Argentina's Agricultural Policies

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I. Introduction

As the world's third largest producer of soybeans and largest producer of soymeal (FAS, 2014), Argentina plays an important role in the global soy market as it is one of the world's leading exporters of soybeans, soymeal and soyoil. In addition to soy products, Argentina is a major producer, consumer, and exporter of beef. Though Argentina has historically been one of the world's top beef-producing countries, over the last decade it has relinquished much of its world market share as its exports have fallen. In the wake of a currency devaluation and in an effort to shift its agricultural sector's focus to value-added exports, in 2002 Argentina's government implemented a regime of export tariffs, with ad valorem duties of 10% on soybeans, 5% on soymeal, and 4.3% on soyoil (USTR, 2013). Since then, the export tariff on soybeans has risen to 35%, while the tariff on meal and oil has risen to 32%. The main goal of these policies is to bolster domestic availability of the products, but they are also used as a source of government revenue (Piermartini 2004; Bouët and Laborde 2012). Since 2006, in an effort to bolster domestic availability and curb rising food prices, the government has periodically imposed a ban on exports of beef and has also used an export tariff of 15% (USTR, 2013). The introduction of these beef trade policies was met with strong opposition from beef producers because of lost export sales. The recent trade restrictions have generated numerous unintended consequences in both the soy and beef sectors.

The export tariffs have had two immediate effects on the soy industry: the first, that the tariff on soybeans curtails soybean exports and makes producers sell their produce domestically to be processed into meal or oil. This effect can be seen in Figure 1. Even though soybean production expanded significantly, soybean exports have stagnated and declined sharply since 2010.

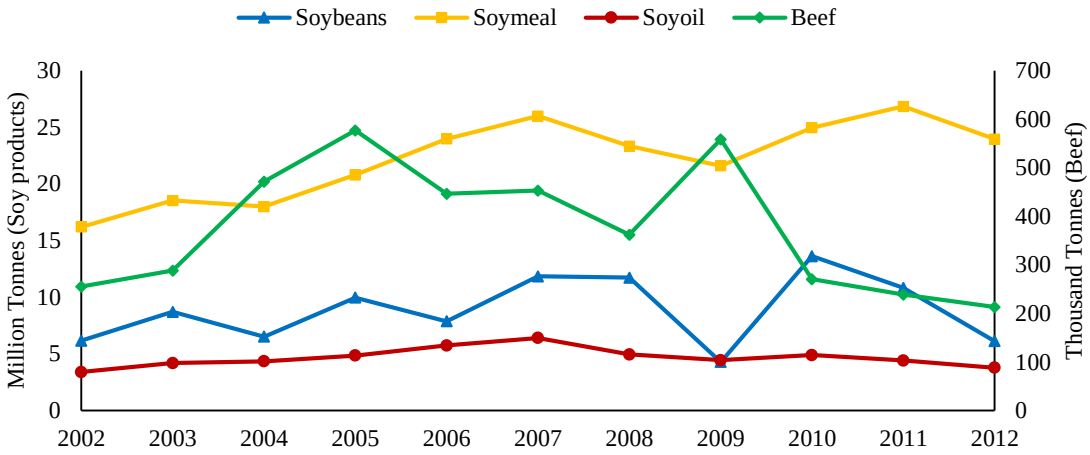

Figure 1. Argentine soy, soy product, and beef exports, 2002-2012
Source: UN Commodity Trade Statistics (Comtrade)

The second effect is inherently related to the first: as more soybeans are sold and processed domestically, coupled with the relatively lower export tariff on soymeal and soyoil, more soymeal and soyoil are exported. This effect is also apparent in Figure 1, as Argentine soymeal exports have been expanding fairly steadily for the last decade. This expansion has occurred in spite of the sizable and increasing tariffs, and has been driven by high global demand and currency devaluations by the Central Bank of Argentina, both of which offset the tariffs' effects on exports (Andino, Mulik and Koo 2005). Argentina's trade policies thus significantly affect the soy and cattle sectors through reduced exports and also adversely impact overall agricultural exports. For instance, Fabiosa et al. (2003) found that complete multilateral liberalization of world agricultural trade policy would drastically expand Argentina's agricultural exports, leading Argentina to become a net exporter of food products.

Argentine cattle and soybean production are closely linked. Soymeal is used extensively as feed for livestock, and Argentine farmers have the ability to substitute their land usage between pasture and soybeans. Since the higher soybean export tariffs relative to soymeal export tariffs make it relatively cheaper to export soymeal than soybeans, more soymeal is shipped

abroad than soybeans, and therefore less soymeal is available as feed domestically. Thus, Argentine cattle producers face the adverse effects of twin problems: a rising feed price driven by foreign demand for soymeal and the beef export tariffs and quotas. Past studies of the Argentine tariffs, such as Deese and Reeder (2007), do not consider the cattle sector from the analysis, which will not provide accurate estimates of the overall effects of the trade policies. Figure 2 illustrates the effect of these trade policies on the interconnection between cattle stocks and soybean supply.

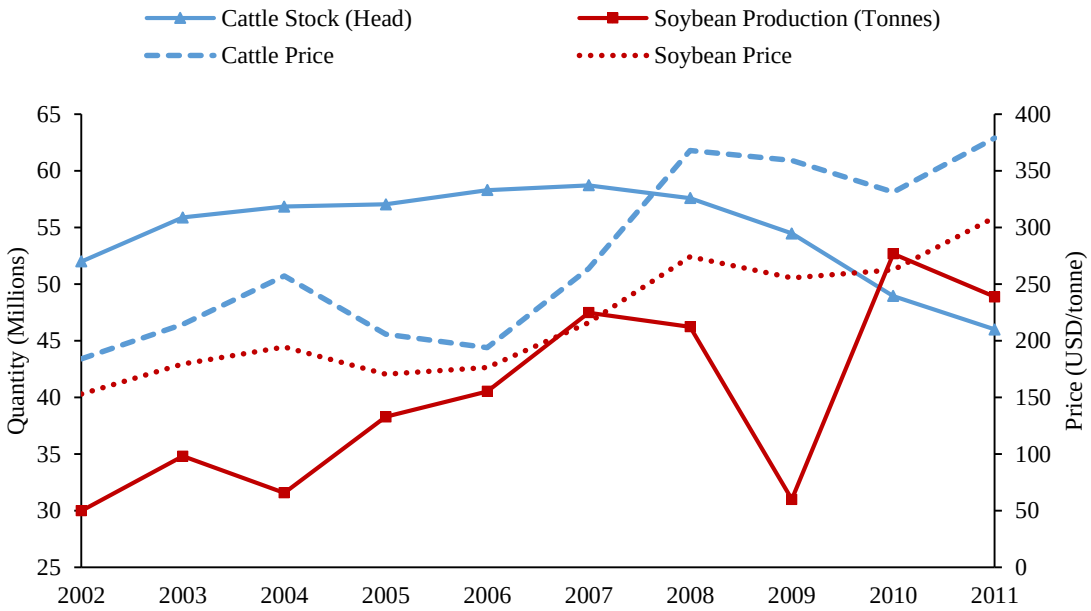

Figure 2. Argentine cattle stock and soybean production and prices, 2002-2011
Source: UN Food and Agriculture Organization (FAO)

Aside from a 2009 lapse due to severe drought, soybean production has increased to meet processing demand, but as a result of the beef export barriers and unprofitable cattle operations, domestic cattle stocks have fallen precipitously from a peak of nearly 59 million head in 2007 to 46 million in 2011. In addition, many ranchers choose to substitute away from cattle production and instead convert their pastures for soybean production, further bolstering the rapidly expanding soybean supply. The government's policies have therefore contributed to lower cattle

stocks and higher beef prices, in spite of the introduction of beef export restrictions with the intent of lowering prices and increasing the amount of beef available on the domestic market. Consequently, an unintended result of this policy shift is that because of reduced availability, domestic beef consumption has declined noticeably. Because of the increased demand for soybeans for soymeal production and exports, along with currency devaluation and economy-wide inflation, soybean prices are also fairly high. In its efforts to control food inflation, encourage soymeal and soyoil exports, and increase domestic availability of beef, Argentina has decimated its cattle industry which has resulted in higher beef prices–even though the original intention of the government was to keep beef prices low–and made consumers worse off.

The objective of this research is to analyze the unintended consequences of these trade policies on soybeans, soymeal, soyoil, cattle, beef, and land use. Toward this goal, we develop a theoretical model capturing the interconnection between these markets and incorporating the export restrictions in the soy and beef markets. The theoretical model is then calibrated to real world data using data on production, consumption, and trade in the different sectors of the Argentine economy. The remainder of the paper is organized as follows. Section II develops a theoretical model of Argentina's soy product and livestock sectors, which is used to motivate the empirical analysis. Section III presents the empirical analysis and discusses results on the effects of Argentina's trade policies. Section IV provides summary and conclusions of the study.

II. Theoretical Model

We first develop an analytical framework to capture the linkages and interactions between the soy and cattle sectors. For simplicity, we consider an open economy that produces, consumes, exports, and imports several goods. Figure 3 depicts the economy's sectors and activities and Table 1 presents the definitions of all the variables used in the model. Progressing from left to

right, the figure shows how factors are used in intermediate and final good production, and which goods are consumed domestically versus exported abroad.

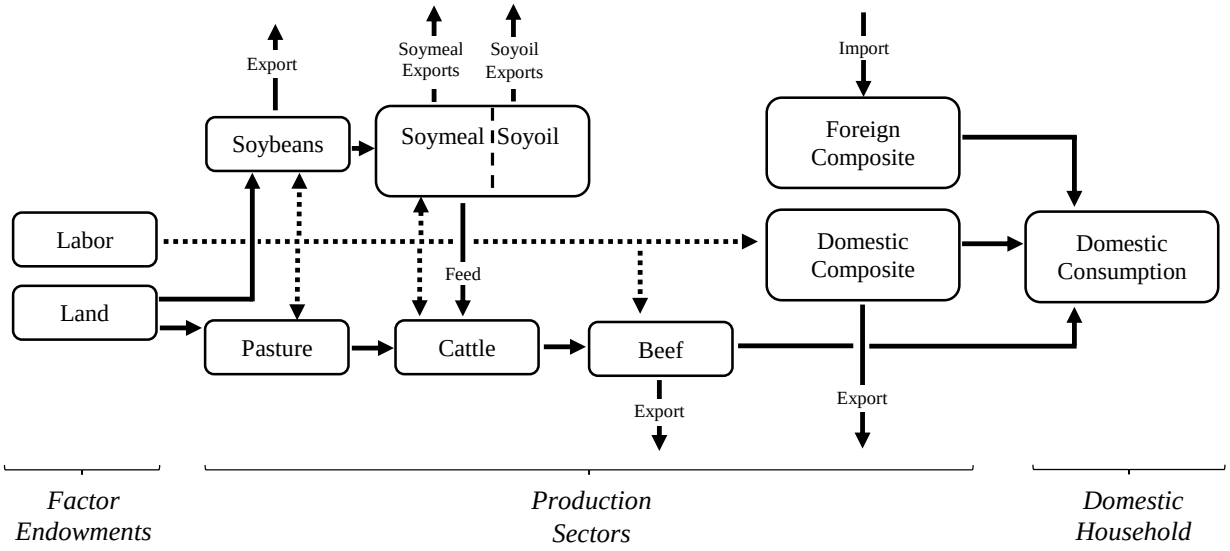

Figure 3. Linkages between sectors and resource uses in theoretical model

Table 1. Model variables and definitions

Variable	Definition	Variable	Definition	Variable	Definition
$\bar{L}$	Labor endowment	D_{BE}	Beef consumption	p_R	Land price
$\bar{R}$	Land endowment	D_{DY}	Domestic composite consumption	p_{FX}	Foreign exchange price
S_{SB}	Soybean production				
S_{SM}	Soymeal production	D_{FY}	Foreign composite consumption	p_{XSB}	Soybean export price
S_{SO}	Soyoil production			p_{XSM}	Soymeal export price
S_{PA}	Pasture production	W	Household welfare	p_{XSO}	Soyoil export price
S_{CA}	Cattle stock	I	Household income	p_{XBE}	Beef export price
S_{BE}	Beef production	p_{SB}	Soybean price	p_{XDY}	Domestic composite export price
S_{DY}	Domestic composite production	p_{SM}	Soymeal price		
		p_{SO}	Soyoil price	p_{MDY}	Foreign composite import price
X_{SB}	Soybean exports	p_{PA}	Pasture price		
X_{SM}	Soymeal exports	p_{CA}	Cattle price	τ_{SB}	Soybean export tariff
X_{SO}	Soyoil exports	p_{BE}	Beef price	τ_{SM}	Soymeal export tariff
X_{BE}	Beef exports	p_{DY}	Domestic composite price	τ_{SO}	Soyoil export tariff
X_{DY}	Domestic composite exports			τ_{BE}	Beef export tariff
		p_{FY}	Foreign composite price		
M_{FY}	Foreign composite imports				
		p_L	Labor price		

The economy is endowed with fixed quantities of two inputs: labor $(\bar{L})$ and land $(\bar{R})$. The production sectors of the economy consist of soybeans (SB), joint soymeal and soyoil production (SM and SO), pasture (PA), cattle (CA), beef (BE), and a domestically-produced composite good (DY). Each sector is comprised of a representative firm which exhibits Cobb-Douglas technology with constant returns to scale (and thus constant average cost). Input and final good markets are perfectly competitive, which is a result of each sector's constant returns to scale technology. Production in sector i is denoted by S_i. Labor is used as an input in production in each domestic sector. Land can either be used to grow soybeans or as pasture for cattle grazing. Soybeans are an intermediate input in the joint production of soymeal and soyoil, which are produced in fixed proportions: one unit of soymeal and κ unit of soyoil. Soymeal is used in conjunction with pasture to maintain the domestic cattle stock. Each sector i's usage of input J is denoted by J_i; for example, the amount of labor used in the soymeal sector is given by L_{SM}, and the amount of soybeans used for processing in the soymeal/soyoil sector is denoted by SB_{SM}. Prices for a given activity/sector i are denoted by p_i.

Soybeans, soymeal, soyoil, beef, and the domestic composite good can be exported abroad in exchange for a foreign composite good (FY), with goods traded fetching the world price which is converted into Argentine peso using the exchange rate (p_{FX}). Exports in these sectors are denoted respectively by X_{SB}, X_{SM}, X_{SO}, X_{BE}, and X_{DY}, while imports of the foreign composite good are denoted by M_{FY}. To capture Argentina's relative prominence in world soybean, soymeal, soyoil, and beef markets, we allow for the domestic country in the model to exert market power in these export markets. This is accomplished by assuming that the foreign excess demand facing exporters of these commodities has a non-zero price elasticity of

demand: specifically, foreign demand for the country's soybean, soymeal, soyoil, and beef exports takes a constant elasticity form, with D_i^* denoting foreign excess demand for commodity i and $\theta_i < 0$ denoting the foreign elasticity of excess demand for commodity i:

$$D_{SB}^* = p_{XSB}^{\theta_{SB}}, \qquad D_{SM}^* = p_{XSM}^{\theta_{SM}}, \qquad D_{SO}^* = p_{XSO}^{\theta_{SO}}, \qquad D_{BE}^* = p_{XBE}^{\theta_{BE}}.$$

Argentina imposes ad valorem export tariffs on exports of soybeans, soymeal, soyoil, and beef, with tariff rates denoted respectively by τ_{SB}, τ_{SM}, τ_{SO}, and τ_{BE}. The effective prices that must be paid to export one unit of either of these goods when they face an export tariff are given by the price linkage equations (2) to (5) in Table 2. Since Argentina periodically implemented beef export bans, we also analyze the effects of beef export quota, which does not require a price linkage equation.

For the consumer side of the economy, we assume preferences can be aggregated such that there exists a representative household which derives utility from consumption of beef as well as domestic and foreign composite goods, with household consumption of good j denoted by D_j. Household utility takes a Cobb-Douglas form that is homogeneous of degree one in consumption of the three goods. The household's income is derived from factor payments to labor and land, as well as lump sum transfers of export tariff revenues from the government.

The competitive equilibrium in this economy is characterized by conditions for zero profit in each sector (including profit's analogue for household welfare), market clearing (i.e., no excess supply or demand), and income balance for the household. The consumer and producer problems are formulated using a dual approach of expenditure and cost minimization. We first solve for the reduced form solutions for input/consumer demands in each sector, which are

needed to characterize the equilibrium. For brevity of exposition, we present only the formulations and solutions for the representative household's and soybean sector's problems[1].

The household problem is to minimize the expenditure subject to a given level of utility[2]:

$$\min_{\{D_{BE},D_{DY},D_{FY}\}} p_{BE}D_{BE} + p_{DY}D_{DY} + p_{FY}D_{FY}$$

$$\text{subject to} \qquad W = \left(\frac{D_{BE}}{\eta_1}\right)^{\eta_1}\left(\frac{D_{DY}}{\eta_2}\right)^{\eta_2}\left(\frac{D_{FY}}{1-\eta_1-\eta_2}\right)^{1-\eta_1-\eta_2}, \qquad (1)$$

where η_1 and η_2 are parameters. The household's budget constraint states that the expenditure is equal to income

$$p_{BE}D_{BE} + p_{DY}D_{DY} + p_{FY}D_{FY} = I = p_L\bar{L} + p_R\bar{R} + \tau_{SB}p_{SB}X_{SB} + \tau_{SM}p_{SM}X_{SM} + \tau_{SO}p_{SO}X_{SO} + \tau_{BE}p_{BE}X_{BE}.$$

The above expenditure minimization yields the Hicksian demand functions

$$D_{BE}\left(p_{BE},p_{DY},p_{FY},W\right) = \eta_1 p_{BE}^{\eta_1-1}p_{DY}^{\eta_2}p_{FY}^{1-\eta_1-\eta_2}W,$$

$$D_{DY}\left(p_{BE},p_{DY},p_{FY},W\right) = \eta_2 p_{BE}^{\eta_1}p_{DY}^{\eta_2-1}p_{FY}^{1-\eta_1-\eta_2}W,$$

$$D_{FY}\left(p_{BE},p_{DY},p_{FY},W\right) = \left(1-\eta_1-\eta_2\right)p_{BE}^{\eta_1}p_{DY}^{\eta_2}p_{FY}^{-\eta_1-\eta_2}W.$$

Substituting these three demands into expenditures yields the household's expenditure function: $e\left(p_{BE},p_{DY},p_{FY},W\right) = p_{BE}^{\eta_1}p_{DY}^{\eta_2}p_{FY}^{1-\eta_1-\eta_2}W,$ which becomes $e\left(p_{BE},p_{DY},p_{FY}\right) = p_{BE}^{\eta_1}p_{DY}^{\eta_2}p_{FY}^{1-\eta_1-\eta_2}$ when $W=1.$ The household expenditure function (and each production sector's cost function) will be used extensively in our characterization of the economy's equilibrium. Because the expenditure function is homogeneous of degree one in welfare level, $e\left(p_{BE},p_{DY},p_{FY},W\right)$ is equal to $W\times e\left(p_{BE},p_{DY},p_{FY}\right).$ This allows for the zero profit condition in the welfare "sector" to be

[1] The full set of optimization problems, first order conditions, and resulting cost/expenditure functions are available from the authors upon request.

[2] The arguments of the utility function and production functions are normalized by their share parameters for convenience. Specifically, this form is chosen since when the model is solved and its equilibrium is characterized, the consumer's expenditure function and producers' cost functions take a highly simplified form.

characterized in unit terms: defining the monetary value of one unit of utility as p_W, in equilibrium, $p_W = e(p_{BE}, p_{DY}, p_{FY}) = p_{BE}^{\eta_1} p_{DY}^{\eta_2} p_{FY}^{1-\eta_1-\eta_2}$.

Turning to the production side, the soybean sector's problem is to minimize the cost subject to the given level of output, with the level of soybean output being determined by the sector's Cobb-Douglas technology:

$$\min_{\{L_{SM}, R_{SB}\}} \; p_L L_{SB} + p_R R_{SB} \qquad \text{subject to} \qquad S_{SB} = \left(\frac{L_{SB}}{\alpha}\right)^{\alpha} \left(\frac{R_{SB}}{1-\alpha}\right)^{1-\alpha}.$$

Solving this minimization problem yields the soybean sector's conditional input demand functions for labor and land:

$$L_{SB}(p_L, p_R, S_{SB}) = \alpha p_L^{\alpha-1} p_R^{1-\alpha} S_{SB}, \qquad R_{SB}(p_L, p_R, S_{SB}) = (1-\alpha) p_L^{\alpha} p_R^{-\alpha} S_{SB}.$$

Substituting these conditional input demands into the firm's cost equation yields the cost function: $c_{SB}(p_L, p_R, S_{SB}) = p_L^{\alpha} p_R^{1-\alpha} S_{SB}$. When $S_{SB} = 1$, $c_{SB}(p_L, p_R) = p_L^{\alpha} p_R^{1-\alpha}$ is the soybean sector's unit cost function. Solving each sector's problem yields similar results.

Table 2 summarizes consumer preferences and producer technology as well as the equations that characterize the model. Equations (2) - (5) show the price linkage equations, which relate domestic commodity prices to the world price of the good and the price of foreign exchange. Equations (6) - (19) depict the zero profit conditions for each sector, which state that cost per unit must be at least as large as revenue per unit in each sector. Equations (20) - (35) give the market clearing conditions, which state that total supply of each commodity must be at least as large as total demand for each commodity. Finally, equation (36) gives the income balance equation, which defines household income as a function of factor payments and tariff revenues disbursed from the government to the consumer.

Because of its complexity and its numerous sectoral interdependences, analytical solutions for many of the theoretical model's endogenous variables are generally intractable. The next section therefore turns to the calibration of the model to real world data and numerical simulation of its solution.

Table 2. Model equations, equilibrium conditions, and associated complementary slackness variables

Consumer Utility and Producer Technology

$$u\left(Q,D_{FY}\right)=\left(Q/\eta\right)^{\eta}\left(D_{FY}/(1-\eta)\right)^{1-\eta},\quad Q\left(D_{BE},D_{DY}\right)=A\left[\alpha D_{BE}^{\rho}+(1-\alpha)D_{DY}^{\rho}\right]^{1/\rho}$$

$$S_{SB}\left(L_{SB},R_{SB}\right)=\left(L_{SB}/\alpha\right)^{\alpha}\left(R_{SB}/(1-\alpha)\right)^{1-\alpha}$$

$$S_{SM}\left(L_{SM},SB_{SM}\right)=\left(L_{SM}/\beta\right)^{\beta}\left(SB_{SM}/(1-\beta)\right)^{1-\beta}$$

$$S_{SO}\left(L_{SM},R_{SM}\right)=\kappa\left(L_{SM}/\beta\right)^{\beta}\left(R_{SM}/(1-\beta)\right)^{1-\beta}$$

$$S_{PA}\left(L_{PA},R_{PA}\right)=\left(L_{PA}/\varepsilon\right)^{\varepsilon}\left(R_{PA}/(1-\varepsilon)\right)^{1-\varepsilon}$$

$$S_{CA}\left(L_{CA},SM_{CA},PA_{CA}\right)=\left(L_{CA}/\lambda_1\right)^{\lambda_1}\left(SM_{CA}/(1-\lambda_2)\right)^{1-\lambda_2}\left(PA_{CA}/(1-\lambda_1-\lambda_2)\right)^{1-\lambda_1-\lambda_2}$$

$$S_{BE}\left(L_{BE},CA_{BE}\right)=\left(L_{BE}/\gamma\right)^{\gamma}\left(CA_{BE}/(1-\gamma)\right)^{1-\gamma}$$

$$S_{DY}\left(L_{DY}\right)=L_{DY}$$

Price Linkage Equations

$$p_{FX}p_{XSB}=(1+\tau_{SB})p_{SB}\quad(2)$$

$$p_{FX}p_{XSM}=(1+\tau_{SM})p_{SM}\quad(3)$$

$$p_{FX}p_{XSO}=(1+\tau_{SO})p_{SO}\quad(4)$$

$$p_{FX}p_{XBE}=(1+\tau_{BE})p_{BE}\quad(5)$$

Zero Profit Conditions

$\mathbf{S_{SB}}$	$p_L^{\alpha}p_R^{1-\alpha}\geq p_{SB}$	(6)	$\mathbf{S_{SM}}$	$p_L^{\beta}p_{SB}^{1-\beta}\geq p_{SM}$	(7)	$\mathbf{S_{SO}}$	$p_L^{\beta}p_{SB}^{1-\beta}\geq p_{SM}$	(8)
$\mathbf{S_{PA}}$	$p_L^{\varepsilon}p_R^{1-\varepsilon}\geq p_{PA}$	(9)	$\mathbf{S_{CA}}$	$p_L^{\lambda_1}p_{SM}^{\lambda_2}p_{PA}^{1-\lambda_1-\lambda_2}\geq p_{CA}$	(10)	$\mathbf{S_{BE}}$	$p_L^{\gamma}p_{CA}^{1-\gamma}\geq p_{BE}$	(11)
$\mathbf{S_{DY}}$	$p_L\geq p_{DY}$	(12)	$\mathbf{X_{SB}}$	$(1+\tau_{SB})p_{SB}\geq p_{FX}p_{XSB}$	(13)	$\mathbf{X_{SM}}$	$(1+\tau_{SM})p_{SM}\geq p_{FX}p_{XSM}$	(14)
$\mathbf{X_{SO}}$	$(1+\tau_{SO})p_{SO}\geq p_{FX}p_{XSO}$	(15)	$\mathbf{X_{BE}}$	$(1+\tau_{BE})p_{BE}\geq p_{FX}p_{XBE}$	(16)	$\mathbf{X_{DY}}$	$p_{DY}\geq p_{FX}p_{XDY}$	(17)
$\mathbf{M_{FY}}$	$p_{MY}p_{FX}\geq p_Y$	(18)	$\mathbf{W}$	$p_{BE}^{\eta_1}p_{DY}^{\eta_2}p_{FY}^{1-\eta_1-\eta_2}\geq p_W$	(19)			

Market Clearing Conditions

$\mathbf{p_{SB}}$	$S_{SB}\geq X_{SB}+(1-\beta)\frac{p_{SM}}{p_{SB}}S_{SM}$	(20)	$\mathbf{p_{SM}}$	$S_{SM}\geq X_{SM}+\lambda_2\frac{p_{CA}}{p_{SM}}S_{CA}$	(21)	$\mathbf{p_{SO}}$	$S_{SO}\geq X_{SO}$	(22)
$\mathbf{p_{PA}}$	$S_{PA}\geq(1-\lambda_1-\lambda_2)\frac{p_{CA}}{p_{PA}}S_{CA}$	(23)	$\mathbf{p_{CA}}$	$S_{CA}\geq\gamma\frac{p_{BE}}{p_{CA}}S_{BE}$	(24)	$\mathbf{p_{BE}}$	$S_{BE}\geq X_{BE}+\eta_1\frac{p_W}{p_{BE}}W$	(25)
$\mathbf{p_{DY}}$	$S_{DY}\geq X_{DY}+\eta_2\frac{p_W}{p_{DY}}W$	(26)	$\mathbf{p_{XSB}}$	$X_{SB}\geq p_{XSB}^{\theta_{SB}}$	(27)	$\mathbf{p_{XSM}}$	$X_{SM}\geq p_{XSM}^{\theta_{SM}}$	(28)
$\mathbf{p_{XSO}}$	$X_{SO}\geq p_{XSO}^{\theta_{SO}}$	(29)	$\mathbf{p_{XBE}}$	$X_{BE}\geq p_{XBE}^{\theta_{BE}}$	(30)	$\mathbf{p_{FY}}$	$p_{MFY}M_{FY}\geq(1-\eta_1-\eta_2)\frac{p_W}{p_{FY}}W$	(31)
$\mathbf{p_R}$	$\bar{R}\geq(1-\alpha)\frac{p_{SB}}{p_R}S_{SB}+(1-\varepsilon)\frac{p_{PA}}{p_R}S_{PA}$	(32)	$\mathbf{p_W}$	$p_WW\geq I$	(33)			

$$\mathbf{p_{FX}}\quad p_{XSB}X_{SB}+p_{XSM}X_{SM}+p_{XBE}X_{BE}+p_{XDY}X_{DY}\geq p_{MFY}M_{FY}\quad(34)$$

$$\mathbf{p_L}\quad\bar{L}\geq\alpha\frac{p_{SB}}{p_L}S_{SB}+\beta\frac{p_{SM}}{p_L}S_{SM}+\varepsilon\frac{p_{PA}}{p_L}S_{PA}+\lambda_2\frac{p_{CA}}{p_L}S_{CA}+\gamma\frac{p_{BE}}{p_L}S_{BE}+S_{DY}\quad(35)$$

Income Balance

$$\mathbf{I}\quad I\geq p_L\bar{L}+p_R\bar{R}+\tau_{SB}p_{SB}X_{SB}+\tau_{SM}p_{SM}X_{SM}+\tau_{SO}p_{SO}X_{SO}+\tau_{BE}p_{BE}X_{BE}\quad(36)$$

III. Empirical Analysis

The theoretical model captures the linkages between the various production, consumption, and trade sectors of the economy. For the empirical analysis, we implement the theoretical model in a computable general equilibrium (CGE) framework, allowing us to simulate the responses of the model's variables to changes in Argentine trade policy. CGE modeling is a widely applied tool for modeling trade liberalization in national and world markets. Löfgren, El-Said and Robinson (1999) conduct a CGE study on the effects of trade liberalization on incomes, welfare, and commodity prices in Morocco in the wake of the country's trade agreement with the European Union. Robinson et al. (1993) study the interaction between agricultural policy and migration leading up to the introduction of the North American Free Trade Agreement. Most relevant for this study, Toulan (2002) constructed a CGE model of the Argentine economy, finding that trade liberalization (in both export and import tariffs) would lead to an increase in Argentine exports.

Despite the derivation of the model in the previous section using a dual approach for each producer/consumer's problem, the empirical model is constructed as a mixed complementarity problem after Mathiesen (1985), in which each complementary slackness condition (listed in Table 2 above) requires that each weak inequality for zero-profits, market clearing, and income balance either hold with equality, or its matched complementary variable takes on a value of zero. Mixed complementarity problems are relatively simple to construct (since the modeler need only know the model's equilibrium conditions) and have been used extensively for simulating the effects of trade policy[3].

[3] See, for example, Liu and Devadoss (2013) and Ridley and Devadoss (2014).

Data and Calibration

To accurately predict the effects of Argentina's policies, the model must be calibrated to real world data on Argentina's various production, consumption, and trade sectors. Data for this empirical analysis are collected from several sources. To mitigate the influence of year-specific shocks, we construct the benchmark dataset by employing a 3-year average of the data over the period 2000 to 2002, during which Argentina did not impose any tariffs or quotas on soy products and beef, and thus this period serves as a free trade baseline. Data on values of Argentine soybean, soymeal, and soyoil production, consumption, processing, and exports, as well as cattle stock and beef production, consumption, and exports are taken from the USDA Foreign Agriculture Service (FAS, 2015). Data on Argentina soybean, soymeal, soyoil, cattle, and beef producer prices, as well as land usage for crops and pasture, are taken from the UN Food and Agricultural Organization (FAO, 2015). Data on the size of Argentina's agricultural and composite goods sectors, imports of foreign goods, and household consumption expenditures are taken from the World Bank. The value of production in the composite goods sector is calibrated to the value of Argentina's domestic consumption component of national GDP.

The data on production, consumption, prices, exports, and imports are used to construct a social accounting matrix that shows the value of flows of factors and outputs between sectors and into/out of the economy. Because of the assumption of perfect competition in each sector of the economy, the total value of production in each sector must be equal to the cost of production in each sector. Thus, for the variables for which we are unable to obtain accurate data (such as the value of payments to labor and capital in individual sectors), the social accounting matrix shows what the value of these transactions must be for the "adding up" conditions (i.e., total costs are equal to total benefits in each sector) to hold. By satisfying this condition, and given

the assumed functional forms in the theoretical model, the model's parameters are calibrated so that the model will be able to replicate the real world benchmark data for the Argentine economy, and we can conduct simulations of counterfactual scenarios of tariff increases and export bans. At its essence, the calibration process chooses parameter values that allow the model's equations to be satisfied given observed values of the variables in the real data. Table 3 shows the relationships between the model's activities/sectors and the associated prices, inputs, technology/preferences, and cost/expenditure functions.

Table 3. Production activities and associated prices, input usage, technology/preferences and cost/expenditure functions

Activity	Price	Inputs	Technology/Preferences	Cost/Expenditure
S_{SB}	p_{SB}	L_{SB}, R_{SB}	$S_{SB} = \left(L_{SB}/\alpha\right)^{\alpha}\left(R_{SB}/1-\alpha\right)^{1-\alpha}$	$p_L^{\alpha} p_R^{1-\alpha}$
S_{SM}	p_{SM}	L_{SM}, SB_{SM}	$S_{SM} = \left(L_{SM}/\beta\right)^{\beta}\left(SB_{SM}/1-\beta\right)^{1-\beta}$	$p_L^{\beta} p_{SB}^{1-\beta}$
S_{SO}	p_{SO}	L_{SM}, SB_{SM}	$S_{SO} = \kappa\left(L_{SM}/\beta\right)^{\beta}\left(SB_{SM}/1-\beta\right)^{1-\beta}$	$p_L^{\beta} p_{SB}^{1-\beta}$
S_{PA}	p_{PA}	L_{PA}, R_{PA}	$S_{PA} = \left(L_{PA}/\varepsilon\right)^{\varepsilon}\left(R_{PA}/1-\varepsilon\right)^{1-\varepsilon}$	$p_L^{\varepsilon} p_R^{1-\varepsilon}$
S_{CA}	p_{CA}	L_{CA}, SM_{CA}, PA_{CA}	$S_{CA} = \left(L_{CA}/\lambda_1\right)^{\lambda_1}\left(SM_{CA}/\lambda_2\right)^{\lambda_2}\left(PA_{CA}/1-\lambda_1-\lambda_2\right)^{1-\lambda_1-\lambda_2}$	$p_L^{\lambda_1} p_{SM}^{\lambda_2} p_{PA}^{1-\lambda_1-\lambda_2}$
S_{BE}	p_{BE}	L_{BE}, CA_{BE}	$S_{BE} = \left(L_{BE}/\gamma\right)^{\gamma}\left(CA_{BE}/1-\gamma\right)^{1-\gamma}$	$p_L^{\gamma} p_{CA}^{1-\gamma}$
S_{DY}	p_{DY}	L_{DY}	$S_{DY} = L_{DY}$	p_L
X_{SB}	p_{XSB}	SB_{XSB}	$X_{SB} = SB_{XSB}$	$\left(1+\tau_{SB}\right)p_{SB}$
X_{SM}	p_{XSM}	SM_{XSM}	$X_{SM} = SM_{XSM}$	$\left(1+\tau_{SM}\right)p_{SM}$
X_{SO}	p_{XSO}	SO_{XSO}	$X_{SO} = SO_{XSO}$	$\left(1+\tau_{SO}\right)p_{SO}$
X_{BE}	p_{XBE}	BE_{XBE}	$X_{BE} = BE_{XBE}$	$\left(1+\tau_{BE}\right)p_{BE}$
X_{DY}	p_{XDY}	DY_{XDY}	$X_{DY} = DY_{XDY}$	p_{DY}
M_{FY}	p_{MFY}	M_{FY}	$M_{FY} = FY_{MFY}$	p_{MFY}
W	p_W	D_{BE}, D_{DY}, D_{FY}	$u\left(D_{BE}, D_{DY}, D_{FY}\right) = D_{BE}^{\eta_1} D_{DY}^{\eta_2} D_{FY}^{1-\eta_1-\eta_2}$	$p_{BE}^{\eta_1} p_{DY}^{\eta_2} p_{FY}^{1-\eta_1-\eta_2}$

Estimation and Results

Having calibrated the model's parameters to the real world data, the model is solved computationally to produce benchmark solutions for each of the model's variables. In the benchmark scenario, Argentina imposes no tariffs or restrictions on exports. Since Argentina is

an important player in the world market for soybeans, soymeal, soyoil, and beef, the world prices of these commodities are determined endogenously through the market clearing condition. The degree of Argentina's market power in each sector is captured by the elasticity of demand for the excess demand facing Argentine exporters; these elasticities are assumed to be -3.3 for soymeal and soyoil, -5 for soybeans, and -10 for beef and depend on the relative magnitude of Argentina's exports in each particular sector.

Since we are interested in capturing the effects of the different policies enacted by the Argentine government, we estimate several counterfactual scenarios for comparison to the free trade benchmark. To do this, we incrementally increase the levels of the export tariffs on the various commodities, which reflects the gradual increase over time in the size of the tariffs that Argentina's government has imposed. Since soybeans face the highest export tariff, the size of the tariff varies from 5% to 40%, while the size of the tariff on soymeal and soyoil varies from 4% to 32%. Since beef products face the lowest export tariffs, the value of the beef tariff ranges from 2% to 16%. The counterfactual scenarios therefore encompass the range of Argentina's various tariff and quota policies. In doing this, we estimate the effects of Argentina's tariff policies on quantities, prices, and welfare, holding all else equal. That is, since we do not account for other changes in global soy and beef markets (such as increased international demand for soybeans and processed soy products) over the period in which the policies were introduced, we capture only the effects of Argentina's trade policies. As previously noted, these contemporaneously changing factors have a strong countervailing effect vis-à-vis the effects of the export restrictions on production and trade, but are not captured by the model. Since beef faces periodic export bans in addition to export tariffs, we also estimate counterfactual scenarios considering the separate effects of tariffs and quota policies.

Table 4 presents the results of the various counterfactuals using different trade policies and the corresponding estimates for the percentage changes in production, exports, prices, and welfare. Scenarios (1) - (8) depict the cases under which the government imposes export tariffs on soybeans, soymeal, soyoil, and beef, while scenarios (9) - (17) depict scenarios under which the government enacts a complete ban of beef exports, and considers cases of tariffs on soybeans and soy products, ranging from 0 to their maximum.

We first examine the results for scenarios (1) - (8). In the domestic production sectors, the tariffs cause an appreciable decline in output in the soybean sector and both processed soy product sectors. At the highest tariff levels, production of soy products declines by just over 14%. Because the tariffs discourage exports of soymeal, more soymeal is available domestically as cattle feed, and thus cattle production is relatively more profitable. This induces an increase in beef production, as well as an increase in the size of the domestic cattle stock. Turning to exports, the tariffs unambiguously decrease exporting activities in each sector that faces an export tariff. Soybean exports are the most affected, with soybean exports declining by over 37% relative to the no-tariff benchmark. Soymeal, soyoil, and beef exports also decline, with a marked decline in soymeal exports attributable to increased domestic demand for soymeal for use as cattle feed. Prices of each of the affected commodities also decline, with decreases ranging from over 10% for beef to over 20% for soybeans.

A key result of the analysis of the export tariff scenarios is the result for consumer welfare. Welfare rises by just under 1% at the highest levels of the export tariffs. This negligible gain to consumer welfare contrasts strongly with the profound losses to producers of the commodities affected by the tariffs. Though more soy products and beef are available domestically, which ultimately benefits consumers, these gains are completely offset by losses to

producers who now have less freedom to export their commodities abroad. Figure 4 graphically depicts the key results for the tariff scenarios. The relatively high tariffs on soybeans and soy products lead to a decline in production of these commodities, with the freed production inputs being shifted into the beef and cattle sectors. The drastic changes in production are accompanied by a positive but insignificant increase in consumer welfare. Thus, the effects of these policies on overall economic efficiency are profoundly negative.

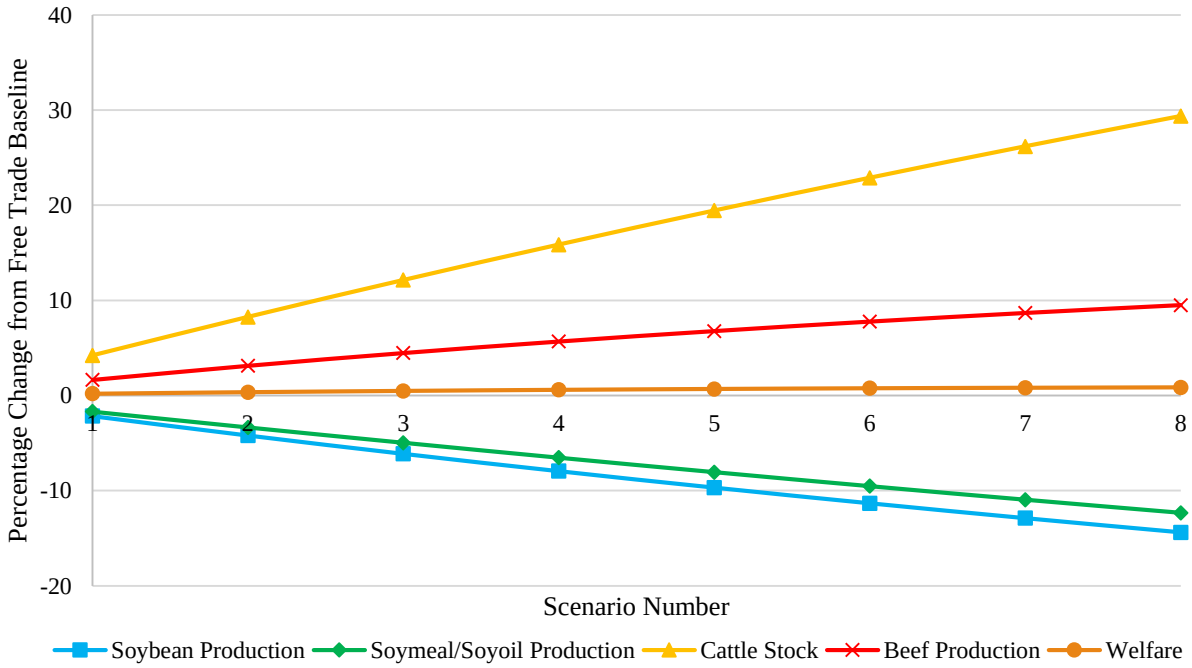

Figure 4. Percentage changes in production, cattle stock, and consumer welfare in tariff scenarios relative to baseline scenario

The export ban scenarios yield similar results, with some key differences. In the absence of tariffs on soy products, beef production and the size of the cattle stock fall noticeably. These declines are accompanied by increases in soybean, soymeal, and soyoil production as land usage is substituted into soybean production, which is translated into increased exports of soybeans and soy products. Domestic prices of soybeans, soymeal, and beef fall because of, respectively,

increased soybean supply and enhanced availability of beef on the domestic market. With the introduction of and gradual increase in tariffs on soybeans, soymeal, and soyoil, however, these results change. Soybean, soymeal, and soyoil production decline even further relative to the distortion-free benchmark, and beef production gradually rises relative to the export ban/no tariff scenario (though beef production is still lower than in the benchmark).

Figure 5 summarizes the results for the export ban scenarios: beef production initially declines with the export ban, but increases as tariffs on soybeans and soy products are raised. As in the export tariff scenarios, the overall effect on consumer welfare is negligible, while producers of soy products and beef are generally worse off.

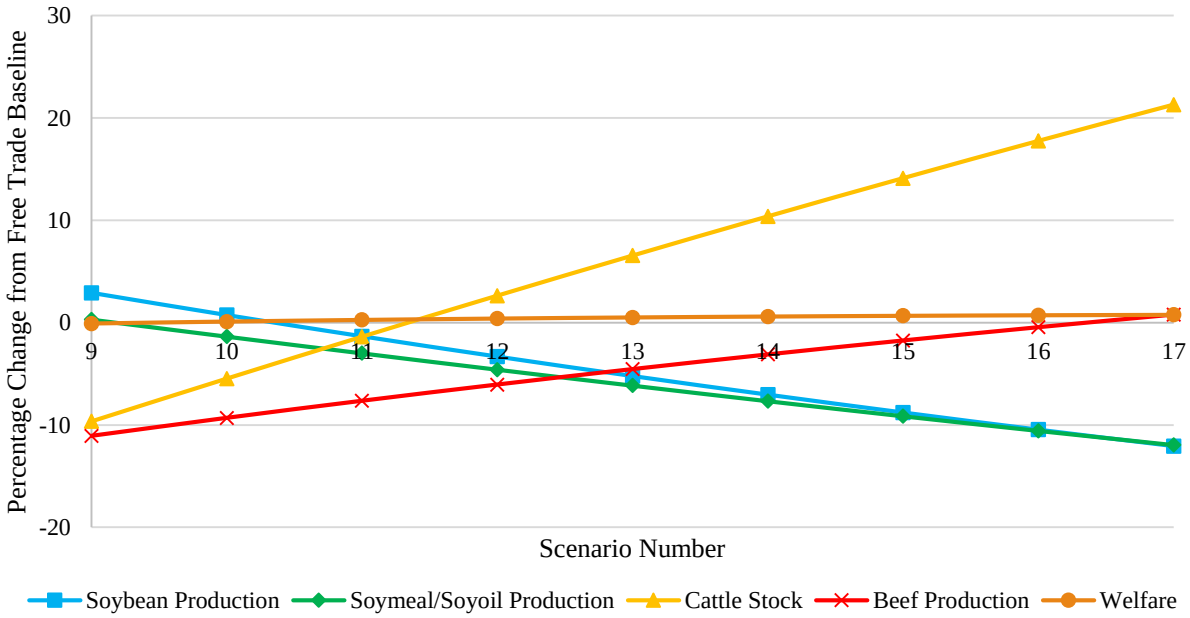

Figure 5. Percentage changes in production, cattle stock, and consumer welfare in export ban scenarios relative to baseline scenario

Table 4. Simulation results for counterfactual scenarios

		Tariff Scenario							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	τ_{SB}	5%	10%	15%	20%	25%	30%	35%	40%
	τ_{SM} & τ_{SO}	4%	8%	12%	16%	20%	24%	28%	32%
Sector	τ_{BE}	2%	4%	6%	8%	10%	12%	14%	16%
S_{SB}		-2.16	-4.19	-6.12	-7.94	-9.67	-11.32	-12.88	-14.37
S_{SM}		-1.69	-3.35	-4.96	-6.53	-8.05	-9.53	-10.95	-12.33
S_{SO}		-1.69	-3.35	-4.96	-6.53	-8.05	-9.53	-10.95	-12.33
S_{CA}		4.21	8.25	12.13	15.85	19.43	22.87	26.18	29.36
S_{BE}		1.64	3.12	4.46	5.67	6.77	7.76	8.66	9.49
X_{SB}		-6.13	-11.73	-16.86	-21.59	-25.95	-30.00	-33.76	-37.27
X_{SM}		-4.21	-8.24	-12.11	-15.81	-19.34	-22.72	-25.95	-29.04
X_{SO}		-1.69	-3.35	-4.96	-6.53	-8.05	-9.53	-10.95	-12.33
X_{BE}		-0.46	-1.58	-3.27	-5.44	-8.01	-10.89	-14.01	-17.33
p_{SB}		-3.34	-6.40	-9.21	-11.81	-14.21	-16.44	-18.51	-20.44
p_{SM}		-2.39	-4.58	-6.62	-8.50	-10.24	-11.87	-13.39	-14.80
p_{SO}		-3.14	-6.06	-8.78	-11.32	-13.70	-15.94	-18.05	-20.04
p_{BE}		-1.70	-3.29	-4.76	-6.14	-7.43	-8.64	-9.78	-10.85
W		0.19	0.35	0.49	0.60	0.69	0.76	0.82	0.86
		Beef Export Ban Scenario							
		(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
	τ_{SB}	0%	5%	10%	15%	20%	25%	30%	35%	40%
Sector	τ_{SM} & τ_{SO}	0%	4%	8%	12%	16%	20%	24%	28%	32%
S_{SB}		2.91	0.74	-1.34	-3.32	-5.22	-7.04	-8.79	-10.46	-12.07
S_{SM}		0.30	-1.36	-2.99	-4.59	-6.15	-7.66	-9.14	-10.57	-11.95
S_{SO}		0.30	-1.36	-2.99	-4.59	-6.15	-7.66	-9.14	-10.57	-11.95
S_{CA}		-9.64	-5.47	-1.37	2.64	6.55	10.38	14.11	17.75	21.29
S_{BE}		-11.07	-9.31	-7.64	-6.06	-4.55	-3.11	-1.75	-0.45	0.78
X_{SB}		10.30	4.00	-1.84	-7.27	-12.34	-17.08	-21.53	-25.71	-29.65
X_{SM}		6.94	2.73	-1.37	-5.34	-9.20	-12.93	-16.53	-20.00	-23.35
X_{SO}		0.30	-1.36	-2.99	-4.59	-6.15	-7.66	-9.14	-10.57	-11.95
X_{BE}		-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
p_{SB}		-1.80	-5.16	-8.23	-11.04	-13.62	-16.00	-18.20	-20.23	-22.12
p_{SM}		-1.86	-4.27	-6.49	-8.53	-10.41	-12.14	-13.75	-15.24	-16.62
p_{SO}		0.05	-3.10	-6.02	-8.75	-11.29	-13.68	-15.91	-18.02	-20.01
p_{BE}		-1.09	-2.82	-4.42	-5.91	-7.30	-8.59	-9.79	-10.92	-11.98
W		-0.09	0.10	0.26	0.40	0.51	0.60	0.67	0.72	0.76

Note: Cell entries display the percentage changes in the activity level or price from those in the free trade benchmark scenario. Scenarios (1) through (8) vary the levels of the export tariffs on the four affected commodities, while scenarios (9) through (17) bound beef exports at zero and vary the level of the tariffs on soybeans and soy products. Argentina's export tariffs on soymeal and soyoil are equal.

IV. Conclusion

The soy product and beef sectors of Argentina's economy are inextricably linked. Soymeal is a primary source of feed for livestock, and cattle producers can readily substitute their land from pasture into soybean production. Thus, the impact of government trade policies in one sector will have profound intersectoral impacts. With the objectives of shielding domestic consumers from food price inflation and encouraging value added exports, Argentina's government has maintained a regime of export restrictions on soybeans, soymeal, soyoil, and beef in the form of export tariffs and periodic beef export bans. These policies, met with vociferous opposition by producers and exporters (particularly in the cattle and beef industries), have persisted in spite of demonstrable negative impacts on the various affected sectors, as cattle stocks have dwindled, domestic beef consumption has collapsed, and pastureland has been increasingly been converted into growing soybeans.

This study was conceived with two objectives: first, to develop an analytical framework with which to model the linkages between the soybean, processed soy product, and cattle/beef sectors, and capture the mechanisms through which changes in export policy affect production, consumption, prices, exports, and consumer welfare; and second, to use the theoretical model to quantify the effects of Argentina's export policies on production, consumption, exports, prices, and welfare by calibrating the model's parameters to real world data and estimating an array of counterfactual scenarios encompassing the range of Argentina's tariff and quota policies.

The results of this analysis suggest that all else equal, the regime of export tariffs on soy products have substantial negative effects on output, exports, and prices, while the tariffs on beef exports increase consumption slightly. The effects of the export ban on beef are also sizable: the cattle stock and beef production are estimated to decline precipitously as beef production

becomes less profitable, leading to conversion of pasture into soybean production. Because these policies bolster domestic availability of the various commodities, consumer welfare generally increases, but the increases are trivial compared to the lost revenues of producers and exporters of beef and soy products. Ultimately, the harm wrought on producers by Argentina's export restrictions drastically outweighs the miniscule benefits to consumers, and economic efficiency is lowered.

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