The meat market in Brazil: an econometric approach

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Summary

We describe the relative participation of the meat market (beef, pork and chicken) in Brazil in the total agribusiness and in total country's exports. An analysis of the world meat market is carried out from the point of view of the values of consumption, production, exports and imports. A multi-criteria DEA (Data Envelopment Analysis) approach is then used to generate world market classifications. Particularly, the Brazilian insertion in the world market is viewed from these perspectives. A partial equilibrium model for the meat market is fit to Brazilian data by three stages least squares. The model is consistent with the data and is used for simulation purposes. In this context we investigate the joint and the separate effects of changes in corn price and in the exchange rate on the market endogenous variables, *ceteris paribus.*

Key Words: Meat markets, Elasticities, Three stage least squares, Simultaneous system of equations, Data envelopment analysis. **JEL: C 32**

Introduction

Researchers and institutions have been showing a growing interest in the use of prediction and of partial equilibrium models for agricultural commodities. Typical examples are provided by Contini *et al*., (2006), Gazzola *et al*., (2006), Souza *et al*., (2008), Heisey *et al*., (2011), OECD-FAO (2011), and Ministério da Agricultura, Pecuária e Abastecimento (2011). The advantage of having a partial equilibrium model available relative to unstructured time series models is the possibility of using it to assess the effects of sector polices through simulation. Indeed, this is the general motivation behind computable equilibrium models, and is frequently carried out in the context of a plethora of applications in agriculture, going from outlook scenarios to risk management.

The problem with the use of computable equilibrium models is that they do not use current information on parameters, and as a result, it is our experience, the models are seldom supported by the data. Typically in such models important elasticities are computed elsewhere and freely used to specify equations. The Aglink/2006 outlook for the meat market, for example, is examined in detail in Gazzola *et al*., (2006). They showed in their article that elasticities estimated from regressions differ markedly from the ones used in the specification of the meat market models and, frequently, sign inversions occur, indicating probable specification errors.

Here, based on the OECD/Aglink data we propose a set of equations to explain the meat market (beef, poultry and pork) that is consistent with the observations available. We estimate elasticities through three stage least squares directly from models suggested by economic theory. The response functions are linear in natural logs, and therefore belong to the Cobb-Douglas family. We achieved a reasonable degree of agreement for all equations (consumption, supply and exports) for all products which are jointly estimated. Our statistical findings improve previous results obtained by Souza *et al*., (2008). To illustrate the use of our model in simulations, we consider a joint effect on the endogenous variables resulting from the increase in 10% in the price of corn and a reduction of 10% in the exchange rate. Effects of this type are of particularly importance for the meat sector, where a concern is frequently raised regarding the increase in input prices associated with the potential increase in corn prices due, for example, the increasing use of corn in ethanol production by the US. Another frequent complain has to do with the over valorization of the Brazilian real relative to the US dollar, generating unfair competition for Brazilian exports. This approach is also an improvement over Souza *et al.*, (2008).

The article proceeds as follows. In Section 2, we update the descriptive results of Souza *et al.*, (2008) on the meat market. In Section 3 we discuss the world market of meat jointly and separately by type of meat, pinpoint the main actors in the market highlighting, in particular, the Brazilian performance. In Section 4 we specify and estimate the partial equilibrium model for the meat sector. Finally in Section 5 we summarize the main findings of our statistical exercise.

Meat market – A domestic perspective

Table 1 bellow updates the corresponding data showed in Souza *et al.*, (2008). The statistics are informative on the importance of the agribusinesses in total exports. It varies in the range 35% to 45% for the 22 years period investigated. Meat in recent years is responsible from 17.5% to near 20% of this market. In this context, one captures the economic importance of the meat market. The meat market is dominated by beef followed by poultry and pork. **Table 2** conveys information on the proportional values of production of each meat type at export prices adjusted for 2011 US dollars. The profile of the shares is approximately constant in the last years and close to 59% for beef, 33% for poultry and 8% for pork. These figures motivate the need for a continuous observation on the variables composing the meat market, and for proper assessment of their agents' behaviors. That is the fundamental economic reason why organizations, like the Brazilian Ministry of Agriculture and the Brazilian Agricultural Research Corporation (Embrapa), are interested in the development of econometric models to describe this market.

Table 1 - Brazil: Total Exports (a), Agribusinesses' Total Exports (b) and Meat Exports (c).

Year	US$ 10^6			%		
	Total (a)	Agribusiness (b)	Meat (c)	(b/a)	(c/a)	(c/b)
1989	34.383	13.921	0.655	40.49	1.91	4.71
1990	31.414	12.990	0.615	41.35	1.96	4.73
1991	31.620	12.403	0.863	39.23	2.73	6.96
1992	35.793	14.455	1.152	40.38	3.22	7.97
1993	38.555	15.940	1.308	41.34	3.39	8.21
1994	43.545	19.105	1.318	43.87	3.03	6.90
1995	46.506	20.871	1.283	44.88	2.76	6.15
1996	47.747	21.145	1.494	44.29	3.13	7.07
1997	52.983	23.367	1.598	44.10	3.02	6.84
1998	51.140	21.546	1.625	42.13	3.18	7.54
1999	48.013	20.494	1.942	42.68	4.04	9.47
2000	55.119	20.594	1.958	37.36	3.55	9.51
2001	58.287	23.857	2.926	40.93	5.02	12.27
2002	60.439	24.840	3.195	41.10	5.29	12.86
2003	73.203	30.645	4.189	41.86	5.72	13.67
2004	96.677	39.029	6.266	40.37	6.48	16.05
2005	118.529	43.617	8.194	36.80	6.91	18.79
2006	137.807	49.465	8.642	35.89	6.27	17.47
2007	160.649	58.420	11.295	36.37	7.03	19.33
2008	197.942	71.806	14.546	36.28	7.35	20.26
2009	152.996	64.785	11.787	42.34	7.70	18.19
2010	201.917	76.441	13.630	37.86	6.75	17.83

Source: SECEX/MDIC: Ministry of the Development, Industry and External Trade, 2011.

Finally Souza *et al.*, (2012) assess the technical efficiency of the major Brazilian companies that operate in the international meat market – Minupar, Excelsior, Friboi, Marfrig, Minupar, Minerva and Brazil Foods. For this purpose they use a stochastic frontier model with a normal-half-normal error structure with variances depending on exogenous factors. The companies found to be fully efficient are Minupar and Excelsior. Each of the other major groups shows decreasing levels of efficiency in the period 2007-2011. All companies are publicly traded on the Bolsa de Valores de Sao Paulo (BOVESPA). The stocks of living animals (beef,

Table 2 - Production shares based on export prices.

Year	Beef	Pork	Poultry
1995	78.96	6.01	15.03
1996	74.04	9.59	16.37
1997	72.08	8.08	19.84
1998	70.69	5.68	23.63
1999	66.81	6.19	26.99
2000	60.98	11.48	27.54
2001	50.85	13.58	35.56
2002	49.51	10.05	40.45
2003	49.60	10.43	39.98
2004	48.74	11.20	40.06
2005	49.54	10.27	40.18
2006	54.91	9.56	35.53
2007	52.56	8.75	38.69
2008	57.84	7.05	35.11
2009	53.99	6.94	39.08
2010	57.40	7.60	34.99
2011	59.89	7.64	32.48

Source: Embrapa-SGE (non-published outlook database) and OECD-FAO (2011).

pork and poultry) and the subprime crisis negatively affects technical efficiency. The firms operate in a market with imperfect competition and, for this reason show increasing returns to scale.

Meat market – An international perspective

A joint (beef, pork, and poultry) view of the meat market for each of the dimensions of major interest (production, imports, and exports) is conveyed here with the consideration of linear programming. The approach we choose for a multivariate country classification is based on the DEA multi-criteria. See Lovell and Pastor (1999), Gomes *et al*., (2008, 2009) for more details.

Tables 3, **4**, **5**, and **6** show the proportional participation (quantum) of selected countries in the world production, consumption, imports and exports of meat for 2009-2010. Data source is OECD-FAO (2011). The countries considered are the ones defined in OECD-FAO (2007). Overall Brazil, United States, European Union and China dominate the world production of meat. Beef consumption is dominated by the United States, European Union, Brazil and China, while pork and poultry consumption by China, European Union and the United States. The world imports of beef are dominated by United States, Russia and Japan. Imports of pork are dominated by Japan, Other Asian countries and Russia, and of poultry by Other Middle East countries, Other Asian countries and by the European Union. Beef exports are dominated by Brazil, Australia and the United States, pork exports by the United States, European Union, Canada, Brazil and China and poultry exports by Brazil and the United States.

Table 3 - World production (2009-2010).

Beef		Pork		Poultry	
Country	**%**	**Country**	**%**	**Country**	**%**
USA*	17.52	China	46.19	USA*	19.77
Brazil	13.92	EU**	20.76	China	16.73
EU**	12.19	USA*	9.44	Brazil	12.63
China	9.62	Brazil	2.97	EU**	12.21
Argentina	4.53	Viet Nam	2.38	Russia	2.82
India	4.39	Total	81.74	Mexico	2.80
Australia	3.62			India	2.79
Russia	2.66			OSAC***	2.70
Mexico	2.62			Iran	1.68
Canada	2.46			Argentina	1.66
LDC Subsaharan Africa	2.28			Indonesia	1.49
Pakistan	2.17			Japan	1.43
OSAC***	2.11			Turkey	1.36
Other Asia Developed	1.52			Total	80.07
Total	81,60				

* USA = United States of America; ** EU = European Union; *** OSAC = Other South America and Caribbean; Source: OECD-FAO (2011).

Table 4 - World consumption (2009-2010).

Beef		Pork		Poultry	
Country	**%**	**Country**	**%**	**Country**	**%**
USA *	18.85	China	46.28	China	16.95
EU **	12.65	EU **	19.22	USA *	16.43
Brazil	11.23	USA *	8.29	EU **	12.05
China	9.66	Russia	2.94	Brazil	8.88
Russia	4.06	Brazil	2.46	Russia	3.57
Argentina	3.82	Viet Nam	2.41	Mexico	3.47
India	3.38	Japan	2.21	OSAC ***	3.42
Mexico	2.83	Total	83.79	India	2.78
OSAC ***	2.52			Other Middle East	1.86
LDC Subsaharan Africa	2.36			Japan	1.85
Pakistan	2.18			Iran	1.74
Japan	1.87			Other Asia	1.63
Other Asia Developed	1.61			Indonesia	1.51
Canada	1.53			Argentina	1.40
Australia	1.37			Turkey	1.35
Colombia	1.29			Canada	1.32
Total	81.19			Total	80.20

* USA = United States of America; ** EU = European Union; *** OSAC = Other South America and Caribbean; Source: OECD-FAO (2011).

Table 5 - World imports (2009-2010).

Beef		Pork		Poultry	
Country	**%**	**Country**	**%**	**Country**	**%**
USA *	20.76	Japan	17.21	Other Middle East	11.58
Russia	10.89	Other Asia	14.89	Other Asia	11.49
Japan	8.59	Russia	14.30	EU **	7.66
Other Asia	5.85	USA *	9.57	OSAC ***	7.11
EU **	5.17	Mexico	7.99	Russia	6.92
OSAC ***	4.83	South Korea	6.00	China	6.66
Other Middle East	4.23	Australia	4.67	Mexico	6.04
Mexico	3.92	Other Eastern Europe	3.35	Saudi Arabia	5.93
South Korea	3.63	Canada	2.98	LDC Subsaharan Africa	4.55
Viet Nam	3.05	Total	80.97	Japan	3.54
Canada	2.72			Viet Nam	3.24
Egypt	2.48			Ukraine	2.84
Indonesia	2.46			South Africa	2.27
Iran	1.96			Other Eastern Europe	2.27
Total	80.54			Total	82.11

* USA = United States of America; ** EU = European Union; *** OSAC = Other South America and Caribbean; Source: OECD-FAO (2011).

Table 6 - World exports (2009-2010).

Beef		Pork		Poultry	
Country	**%**	**Country**	**%**	**Country**	**%**
Brazil	21.32	USA *	28.79	Brazil	33.55
Australia	16.72	EU **	27.25	USA *	30.69
USA *	10.80	Canada	20.43	EU **	9.07
Canada	9.50	Brazil	8.71	Thailand	5.81
India	7.79	China	5.69	Other Asia	5.01
New Zealand	5.99	Total	90.87	China	4.44
Argentina	5.61			Total	88.56
Uruguay	4.92				
Total	82.65				

* USA = United States of America; ** EU = European Union; Source: OECD-FAO (2011).

Data envelopment analysis

Data envelopment analysis (DEA) is a technique developed to measure the efficiency of a firm based on production data. For details regarding DEA see, for instance, Cooper *et al.*, (2004). Assuming constant returns to scale, a one input and one output model leads to DEA efficiency measurement, which are simply normalized measures of productivity. For a general discussion, consider a sample of n firms producing each a vector y of s outputs based on a vector x of p inputs. Let Y be the s by n matrix of output responses and X be the p by n matrix of inputs use. Let (x_0, y_0) denote the production pair of firm under evaluation o. For any firm, the input and output vectors are nonnegative with at least one component strictly positive. Under an input orientation approach, and constant returns to scale, the efficiency measure of firm o is defined to be the solution θ_0 of the linear programming problem bellow.

$$\mathrm{Min}_{\lambda,\theta}\,\theta$$
$$\text{s.t.}$$
$$Y\lambda \geq y_0 \qquad X\lambda \leq x_0 \qquad \lambda \geq 0$$

See Coelli *et al.*, (2005) for more details.

In multi-criteria classification analysis one uses a DEA analysis with unit inputs and unit outputs to generate an efficiency measurement that serves the purpose to classify the firms under consideration on the basis of a nonnegative multivariate construct (vector). For each case or firm the vector is considered, in turn, as outputs and inputs in the model, generating two types of production models one with unit input and the other with unit output, respectively. Efficiency calculated with unit output (inverted frontier) is subtracted from one. The final score of a given firm is the average of these two quantities.

Following some of the above ideas, Gomes *et al.*, (2009) report the US, China, Japan, Denmark, Canada and Brazil as the most outstanding in market importance. In the dimension of imports, or of businesses opportunities for producers, the main group is formed by Japan, Mexico, South Korea, Italy, Germany and England. Their analysis was based on Tornqvist indexes and the variation observed in the period 1995-2003, with the base period being 1995. Here we refine this analysis to define a new combined measure of market importance, considering the quantities of production, imports and exports for the year 2010. The analysis is therefore in absolute, not relative, terms. The response vector used in the final DEA analysis is defined by the intermediate DEA scores in each marginal dimension (production, imports, and exports). The intermediate DEA analysis is performed on ranks and the final DEA analysis on the efficiency scores. The results are reported in **Table 7**.

A simultaneous equilibrium model for beef, poultry and pork

The equilibrium models we consider jointly for beef, poultry and pork all obey some variation the following simple structure. The basic model is a system with nine equations in blocks of three equations, one for each type of meat. It is given by

$$q_c = f(p, p_s, rpc, pop, ex, v) + \varepsilon_1$$
$$q_p = g(p, p_{in}, r, u) + \varepsilon_3$$
$$ex = k(p, c, \tau) + \varepsilon_3$$
$$q_p - q_c + imp - \Delta = 0$$

where q_c is the demand function, q_p is the supply function, *ex* denotes exports, p is own price, p_s is a price vector of substitutes, *rpc* is *per capita* income,

Table 7 - DEA results.

Country	Final DEA Score	Country	Final DEA Score
Brazil	1.0000	Indonesia	0.8214
China	1.0000	Turkey	0.8214
European Union	1.0000	Ukraine	0.8167
Japan	1.0000	Pakistan	0.8036
Other Asia	1.0000	South Africa	0.7857
Russia	1.0000	Other Asia Developed	0.7768
United States of America	1.0000	Colombia	0.7679
Australia	0.9821	Other Subsaharan Africa	0.7585
Other Middle East	0.9821	Israel	0.7500
Canada	0.9818	LDC Asia	0.7299
Other South America and Caribbean	0.9643	Kazakhstan	0.7260
Thailand	0.9464	Norway	0.6786
Mexico	0.9419	Peru	0.6607
India	0.9286	Ghana	0.6429
Viet Nam	0.9286	Algeria	0.6250
Argentina	0.9107	Other North Africa	0.5932
New Zealand	0.9107	Ethiopia	0.5714
South Korea	0.9107	Switzerland	0.5714
Chile	0.8929	Nigeria	0.5536
Saudi Arabia	0.8929	Other Oceania	0.5536
Uruguay	0.8929	Sudan	0.5357
Other Eastern Europe	0.8815	Haiti	0.4882
LDC Subsaharan Africa	0.8750	Mozambique	0.4107
Philippines	0.8750	United Republic of Tanzania	0.3929
Malaysia	0.8571	LDC Oceania	0.3448
Paraguay	0.8571	Bangladesh	0.3214
Iran (Islamic Republic of)	0.8393	Zambia	0.3214
Egypt	0.8293	Other Western Europe	0.2321

pop is population, v, u and τ are covariates which may include dummies and lagged endogenous variables, p_{in} is a vector or index of input prices, r is the interest rate (Brazilian - Selic), c is the exchange rate, imp are imports, Δ is stock variation and the ε_i are non observable errors. All quantitative variables entering a regression are measured in natural logs. Not all variables show statistical significance. In these instances they are eliminated from the model specification when convenient. The actual models considered here refine Souza *et al.*, (2008).

Relationships are assumed to be linear in natural logs so that the response functions belong to the Cobb-Douglas family. Prices for beef, poultry and pork are computed dividing the OECD-FAO (2011) price (Atlantic price for beef and pork and USA for poultry) by the USA consumer price index, and multiplying the result by the exchange rate. Prices are therefore measured in 2011 Brazilian real values.

Table 8 describes the main variables used in our models. The source information on annual data is available in the Embrapa-SGE outlook data base. We used the period 1995-2011 in our analysis.

Estimation

Table 9 shows three stage least squares estimates (Johnston and Dinardo, 1997) overall statistics for all markets. We see that regression r-square values

Table 8 - Variables.

Variable	Description	Unity
q_c^{beef}	Beef domestic consumption	1000 t
p^{beef}	Beef price	$BRL/t
q_p^{beef}	Beef production	1000 t
$q_c^{poultry}$	Poultry domestic consumption	1000 t
$p^{poultry}$	Poultry price	$BRL/t
$q_p^{poultry}$	Poultry production	1000t
q_c^{pork}	Pork domestic consumption	1000t
p^{pork}	Pork price	$BRL/t
q_p^{pork}	Pork production	1000 t
p^{corn}	Corn price	$BRL t
ex^{beef}	Beef exports	1000 t
$ex^{poultry}$	Poultry exports	1000 t
ex^{pork}	Pork exports	1000 t
pop	Population	-
r	Selic interest rate	-
rpc	*Per capita* income (nominal)	$USD/inhab
c	Exchange rate	$BRL/$USD

Table 9 - Stata output. Overall statistics. Three-stage least-squares regression. For products q_c is demand, q_p is supply, and *ex* is export

Equation	Observations	Parms	RMSE	R-square	chi²	P-value
q_c^{beef}	16	6	0.0299818	0.9106	198.38	0.0000
q_p^{beef}	16	3	0.0720470	0.8349	91.22	0.0000
ex^{beef}	16	2	0.2159337	0.9189	187.02	0.0000
$q_c^{poultry}$	16	2	0.0235789	0.9928	2512.59	0.0000
$q_p^{poultry}$	16	3	0.0265531	0.9948	3183.39	0.0000
$ex^{poultry}$	16	3	0.1549441	0.9559	438.79	0.0000
q_c^{pork}	16	4	0.0384825	0.9603	422.16	0.0000
q_p^{pork}	16	4	0.0655164	0.9321	268.68	0.0000
ex^{pork}	16	2	0.1982686	0.9542	380.94	0.0000

are high, giving indication of a reasonable fit for all equations. The complete list of instruments is trend, price of corn, per capita income, exchange rate, interest rate, and lag of exports for beef, poultry, and pork.

Statistical estimates for the beef market are given in **Table 10**. Since the own price elasticity was not significant for the export equation, the demand price elasticity can be read directly from the table. All coefficients show the right sign. It is interesting to note that the supply function for the beef market is more sensitive to the exchange rate and the interest rate than to prices. We kept the price variable, although only marginally significant, since its absence would destroy the dependence on price. The two exogenous variables affect differently the supply. The interest rate has a negative effect and the exchange rate a positive effect. Exports in the beef market are also more sensitive to the exchange rate than to price, which we did not find significant.

Estimates for the poultry market are given in **Table 11**. The price demand elasticity for poultry has to be computed indirectly through the export equation. Is given by -0.28917, with a standard error of 0.07218. It is significantly different from zero and has the proper sign. Beef and pork are not significant as substitutes. The price of corn affects negatively the supply equation and a trend variable was more important than the interest rate and the exchange rate. Prices and the exchange rate act in opposite directions for exports. An increase in the exchange rate does not appear to be good for the market, *ceteris paribus*. It is interesting to notice in the poultry market the non significance of the income component. The same occurs with the pork demand function. A relative increase in income, *ceteris paribus*, will increase only the beef consumption.

Estimates for the pork market are given in **Table 12**. As in Souza *et al.*, (2008), the dummy variable explains a significant shift in the demand curve beginning in 2000. Price was kept in the demand function to maintain consistency with our approach in the beef supply function. It has the proper sign and it is only marginally significant. Its absence will not affect the statistical results. The demand price elasticity has to be computed indirectly through the export equation. It is -0.140548, with a standard error of 0.053514. Thus significantly distinct from zero. The supply function for pork is highly sensitive to price, the interest rate and the price of corn. The last two variables have a negative effect.

Table 10 - Stata output from three stage least squares estimation – beef market. Coefficients are elasticities. Variables are in natural logs.

	Coefficient	Std. Err.	z	P>|z|	[95% Conf. Interval]	
q_c^{beef}						
p^{beef}	-0.3182818	0.1011790	-3.15	0.002	-0.516589	-0.119975
p^{pork}	0.1023683	0.0421958	2.43	0.015	0.019666	0.185071
$p^{poultry}$	0.3886231	0.1895959	2.05	0.040	0.017022	0.760224
Rpc	0.3019892	0.0997886	3.03	0.002	0.106407	0.497571
Pop	1.3891340	0.6060052	2.29	0.022	0.201386	2.576882
ex^{beef}	-0.1940293	0.0546969	-3.55	0.000	-0.301233	-0.086825
Cons	-10.441230	5.9575290	-1.75	0.080	-22.11777	1.235311
q_p^{beef}						
p^{beef}	0.1805785	0.1469306	1.23	0.219	-0.107400	0.4685573
R	-0.3749816	0.0510532	-7.34	0.000	-0.475044	-0.2749193
C	0.1209324	0.0566313	2.14	0.033	0.009937	0.2319276
Cons	8.3511930	1.3372330	6.25	0.000	5.730265	10.972120
ex^{beef}						
C	1.026833	0.1684319	6.10	0.000	0.6967121	1.356953
Trend	0.108022	0.0118770	9.10	0.000	0.0847433	0.131300
Cons	5.315887	0.1349446	39.39	0.000	5.0514010	5.580374

Table 11 - Stata output from three stage least squares estimation – poultry market. Coefficients are elasticities. Variables are in natural logs. Variable pt3 is lag of exports.

	Coefficient.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
$q_c^{poultry}$						
Pop	5.838810	0.1670175	34.96	0.000	5.511461	6.166580
$ex^{poultry}$	-0.111132	0.0124996	-8.89	0.000	-0.1356312	-0.086634
Cons	-60.98638	1.9409550	-31.42	0.000	-60.479058	-57.18218
$q_p^{poultry}$						
$p^{poultry}$	0.1230194	0.0146662	8.39	0.000	0.0942743	0.1517645
p^{corn}	-0.0517961	0.0120477	-4.30	0.000	-0.0754092	-0.0281831
Trend	0.0754462	0.0015129	49.87	0.000	0.0724810	0.0784114
Cons	7.5210140	0.1588759	47.34	0.000	7.2096230	7.8324040
$ex^{poultry}$						
$p^{poultry}$	2.602043	0.5696914	4.57	0.000	1.485468	3.718618
C	-2.132440	0.5238582	-4.07	0.000	-3.159184	-1.105697
pt3	0.7682293	0.0505485	15.20	0.000	0.669156	0.867301
Cons	-18.070260	4.2224700	-4.28	0.000	-26.34572	-9.794811

A simulation exercise

We now use the results of section 4.1. to simulate the meat market model. We consider the joint effect of increasing corn price by 10% and decreasing the exchange rate by 10%. The joint and also the separate effects are of relevance, particularly in the context of the recent discussions

Table 12 - Stata output from three stage least squares estimation – pork market. Coefficients are elasticities. Variables are in natural logs. Variable pk3 is lag of exports.

	Coefficient.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
q_c^{pork}						
p^{pork}	-0.0551803	0.0499668	-1.10	0.269	-0.1531133	0.0427528
ex^{pork}	-0.1757048	0.0350049	-5.02	0.000	-0.2443131	-0.1070966
Trend	0.0288637	0.0052233	5.53	0.000	0.0186262	0.0391013
Dummy	0.5383728	0.0499193	10.78	0.000	0.4405328	0.6362128
Cons	8.4168310	0.3643245	23.10	0.000	7.7027680	9.1308940
p_g^{pork}						
p^{pork}	0.2399476	0.0460675	5.21	0.000	0.1496569	0.3302383
R	-0.2530133	0.0611638	-4.14	0.000	-0.3728921	-0.1331344
p^{corn}	0.0754462	0.0015129	49.87	0.000	0.0724810	0.0784114
Trend	0.0297338	0.0056006	5.31	0.000	0.0187568	0.0407108
Cons	6.9406520	0.5194015	13.36	0.000	5.9226440	7.9586610
ex^{pork}						
p^{pork}	0.4858558	0.1669079	2.91	0.004	0.1587224	0.8129892
pk3	0.8098238	0.0491407	16.48	0.000	0.7135098	0.9061377
Cons	-2.6998220	1.2617270	-2.14	0.032	-5.1727620	-0.2268821

put forward by the supply sector regarding the over value of the Brazilian real relative to the US dollar, and the potential use of corn in the production of ethanol, notably by the US, which would imply an increase in corn price, given the importance of this country for the market. We solved the model for market values of 2011 to access this effect, and exogenously added the modifications in the exchange rate and in the corn price, and recomputed the equilibrium values for the endogenous variables. **Table 13** shows the results of our exercise. Separate exogenous variation in the price of corn will not affect the market variables that remain close to their actual values. Separate change in the exchange rate will affect beef exports, poultry exports and the prices of beef and poultry. The joint effect is more worrisome. It will affect exports of beef and poultry, and internal prices of these commodities. Pork will be unaffected. The pork market seems to be robust against the changes, jointly or separate.

Conclusions

We studied the meat market in Brazil from a domestic and from an international perspective. We see that the agribusiness in Brazil is responsible for a sizable part of total Brazilian exports. Roughly, 38% in 2011. Approximately 18% of the agribusiness total exports comes from meat, which is about 8% of total Brazilian exports. From the point of view of its insertion in the world meat market, Brazil is the leading country in the export of beef and poultry, and the fourth in pork.

From the point of view of a combined meat effect measured by DEA multi-criteria USA, Brazil, EU, Japan, Other Asia Countries, and China are the leading countries in the dimension of overall market importance. These countries are closely followed by Australia, Other Middle East countries and Canada.

Using simultaneous equilibrium models and three stage least squares we were able to fit jointly equations of demand, supply and export for the markets of beef, poultry and pork. The response functions belong to the Cobb-Douglas family. The high values of r-squares indicate agreement with actual data. The estimated elasticities may be used for simulation purposes to evaluate the effects of marginal changes in the exogenous variables on the endogenous variables. They all show the correct signs. The price of corn was added as a production variable in the supply functions for pork and poultry. In this context simulations were performed to investigate the separate and the joint effects of unwanted changes in the corn price, and in the interest rate. We conclude that a change in corn price will not affect equilibrium by much. A separate change in the exchange rate will affect exports and

Table 13 - SAS output on equilibrium solutions resulting from actual 2011 values, separate and joint changes in corn price – corn (+10%) and exchange rate – c (-10%). Columns v1-v3 are proportional changes of values in the original scale.

Var	p^{corn} (log)	c (log)	Joint (log)	Actual (log)	v1 (p^{corn})%	v2 (c)%	v3 (both)%
q_c^{beef}	8.897	8.897	8.896	8.896	100.011	99.932	99.923
q_p^{beef}	9.154	9.154	9.129	9.129	100.008	97.538	97.531
ex^{beef}	7.705	7.705	7.597	7.597	100.000	89.746	89.746
$q_c^{poultry}$	9.156	9.159	9.163	9.167	100.324	100.717	101.078
$q_p^{poultry}$	9.511	9.505	9.497	9.491	99.371	98.643	98.008
$ex^{poultry}$	8.303	8.274	8.239	8.206	97.134	93.777	90.802
q_c^{pork}	7.874	7.867	7.874	7.867	99.371	100.000	99.371
q_p^{pork}	8.074	8.073	8.074	8.073	99.893	100.000	99.893
ex^{pork}	6.386	6.408	6.386	6.408	102.205	100.000	102.205
p^{beef}	9.184	9.184	9.116	9.116	100.046	93.474	93.436
p^{pork}	8.154	8.199	8.154	8.199	104.592	100.000	104.592
$p^{poultry}$	8.144	8,133	8,033	8.021	98.889	89.490	88.388

prices for beef and poultry. This effect is enhanced in the joint effect. It is interesting to notice that pork variables seem to be robust against the changes considered.

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