simulation period, due to the combined effects of rising internal feed demand and an approximate doubling of India's non-crush demand for soybeans.

Rising oilseed production leads to an improvement in capacity utilization rate to 36 percent, computed by dividing the quantity of crush in the final year of the simulation (10.9 MMT) by the crush capacity (30 MMT). Increased capacity use generates modest declines in unit processing costs, but processor "quasi-profits"[5] per unit of production remain constant in real terms because with competitive markets the benefits of cost reductions are passed on to oilseed producers. Throughout the simulation period, domestic oilseed producer prices are linked to changes in world oil and meal prices, tariffs, and processing costs. Soybean farm prices do not fall as rapidly as world prices for two reasons. First, reductions in processing costs exert an upward influence on producer prices, partially offsetting the effects of decreasing world prices of soybean oil and soybean meal. Second, soybean oil tariffs rose progressively from its initial level of 12.5 percent in the base, ultimately reaching 30 percent in accordance with recent policy developments. This increase in the import tariff partially offsets the economic effects of decreasing world prices of soybean oil. Although processors do not realize higher quasi-profits per unit, they benefit from higher total profits because of increased volumes processed and marketed. Total processor quasi-profits expand 1.9 percent per year.

India's consumers continue to bear the costs of the 30 percent tariff on soybean oil imports. Nevertheless, spurred by rising income and falling real world prices, India's projected demand for soybean oil outpaces domestic production, leading to rising imports. Soy oil consumption increases by about 30 percent, from 5.3 MMT in 2016 to about 7.0 MMT in 2026.

[5]Quasi-profits, account for the major costs and revenues associated with processing, including the cost of raw materials, labor, power, steam, and hexane, and revenues from sale of oil and meal. Excluded items include such costs as bags and brokerage for de-oiled cake, local and central taxes, and from the sale of processing wastes.

Prospect for India's Soybean Complex: Soybean Imports Are Permitted

The oilseed import liberalization scenarios examined below assume reduced oilseed tariffs and the removal of existing phytosanitary barriers to soybean imports. All other assumptions on exogenous variables remain the same as in the Reference Scenario. However, to implement this alternative scenario, important changes are introduced into the analytical framework. With the removal of phytosanitary barriers, domestic oilseed prices become linked directly to world oilseed prices rather than domestic oil and meal prices. The only remaining protection of domestic oilseeds arises from soybean import duties, which have been sharply reduced and the "natural" protection afforded by transport and handling costs. A key implication of oilseed import liberalization is that India's high oil tariffs would have little to no effect on the oilseed prices received by Indian farm producers or paid by processors. The processors, however, would continue to benefit from high domestic oil prices and crush margins resulting from oil tariffs.

Even with the removal of trade restrictions, the vast majority of processors continue to rely on domestically produced soybeans—75 percent of India's soybean crush capacity is concentrated in the interior of the country, and they would not crush imported soybeans.[6] Only 25 percent of India's crush capacity is close enough to the coast to process imported soybeans, which limits the magnitude of India's import demand for soybeans.

Scenario II: Oilseed Imports: Transferring Benefits to Farmers

Scenario II is conducted in a way that prevents oilseed imports from leading to losses for oilseed producers. Producer prices are not allowed to fall below the levels seen in the Reference Scenario. This is a realistic approach because of the priority that policymakers place on producer welfare. Farm prices of soybeans are maintained at levels above those in the Reference Scenario due to tariffs on soybean imports, as well as the "natural" protection afforded by transport and handling costs that remove incentives for moving imported soybeans into the main (inland) areas of domestic soybean cultivation. The soybean oil tariff is maintained at 30 percent, as in the previous scenarios. The import price of soybeans is determined from the tariff-adjusted world price of soybeans plus transport costs that were drawn from the USDA Baseline. Domestic prices of oils and meals remain linked to world prices.

In effect, this policy experiment investigates whether processors' willingness to pay for oilseeds actually exceeds the autarchy prices from the Reference Scenario—the soybean import tariff is computed to transfer benefits to soybean farm producers without preventing growth in processors' surplus. In this policy experiment, Indian soy oil consumers are indifferent, since the soy oil tariff is unchanged.

By comparing the final years of Scenario II and the Reference Scenario, we can draw conclusions about the likely effect of the elimination of the trade barriers currently facing oilseed exports to India.

[6]The 75 percent figure is according to Mark Ash, an ERS Agricultural Economist, who has published extensively on topics related to the oilseed industry during his ERS tenure (1985-2019).

Beginning in 2017, crushers near the coast are free to expand production to levels that are larger than those in the Reference Scenario, since their supplies of raw materials are no longer constrained. Soybean imports occur, and unit-crushing costs decrease at a faster rate than in the Reference Scenario because of stronger growth in capacity utilization. Coastal crushers can operate at close to full capacity using imported soybeans. Inland processors also achieve higher utilization rates, relying on domestically produced soybeans. For India as a whole, the average capacity utilization rises to 61 percent versus only 36 percent in the Reference Scenario. In the processing sector, surplus per unit falls even with the observed decreases in unit costs of crushing, because processors, who previously paid the autarchy price for oilseeds, must now pay an even higher price for raw materials. Although processors earn about 39 percent less per unit of output, they make it up on volume by greatly increasing sales. Thus, total surplus in processing is higher than in the Reference Scenario, despite decreases in surplus per unit—a key result of expanding production using imported raw materials.

Processors can afford to pay somewhat more for oilseeds if the modest cost increase allows them to expand output. Therefore, oilseed trade liberalization is consistent with higher farm prices of soybeans that can be enforced by setting and defending farm support prices (Minimum Support Prices) accordingly. In the terminal year of Scenario II, the farm price of soybeans is 2.6 percent higher than the Reference Scenario. However, note that soybean prices still fall over the projection period while processors' surplus grows at roughly 2 percent per year in both scenarios, implying scope for further raising the soybean tariff to transfer more benefits from processors to farmers.

India's production of oil and meal exceed the levels in the Reference Scenario, as increased domestic production of soybeans is further augmented by imports of soybeans. Soy oil consumption is unchanged from the Reference Scenario, as India continues to impose the current 30 percent tariff on soybean oil, and gains in domestic output displace imports. India's consumption of soybean meal is the same as in the Reference Scenario, since the determinants of soy meal demand do not change from one scenario to the other. When soybean imports are permitted, domestic prices of meals are unchanged from the Reference Scenario because they remain linked to world prices as before.

Exports of soybean meal rise to about 6 million tons in the terminal year of Scenario II. By way of comparison, India's soybean meal exports peaked at 5.9 MMT in MY 2007/08 (USDA, 2018a). The globally significant projected exports of soybean meal in Scenario II are consistent with simulation results from Persaud and Landes (2006), wherein oilseed trade liberalization leads to projected soybean meal exports of 8.8 MMT in the terminal year (2011) of their simulation.

If India were in the future to shift toward larger scale crushing facilities, then the trade implications of this report would not change in that soybean imports would still be beneficial. With larger scale plant sizes, unit costs fall even more sharply as capacity utilization rises, suggesting greater gains from unrestricted oilseed imports. Consequently, multiyear projections that hold plant size constant could be considered lower bound estimates for future benefits of oilseed trade liberalization. Improved access to imported oilseeds could foster the growth of larger scale plants, further reinforcing the demand for reduced barriers to world markets for the raw material. These dynamics—i.e., the potential interactions between plant size and oilseed trade policy—are not modeled in this report.

Conclusion

Strong gains in income have spurred rapid growth in India's markets for vegetable oils and the oilseed meals used to feed livestock. India is a significant producer of oilseeds, but its demand for edible oils far outstrips its current capacity to supply oil from domestically produced oilseeds. As a result, India is the world's largest importer of soybean oil, despite its high tariffs. In recent years, rising internal demand for soybean meal has been met by drawing down exportable surpluses.

Market developments in the Indian oilseed sector are heavily influenced by domestic and trade policies, as policymakers attempt to weigh the competing priorities of different interest groups. Through fluctuating edible oil tariffs and policies that prevent the importation of whole oilseeds, Indian policymakers have simultaneously attempted to protect consumers from food price inflation—in part through increased imports of edible oils—and to protect India's sizable domestic production base of oilseeds from foreign competition.

India's trade restrictions that prevent soybean imports do not insulate domestic soybean producers from changes in world prices. India's soybean prices parallel world prices because they are determined primarily by the prices of their derived products (soy oil and soy meal), which are traded internationally as well as domestically. Thus, domestic soybean prices do not receive protection equivalent to India's 30-percent import tariff. Current policies, which aim to support soybean producers by imposing high tariffs on oil and prohibitive restrictions on soybean imports, have not led to significant gains in soybean yields. Limited supplies of soybeans have constrained processors to operate at low rates of capacity utilization, contributing to relatively high crushing costs and foregone sales and profits.

By effectively prohibiting oilseed imports, the Indian Government has given up a measure of policy flexibility that could balance the interests of soybean farmers and processors, to the advantage of both groups. Even without the adoption of more efficient, larger scale plants, the gains in processors' surplus from access to imported soybeans are sufficiently large to permit welfare-enhancing transfers to farmers. Under an alternate scenario, we show potential gains in sales revenues as well as cost savings associated with the ability to import soybeans and improve utilization rates in India's processing industry. We also demonstrate the means to distribute those gains through adjustments to India's tariffs on imported soybeans. A key finding is that imported soybeans are economically attractive to processors, even with a soybean tariff that protects Indian soybean farmers. Access to imported soybeans also allows India to expand domestic meal production and keep domestic meal prices in check, which is supportive of continued rapid growth in India's livestock sector.

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Appendix 1: Model Framework and Component

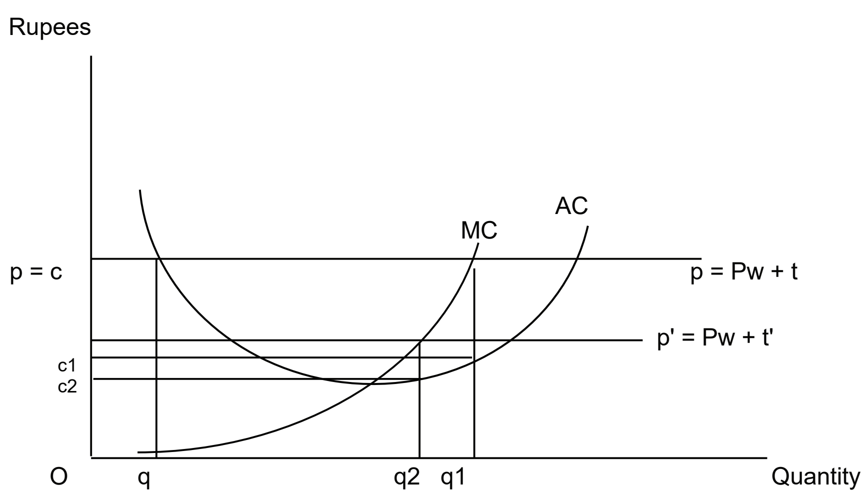
Model-based simulations are useful for investigating the potential economic outcomes of a hypothetical policy package that would permit the Indian soybean sector to emerge as a high-volume, low-margin business. In such a case, adjustments to India's oilseed and vegetable oil tariffs would be a key mechanism for redistributing to farmers and consumers the gains from oilseed imports.

The underlying analytical framework illustrates possible impacts on farmers, processors, and consumers of permitting imports of the raw material, taking into account that processors currently operate on the high-average-cost part (downward sloping) of their cost curves due to low capacity utilization. If imports of the raw material are permitted and processors continue to pay the same input prices, processors find it profitable to increase capacity use and move down their cost curves. Thus, processors gain in two key ways: their unit costs fall and their sales volumes increase. Moreover, liberalizing imports of raw materials may be supportive of lower output prices charged to consumers.

Reference (disequilibrium). The impacts of allowing imports of raw material (soybeans) are illustrated in fig. 1.1. The quantity shown on the X-axis is defined as the amount of raw material provided by farmers to produce output purchased by consumers; that is, the output is placed on a farm product equivalent basis. The Y-axis, which is in monetary terms, represents prices and costs. Average processing costs (AC) include labor, electricity, steam, interest, other costs, and most importantly, the price of raw material. In general form, average costs are written as:

AC = AC (Labor, Electricity, Steam, Interest, Other Costs, Oilseed).

Appendix Figure 1.1
Impacts of Oilseed Imports



The fixed [7]quantity, q, in turn determines the cost of crush, c, on the downward-sloping part of the cost curve. The processor would prefer not to operate on the downward-sloping part of the cost curve because doing so implies foregone profits. However, subsidy-driven over-investment in processing plants and policies preventing raw material imports lead to an artificially depressed rate of capacity use and a relatively high cost, as reflected in the figure. The output price, p, is exogenously determined from a world price (Pw) and a tariff (t), i.e.,

$p = Pw + t$.

For simplicity, it is assumed that p is identical to the unit cost, c. The cost of producing at q is given by the rectangle with width Oq and length Oc, i.e., (Oq)(Oc). The revenues obtained from producing q are given by the rectangle with width Oq and length Op, i.e., (Oq)(Op). But since p = c, profits, computed as ((Oq)(Op) - (Oq)(Oc), are zero.

Oilseed imports. In this scenario, nontariff barriers on imports of the raw material are eliminated, and tariffs are reduced. Nonzero tariffs are used to prevent imports of the raw material from depressing domestic prices below the reference scenario. Since the cost of the raw material and all other inputs does not change, the cost curves do not shift. In other words, the tariff is set to eliminate the price advantage of imported raw materials, thereby controlling for shifts in the cost curves. However, processors operate at a different point (q1), where p intersects marginal cost (MC). That is, processors find it profitable to increase the quantity produced using imported raw materials, where the quantity of imports is given by the difference, q1-q. Consequently, capacity utilization rises, and unit costs fall to c1. The total cost of processing q1 is the rectangle (Oq1)(Oc1). If the world price of the output and its tariff remain constant, the output price remains at p, leading to revenues of (Oq1)(Op). Profits, which are now positive, exceed those in the reference (disequilibrium) case, implying that processors benefit:

$((Oq1)(Op) - (Oq1)(Oc1) > (Oq)(Op) - (Oq)(Oc)$.

This result is noteworthy since it is based on an assumed tariff on raw material imports that protects farmer welfare. Consumers neither gain nor lose because the price of the output has not changed.

The analysis is taken a step further to determine if lower trade barriers on imports of the raw material can be used to compensate processors for reduced duties on imports of the output. The price of the output is reduced to p’ from p due to a reduction in the tariff to t’ from t. Imports of the raw material are curtailed, leading to a decrease in the quantity processed from q1 to q2. With unit costs at c2 and the output price at p’, profits now equal (Op’)(Oq2) - (Oc2)(Oq2), which still exceeds zero, the level of profits in the reference scenario. In other words, processors are still better off, even with reduced output tariffs, since the benefits of improved access to raw materials more than offset the impacts of lower output prices. The tariff on raw material imports maintains farm revenues at (Oq)(Oilseed), implying that farmers are indifferent to the policy package. Consumers benefit from the reduction in the output price from p to p’. Thus, reductions in the output tariffs transfer rents from processors to consumers.

[7]It follows that q is predetermined for the following reasons (1) q is defined as output placed on a farm product equivalent basis (2) biological lags exist in the farm production of the raw material (3) q only reflects production using domestically produced raw material supplies.

Although it is not shown in appendix fig. 1.1, there could also be scope for transferring processor rents to farmers by imposing a higher tariff on oilseeds, such that the import price exceeds the autarchy level. This would have the effect of shifting the cost curves upward due to higher raw material costs. Processors would then have to weigh the benefits of moving down a higher cost curve via oilseed imports, against operating at the autarchy crush level on the original cost curve.

Unlike the Indian poultry sector, which has experienced considerable changes in market structure as large-scale integrated producers achieved a dominant share of the poultry market, the country's oilseed processing industry underwent relatively little change in terms of technology and consolidation. Consequently, Persaud and Landes (2006) continue to provide a useful understanding of how unit crush costs vary with capacity utilization.

The quadratic equation that represents the cost curve for soybean processing (excluding the cost of the raw material) is given by:

$$(1)\ CRcost_1 = CR_1^1 \times CapUtil_1{**}2 + CR_1^2 \times CapUtil_1 + CR_1^0$$

$$= 2972.888 \times CapUtil_1{**}2 - 5374.413 \times CapUtil_1 + 2905.47,$$

where $CRcost_1$ is the average variable cost of crush, $CapUtil_1$ is capacity utilization, and "**2" indicates squared. Total crush costs ($TCRcost_1$) are represented by:

$$(2)\ TCRcost_1 = SCrush_1 \times \{2972.888 \times (SCrush_1/Cap){**}2 - 5374.413 \times (SCrush_1\ /Cap) + 2905.47\} + FC,$$

where $SCrush_1$ is the quantity of soybean crush, FC is the fixed cost, and Cap is the soybean crush capacity, such that capacity utilization ($CapUtil_1$) is given by $SCrush_1/Cap$ in (2).

When oilseed imports are permitted, the optimal crush quantity cannot be computed as a residual, since optimal oilseed crush may exceed domestic production. The optimizing framework computes the level of soybean crush to maximize processors' surplus, subject to the cost equation, and given output and input prices.

$$(3)\ \underset{SCrush1}{Max}\ \{SCrush_1[OEXT_1 \times OPriceW_1 + MEXT_1 \times MPriceW_1] - TCRcost_1 - SCrush_1\ SPriceW_1\}$$

where $OEXT_1$ is the soybean oil extraction rate, $OPriceW_1$ is the domestic price of soy oil, $MEXT_1$ is the soybean meal extraction rate, $MPriceW_1$ is the domestic price of soy meal, and $SPriceW_1$ is the domestic price of the raw material (soybeans).

Substituting (2) into (3) for the crush cost and rearranging terms yields:

$$(4)\ \underset{SCrush1}{Max}\ \{SCrush_1 \times [OEXT_1 \times OPriceW_1 + MEXT_1 \times MPriceW_1 - SPriceW_1]$$

$$- [SCrush_1 \times (2972.888 \times (SCrush_1/Cap){**}2 - 5374.413 \times (SCrush_1/Cap) + 2905.47) + FC]\}$$

Rather than solving explicitly for the crush demand, the optimization framework used in this study iterates to compute the profit-maximizing quantity of oilseed crush. A non-deterministic approach is preferable, since the cost curves are nonlinear, and it is difficult to obtain closed-form solutions. Crush levels that exceed the predetermined quantity of domestic production give rise to oilseed imports. Domestic oil, meal, and oilseed prices, which are influenced by world prices, transport costs, and tariff levels in the case of the oil and oilseed, will affect the profit-maximizing quantity of oilseed crush. Additionally, the ratio of the tariffs on oils to oilseeds will affect the crush and oilseed import decision. All other things equal, an increase in the oil tariff relative to the oilseed tariff tends to favor oilseed imports. Similarly, the ratio of the world prices of the outputs (oil and meal) to the world oilseed prices, coupled with the ratio of the transport costs of oils to oilseeds, will influence the oilseed import decision. This information is summarized in the crush margins that prevail in the domestic market.

Appendix 2: India Soybean Model: Equations

Oilseed Block

(A.1) Soybean Area $SArea = SA_1*SArea_{t-1} + SA_2*SPriceF_{t-1} + SA_3*SYield_{t-1} + SA_4*COPrice_{F,\, t-1} + SA_0$

(A.2) Soybean Yield $SYield = SYield_{t-1} *TREND$

(A.3) Soybean Production $SProd = SArea*SYield$

(A.4) Non-crush demand $SNonCrush = NC_1*SNonCrush_{t-1} + NC_2*SPriceW_{t-1} + NC_3*SNonCrush_{t-1}*Trend + NC_0$

(A.5) Total Crush Cost $TCRcost = [CR_1*CapUtil**2 - CR_2*CapUtil + CR_0]*SCrush + FC$

(A.6) Capacity utilization $CapUtil = SCrush/Cap$

(A.7) Soybean crush SCrush =

Autarchy:
$SProd - SNonCrush$

Oilseed Trade:
$$\max_{SCrush} \; SCrush*[OEXT*OPriceW + MEXT*MpriceW] - TCRcost - SPriceW*SCrush$$

(A.8) Soybean imports $IMS = SCrush + SNonCrush - SProd$

Soy Oil Block

(A.9) Oil Production $OProd = OEXT*SCrush$

(A.10) Oil Demand $ODemand = OD_1*OPrice + OD_2*GDP + OD_3*OOPrice + OD_0$

(A.11) Oil imports $IMOil = ODemand - OProd$

Soy Meal Block

(A.12) Meal Production $MProd = MEXT*SCrush$

(A.13) Meal Demand $MD = MD_{t-1}*$ **TREND**

(A.14) Meal exports $EXMeal = MProd - MD$

Oil, Meal, and Seed Price Block

(A.15) Wholesale price of oil $OPriceW = (1+t_O)*OPriceREF + Margin_O$

(A.16) Oil margin $Margin_O = OCEAN_O + Inland_O$

(A.17) Farm price of seed SPriceF = SPriceW - SHandle

(A.18) Wholesale price of meal MPriceW = MPriceREF - MarginM

(A.19) Wholesale price of seed SPriceW =

Autarchy:
OEXT*OPriceW + MEXT*MPriceW – CRcost

Oilseed Trade:
SPriceREF*(1 + t_S) + STRAN

Variable list	
SArea	Oilseed area
SYield	Oilseed yield
SProd	Oilseed production
SNonCrush	Non-crush demand
IMS	Oilseed imports
SCrush	Oilseed crush
TCRcost	Total crush cost
CapUtil	Capacity utilization
Cap	Oilseed processing capacity
FC	Fixed cost
OProd	Oil production
OEXT	Oil extraction rate
ODemand	Oil demand
OPrice	Price of oil (own-price)
OOPrice	Prices of competing oils
GDP	Gross domestic product per capita
IMOil	Oil imports
MProd	Meal production
MEXT	Meal extraction rate
MD	Total soy meal demand
MPriceW	Wholesale price of meal
EXMeal	Meal exports
t_o	Oil tariff
t_s	Oilseed tariff
OPriceREF	Reference price of oil
$Margin_o$	Wholesale-reference price margin for oil (oil margin)
$OCEAN_o$	Ocean freight & insurance for oil imports
$Inland_o$	Inland transportation and marketing costs for oil
MPriceW	Wholesale price of meal
MPriceREF	Reference (border) price of meal
$Margin_m$	Reference-wholesale price margin for meal (meal margin)
SPriceF	Farm price of oilseed
SPriceW	Wholesale price of seed
SHandle	Wholesale-farm price spread for oilseed
SPriceREF	Reference (border) price of seed
STRAN	Ocean freight plus inland transportation and handling cost for oilseed
PCGDP	Real GDP per capita

Appendix 3: Parameters and Elasticities for India Soybean Model

The projections presented in this report rely on elasticities, which measure the impacts of changes in income and price on the demand for soybean oil, as well as the responsiveness of area cultivated with soybeans to changes in the prices of soybeans and corn.

The existing literature does not provide formal estimates of income or own-price elasticities of demand for soybean oil in India. Time-series price data provide relatively few observations for econometric estimation. Kumar (1998) estimated demand elasticities for "oil" as an aggregate commodity group, with expenditure elasticities of 0.389 (rural) and 0.234 (urban), and own-price elasticities of -0.567 (rural) and -0.522 (urban). For the edible oils food group, Kumar's (2011) quadratic almost ideal demand system (QUAIDS) model specification resulted in own-price and income elasticities of -0.377 and 0.772, respectively, for all income groups. Based on a food characteristic demand system (FCDS) for edible oils, Kumar (2011) found own-price and income elasticities of -0.504 and 0.297, respectively, (all income groups). For the commodity group "edible oil", Dev et al. (2004) obtained results of 0.85 (rural) and 0.3662 (urban) for the expenditure elasticities and -0.5698 (rural) and -0.3547 (urban) for the own-price elasticities.

In this report, the income and own-price elasticities for soybean oil consumption are 0.60 and -0.32, respectively. These estimates are similar to two other sets of estimates in the literature: (a) Persaud and Dohlman (2006), which reports analogous figures of 0.78 and -0.54 for soybean oil; and (b) the elasticities from Persaud and Landes (2006) of 0.50 for income and –0.44 for the own-price. The scenarios developed in the current study hold constant the prices of substitutes and complements, such that demand is influenced only by changes in own-price and income.

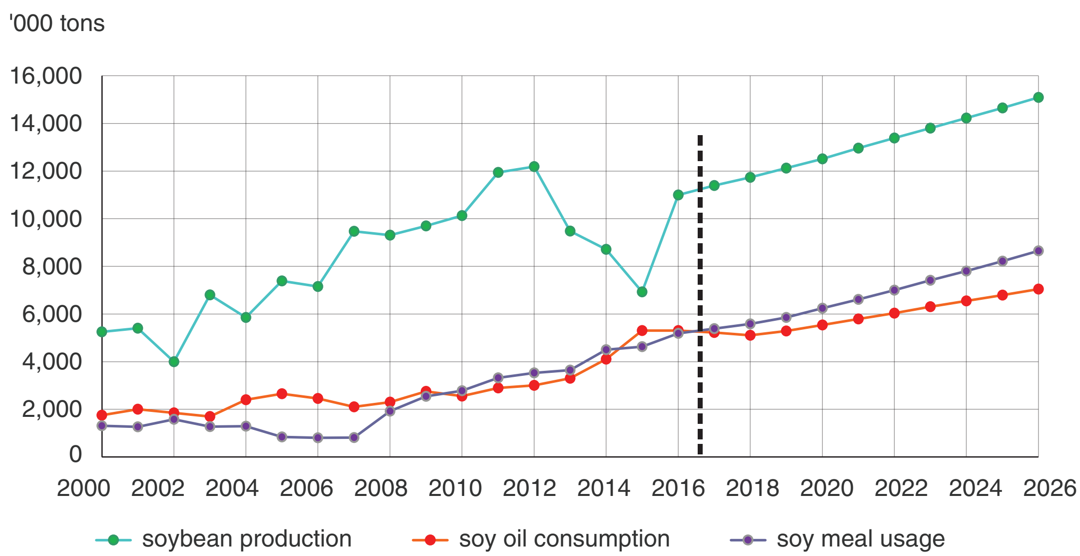
For soybean area, this report utilizes short and long run own-price elasticities of 0.21 and 0.525, respectively, in line with Persaud and Dohlman (2006), where the analogous figures were 0.20 and 0.60. Similarly, Persaud and Landes (2006) used an own-price elasticity of 0.63, where the soybean area response was not specified with a lagged dependent variable. Other published studies found smaller soybean area responses. Berry and Schlenker (2011) estimated own price elasticities ranging from 0.133-0.357, where the results with higher levels of statistical significance were 0.348 and 0.357. Haile, Brockhaus, and Kalkuhl (2016) estimated the own-price elasticity to be 0.157 for soybean area, with corn as a competing crop (cross-price elasticity of -0.046). Simulations developed by Jha et al. (2012) used an own price elasticity of 0.50 for total oilseed production.

The current body of literature provides limited guidance for determining and selecting the model parameters. Studies on demand and supply elasticities in India reveal a range of estimates across studies as well as within studies. In the case of India's non-crush demand for soybeans, no published studies exist. Rather than being fixed parameters, elasticities can vary over time as income and expenditure levels change. Although rigorously estimated within sample, published elasticities may generate implausible out-of-sample supply and demand projections that diverge from insights and expectations of industry experts. Finally, published econometric estimates are not always statistically significant. The existing literature suggests that the actual magnitudes of supply and demand elasticities are uncertain. Accordingly, the elasticities used in this study are derived from a synthetic approach that generates projections that are roughly in line with recent historical trends (2000-16) for soy oil and soy meal demands and soybean production (appendix fig. 3.1).

Equation & Coefficient	Parameter	Elasticity
Soybean area equation:		
$SArea_{t-1}$ (SA_1)	0.58	0.60
$SPrice_{Ft-1}$ (SA_2)	90	0.21
$SYield_{t-1}$ (SA_3)	4000000	0.35
$COPrice_{Ft-1}$ (SA_4)	-25	-0.02
Constant (SA_0)	-814737	--
Non-crush demand equation:		
$SNonCrush_{t-1}$ (NC_1)	0.20	0.14
$SPriceW_{t-1}$ (NC_2)	-25	-0.34
$SNonCrush_{t-1}$*Trend (NC_3)	0.06	
constant (NC_0)	410000	--
Crush cost equation:		
$CapUtil^2$ (CR_1)	2972.8877	--
CapUtil (CR_2)	-5374.4133	--
Constant (CR_0)	2905.47.	--
Soy oil demand equation:		
OPrice (OD_1)	-25.13	-0.32
GDP (OD_2)	20.77	0.54
constant (OD_0)	4190077	--

Appendix figure 3.1

Consumption of soy oil, soy meal, and production of soybeans, historical and projected



Notes: historical is 2000-16; the projected quantities are from Reference Scenario.

Sources: USDA PS&D and author's model simulations.