Regulatory SPS Instruments in Meat Trade[1]

Simon W. Schlueter and Christine Wieck[2]

Institute for Food and Resource Economics, University of Bonn

Bonn, Germany

Selected Paper

IATRC Annual Meeting "Private Standards and Non-Tariff Barriers: Measurement, Impacts, and Legal Issues"

December 13-15, Fort Meyers, FL

Abstract

This paper analyses SPS regulations on meat trade using a gravity model between the most important exporters and importers of meat worldwide. Detailed regulation specific data on sanitary regulations is manually collected and compiled for the years 1996 to 2007 from various international data sources giving rise to a unique data set of regulatory measures for the meat sector.

Keywords: SPS regulation, meat, gravity model

1 Introduction

Market failure is one important reason for agri-food trade regulations: minimizing trade related risks, they ensure public goods such as food safety, animal health, plant protection, and the protection of humans from pests or diseases. However, given that the implied trade effects of the chosen regulatory instruments are similar to the effects of classical trade policy instruments governing domestic market access, they may also be applied for other than risk reducing effects, i.e. to support domestic producers.

Multilateral trade rules as in the Sanitary and Phytosanitary (SPS) agreement (WTO 1994) on trade in food and agricultural goods offer guidelines to policy makers on how to make use of regulatory instruments governing agri-food trade. The provisions of

[2] Corresponding author: Christine Wieck (christine.wieck@ilr.uni-bonn.de)

the SPS agreement require that regulations targeting specific national agri-food safety objectives are minimal with respect to their trade effects (Art. 5.4) and not more trade-restrictive than required (Art. 5.6). Accordingly, Wilson and Antón (2006) define the most welfare-efficient SPS measure as one which is least trade-distorting but protective in terms of providing the desired health and safety level. However, only limited knowledge exists on the specific trade impacts of different regulatory instruments available to enforce desired policy goals. Furthermore the trade impact of regulatory instruments is not always negative; safe and healthy food, information transmission, increased producer efficiency, and increased consumer confidence may also imply positive trade impacts.

Gravity models at various levels of detail have been mostly used to provide evidence on the trade impact of regulatory measures. At the aggregate level of agricultural trade, an example includes Disdier, Fontagné, and Mimouni (2008), whereas Otsuki, Wilson, and Sewadeh (2001) analyze product-specific regulations. Another body of literature applies partial equilibrium models in the quest for an optimal set of SPS measures regarding welfare impacts and risk mitigation strategies. Peterson and Orden (2008) identify an efficient sequence of SPS measures to address pest risks from Mexican avocado imports to the U.S. market. The mentioned studies use different methodological approaches but are similar in that they do not systematically compare the trade impacts of different regulatory instruments with equivalent risk reduction effects.

In analyzing the meat sector, the objective of this paper is to analyze the trade impact of different regulatory measures imposed to achieve a desired level of SPS health in a country. Meat products are chosen because trade in meat is exposed to a wide number of market failures. Diseases, pandemics, meat and feed scandals in the last decade have increased consumers' and producers' awareness of external effects associated with trade in meat products. This motivates policy makers to implement regulatory instruments, which may also serve protectionist purposes.

Detailed regulation specific data on sanitary regulations is manually collected and compiled for the years 1996 to 2007 from various international data sources giving rise to a unique data set of regulatory measures for the meat sector. The information on these regulations is further differentiated by trading partner and year for each meat product line. This results in a data set that distinguishes all relevant SPS instruments applied for the various purposes in the meat sector. A first focus of the paper will lie on the analysis of the data base with respect to the measures applied in the meat sector. The data on regulatory instruments will be presented differentiated by groups of measures and countries that apply these measures or subsets of these. Hence a comparison of regulatory heterogeneity across countries and across importers and exporters is possible. In addition, a non-linear panel data gravity model is estimated for the ten most important meat exporters and importers by fixed effects Poisson pseudo-maximum likelihood (PPML) at the level of Harmonized System (HS) 4-digit data.

The remainder of the article is organized as follows. Section two derives the applied gravity model and introduces the PPML estimator. Section three describes the explanatory and dependent variables and their data sources. Section four presents estimation results on the impact of different aggregation levels of regulatory instruments and section five concludes.

2 Theory and Methodology

A non-linear panel data gravity model with fixed effects is estimated by Poisson pseudo-maximum likelihood (cf. Silva and Tenreyro 2006). Assuming frictionless trade, perfect competition, indifference of consumers' choices between otherwise homogenous products of different origins, and specialization of countries in different products, the gravity model describes bilateral trade flows by a function of exporter and importer gross domestic product (GDP) and world GDP (Deardorff 1998). The simple gravity equation implies that each country exports its specific product everywhere. Product differentiation can either be obtained using the Heckscher-Ohlin theory, where trade is distorted and factor prices are not equalized, as in Deardorff (1998); by Armington-like specifications assuming differentiation by country of origin as in Anderson (1979); by Ricardian elements as in Eaton and Kortum (2002); or by monopolistic competition and increasing returns as in Redding and Venables (2004). Dropping the assumption of frictionless trade generally allows assessment of the impacts of any form of tariff or non-tariff barriers, including sanitary regulatory measures, by integrating different relevant variables potentially leading to “distance” between countries.

One difficulty of estimating gravity-type trade models is the existence of heteroscedasticity, which may cause inefficient and inconsistent estimates (Silva and Tenreyro 2006). Heteroscedasticity is present when trade flows for small and remote countries may approach zero. This causes the conditional variance $Var(m|x)$ of the explained trade flow variable m, given a set of explanatory variables x, to tend to zero, as positive dispersions from the conditional mean cannot be offset by negative ones contrary to large trade flows where the variance can be expected to be larger as the dispersion from the conditional mean can go in either direction. For estimating gravity models, the least squares and nonlinear least squares estimators cannot be efficient, as they require the conditional variance to be constant. Also, in the presence of heteroscedasticity, the error term of the log-linearized version of the simple gravity equation can only be assumed to be independent from explanatory variables under very specific conditions on proportionality of the conditional variance. Consequently, all estimators of log-linear models which ignore heteroscedasticity are generally inconsistent (Silva and Tenreyro 2006).

Pseudo-maximum likelihood (PML) estimation is able to handle inefficiencies and inconsistencies caused by heteroscedasticity. Furthermore, zero trade between particular country pairs does not create inconsistencies, as in the case when the log-linear form of the gravity equation is used. The pseudo-likelihood function is specified appropriately as long as it is based on a probability density function that is a member of the family of linear exponential functions, such as the Poisson probability density function (Gourieroux, Monfort, and Trognon 1984). In employing a PPML estimator in their gravity application, Silva and Tenreyro (2006) start with a stochastic model explaining a vector of bilateral trade flows m, which is derived from a utility-maximizing model assuming constant elasticity of substitution preferences (cf. Anderson 1979):

(1) $$m = \exp(x\beta) + \varepsilon$$

with $m \geq 0$ and $E[\varepsilon | x] = 0$, where x is the vector of explanatory variables, β is the vector of coefficients of interest, and ε is the error. This functional form is a good choice in modeling gravity equations because it produces non-negative conditional expectations (the value of bilateral trade flows is by definition non-negative) without constraining the explanatory variables. When m for given x is assumed to follow a Poisson distribution, a pseudo likelihood function can be derived, whose first and second order moment conditions can be solved to obtain the vector of coefficients β (Gourieroux, Monfort, and Trognon 1984). The PPML estimator is fully robust to distributional misspecifications (Wooldridge 1999).

The multiplicative gravity model in this analysis is as follows:

$$(2) \qquad m_{ijt} = p_{it}^{\beta_1} c_{jt}^{\beta_2} d_{ij}^{\beta_3} \exp\left(\alpha_i + \alpha_j + \beta_4 z_t + \beta_5 t_{ijt} + \sum_k \beta_k r_{ijt}^k \right) \eta_{ijt},$$

where m_{ijt} is the trade flow value from exporter i to importer j at time t; p_{it} and c_{jt} present the annual meat production and meat consumption quantities of exporter i and importer j representing the country's economic size in this sectoral analysis; d_{ij} is the bilateral distance between exporter i and importer j; α_i and α_j are country-specific exporter and importer fixed effects capturing unobserved country heterogeneity; z_t is the time dummy variable; t_{ijt} is the tariff variable; $\sum_k r_{ijt}^k$ present k different regulatory measures which are included in varying aggregation levels; and η_{ijt} is a transformed error with $E\left[\eta_{ijt} \mid x\right] = 1$ according to Silva and Tenreyro (2006, p.644).

Equation (2) can be written as an exponential function:

$$(3) \qquad m_{ijt} = \exp\left(\beta_1 \ln p_{it} + \beta_2 \ln c_{jt} + \beta_3 \ln d_{ij} + \alpha_i + \alpha_j + \beta_4 z_t + \beta_5 t_{ijt} + \sum_k \beta_k r_{ijt}^k \right) + \varepsilon_{ijt},$$

which has the functional form of equation (1) and is estimated by PPML.

3 Data

3.1 SPS data base

Data on sanitary regulations is taken from the World Trade Organization (WTO) SPS Information Management System (WTO 2009) and the International Portal on Food Safety, Animal and Plant Health (IPFSAPH 2009). This manual search and gathering of information on regulatory measures in the meat sector was necessary given that the conventional databases for non-tariff measures such as the UNCTAD Trade Analysis and Information System (TRAINS) do not provide the necessary detail for a sector-specific analysis distinguishing different types of instruments applied.

Table 1 Regulatory instruments and their trade policy goals, 1996-2007

	food safety	animal healht	plant protection	protect humans from animal/plant pest or disease
Disease prevention measures				
pest/disease status	x	x		x
quarantine		x		
regionalization		x		
Requirements for microbiological testing				
e. coli	x			x
listeria monocytogens	x			x
salmonella	x			x
Tolerance limits for residues and contaminants				
dioxin	x			
food additives	x			x
pesticides	x		x	x
drugs	x	x		
other toxins	x			
retained water content	x			
Production process requirements				
GMO/biotechnology	x	x		
hormones	x			
other production processes	x			
Conformity assessment and information requirements				
certification	x	x		
contr., inspect., approv. procedures	x			
HACCP	x			
international standards/harmonization	x			
labelling	x			
traceability/registration	x	x		x
risk assessment	x			
sanitat. requirem. meat establishm.	x			
Requirements for handling of meat after slaughtering				
irradiation	x			
meat/bone separation	x			x
packaging	x			
storage	x			
TBT	x			
transportation	x			
number of counts	102597	17624	24193	36867

Source:Own compilation.

29 specific regulatory instruments are arranged into six classes which describe different agri-food safety purposes (Table 1): (1) Disease prevention measures; (2) Requirements for microbiological testing for zoonoses; (3) Tolerance limits for residues and contaminants; (4) Production process requirements; (5) Conformity assessment and information requirements; and (6) Requirements for handling of meat after slaughtering. The 29 instruments are additionally assigned to one or more of four different policy goals that are part of the mandatory national WTO notifications: Food safety; Animal health; Plant protection; and Protection of humans from animal/plant pests or diseases.

Regulatory measures are treated as being imposed in a given year if the date of entry into force, adoption, or notification (depending on data availability) is in the first half of the year; otherwise, it is assumed that the measures take effect in the following year. All regulatory measures within the classes (2) to (6) are assumed to be in effect permanently from the year when they were imposed. Regulations on (1) Disease prevention measures are assumed to be in force from the year they were imposed through the following year allowing for the improvement of the countries' disease status.

3.1.1 Overview on number of measures

Measures have to be distinguished by its scope of application[3]. Within the compilation of the above mentioned data base, only measures that apply to foreign countries are considered given that no indication of the measure's relevance for domestic producers is provided in the notifications. Within these measures targeted at imports we have to distinguish measures that are equally applied to imports from all origins, i.e. that are uniform across all exporters, and measures that are only targeted to specific origins, i.e. that are considered to be bilateral. In total, 4203 regulatory measures are imposed on meat trade over the time 1996-2007 and the ten most important meat exporters and importers considered in this study. Out of these 4000 measures, around 1000 measure relate to issues of disease prevention, tolerance limit requirements and conformity assessment (Table 2). The number of uniform measures across all exporters is with around 3200 measures four times as high as the number of measures that are specifically

[3] See e.g. Josling et al. 2004 (p. 18) for a classification scheme of measures.

in place in bilateral trade (around 900 measures). Under these bilateral regulations, the number of disease prevention measures stands out which makes sense given that reisk of disease transmission and outbreaks is usually restricted to local or regional events and demand regulations that consider the specific situation in the countries of origin.

Table 2 Number of measures per regulation class

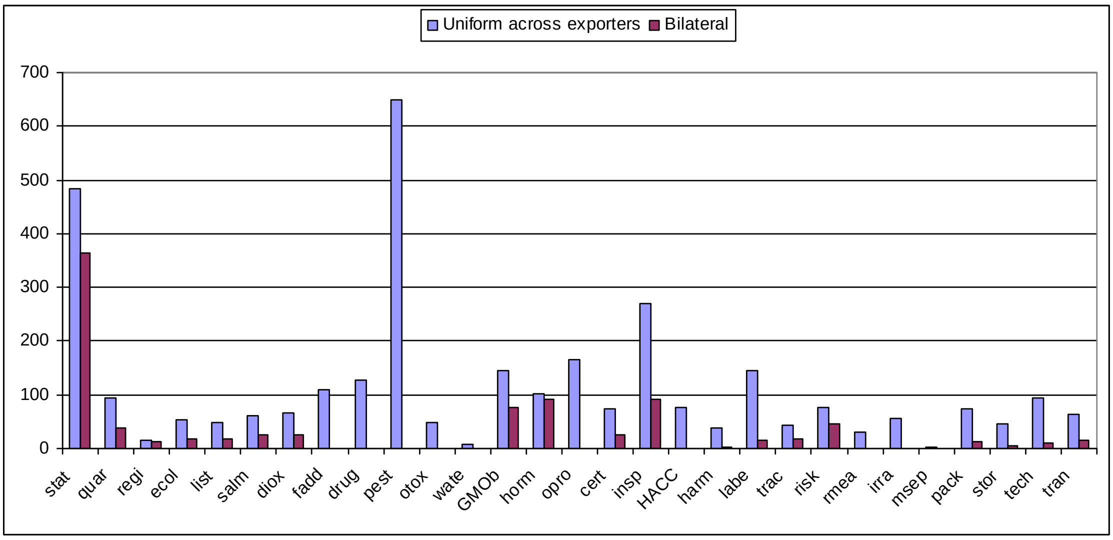
Number of measures applied	dise	micr	tole	proc	conf	hand
Equal across all exporters	594	163	1006	413	757	335
Bilateral measures	418	64	36	169	202	46
Total	1012	227	1042	582	959	381

Note: dise = disease prevention measures, micr = requirements for microbiological testing, tole = tolerance limits for residues, proc = production process requirements, conf = conformity assessment, hand = handling of meat after slaughtering.

Source: Own calculation.

The regulatory instruments used in each class are presented in Figure 1 differentiated for uniform and bilateral measures. The figure shows that most policies target pesticide residue levels in meat and pest/disease status notification.

Figure 1 Number of each single regulatory measure applied



Note: the name of the regulatory instruments refers to the first four letters of each regulatory instrument as presented in Table 1.
Source: Own calculation.

If we disaggregate the meat aggregate into the subcategories as given by the HS classification, Table 3 displays that the measures are rather evenly distributed across the HS subgroups. With a slight margin, measure relevant for bovine meat, fresh (HS 0201) and frozen (HS 0202) lead before measures applied to pork meat (HS 0203) and poultry (0207).

Table 3 Number of measures per HS subcategory

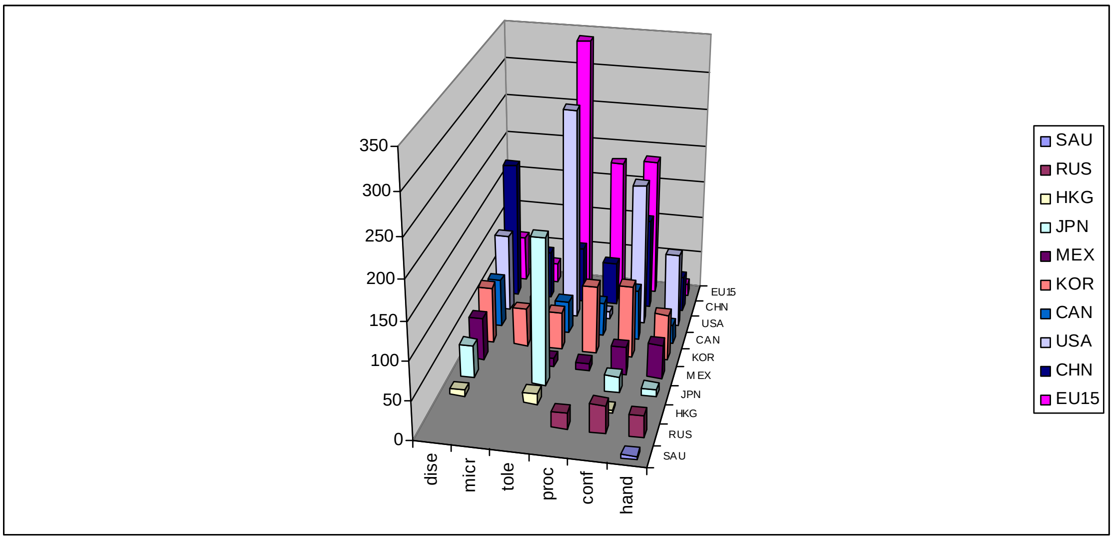
HS code	0201	0202	0203	0204	0205	0206	0207	0208	0209	0210
Equal across all exporters	455	432	362	358	306	325	345	201	237	247
Bilateral measures	169	148	103	98	66	80	99	40	69	63
Total	624	580	465	456	372	405	444	241	306	310

Note: 0201: meat of bovine animals, fresh or chilled; 0202: meat of bovine animals, frozen; 0203: meat of swine (pork), fresh, chilled or frozen; 0204: meat of sheep or goats, fresh, chilled or frozen; 0205: meat of horses, asses, mules etc; 0206: ed offal, bovine, swine, sheep etc; 0207: meat & ed offal of poultry, fresh, chilled or frozen; 0208: meat & edible offal nesoi, fresh, chilled or frozen; 0209: pig & poultry fat fresh chld frzn salted dried smkd; 0210: meat & ed offal salted, dried etc.
Source: Own calculation.

3.1.2 Measures that are equal across all exporting countries

EU and US, followed by a wide margin by China and Korea apply the most SPS measures to the import of meat (Table 4).

Figure 2 Number of uniform measures in each class applied by importing countries



Note: dise = disease prevention measures, micr = requirements for microbiological testing, tole = tolerance limits for residues, proc = production process requirements, conf = conformity assessment, hand = handling of meat after slaughtering.

Source: Own compilation.

Figure 2 and Table 5 show a further disaggregation of the classes into single regulatory instruments for each country. For the EU and a lower extent also for the US for example, it is noticeable that most of the regulations are applied in the area of tolerance limits and within the class of tolerance limits, basically all measures relate to residue limits of pesticides in meat and meat products. Opposite to the highly safety regulated importing markets of US and EU, meat imports into Hong Kong (25) and Saudi Arabia (4) face the fewest SPS regulation. The focus of the regulatory activity differs as well with animal disease status and dioxin tolerance levels and the regulation of meat irradiation being the areas that are regulated.

Table 4 Number of measures per importer that are equal for all exporters

Number of measures applied	USA	CAN	CHN	EU15	HKG	JPN	KOR	RUS	SAU	MEX
Equal across all exporters	704	245	547	809	25	267	422	85	4	160

Source: Own calculation.

Table 5 Number of uniform measures per regulatory instrument applied by importing country

class	regulatory instrument	USA	CAN	CHN	EU15	HKG	JPN	KOR	RUS	SAU	MEX
dise	stat	97	61	115	62	8	41	57			43
	quar			66			2	16			10
	regi	7	2	2				2			3
micr	ecol	5		19	9			20			
	list	11		19	9			10			
	salm	5		26	10			20			
tole	diox	2		10	35	14		4			
	fadd	33		23	10		4	40			
	drug	10		10			101	6			
	pest	229	43		289		87				
	otox			31	5						12
	wate	7			1						
prod	GMOb			50	76			10	10		
	horm				102						
	opro	10	46	7	1			80	11		10
conf	cert	2	3	16	20				32		
	insp	53	46	63	83		2	10	4		10
	HACC	48	1	1	17						10
	harm	7			20		10				2
	labe	49	5	10	3	3	10	66			
	trac	14	10					19			
	risk		3	32	42						
hand	rmea	16									15
	irra	42		1				10		4	
	msep	2									
	pack		15	21				10	13		15
	stor	17	1	7				6			15
	tech	31	7		15		10	30			
	tran	7	2	18				6	15		15
	SUM	704	245	547	809	25	267	422	85	4	160

Note: the name of the regulatory instruments refers to the first four letters of each regulatory instrument as presented in Table 1.

Source: Own compilation.

Finally, in Figure 3 and Table 6, the number of measures in each class is presented differentiated by the date of initiation. Two observations can be made: staring with the year 2001 the number of new measures initiated nearly doubled compared to the first years of the SPS agreement that entered into force in 1995. Second, in the years 2001 and 2002, we note a significantly increased number of notifications in the class of disease prevention measures (131 and 203, respectively), and here particularly in the regulatory instrument disease/pest status. In 2001, most of these notifications result from US (28), Canada (19), Korea (29), and Mexico (30) whereas in the year 2002, 165 out of 203 notifications just alone result from China[4] and must be explained by the accession process of China to the WTO.

Table 6 Development of number of uniform measures over the period 1006-2007

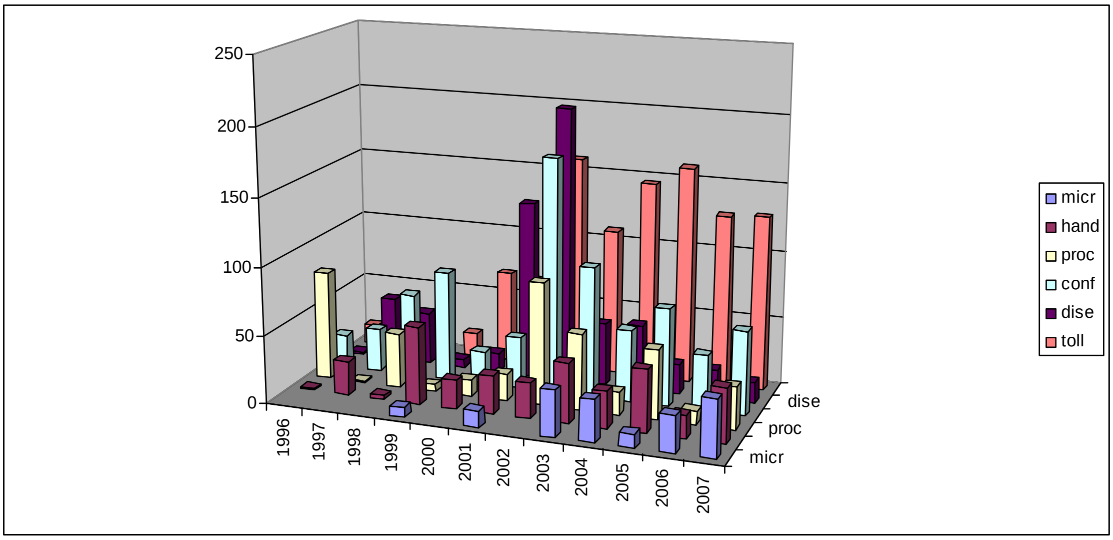
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of measures	122	113	145	174	139	294	652	384	322	361	243	319

Source: Own compilation.

The implementation of new conformity assessment and information requirement regulations also has a peak in 2002 (and 2003) with again China being the country with most new measures implemented (105).

[4] Note that China became a WTO member, December 11, 2001.

Figure 3 Number of measures in each class applied by importing countries differentiated by year of initiation



Note: dise = disease prevention measures, micr = requirements for microbiological testing, tole = tolerance limits for residues, proc = production process requirements, conf = conformity assessment, hand = handling of meat after slaughtering.

Source: Own compilation.

3.1.3 Specific bilateral measures

China and the EU, followed by the US by a wide margin, have by far implemented most bilateral measures across our sample of analysis (Table 7).

Table 7 Number of bilateral measures implemented by importing countries

	USA	CAN	CHN	EU15	HKG	JPN	KOR	RUS	MEX
dise	99	50	123	24	8	26	44		44
micr			64						
tole	2		20		14				
proc				169					
conf	16	5	34	102		2	35	6	2
hand			23	1		10	12		
SUM	117	55	264	296	22	38	91	6	46

Note: dise = disease prevention measures, micr = requirements for microbiological testing, tole = tolerance limits for residues, proc = production process requirements, conf = conformity assessment, hand = handling of meat after slaughtering.

Source: Own compilation.

For China and the US, most of these measures result to disease and pest prevention measures. For the EU, most bilateral measures are located in the area of production processing requirements and conformity assessment regulations.

If we focus on the trade partners that face these bilateral regulations, we see in Table 8 that most of the US measures are targeted towards the EU, and with respect to content, mostly regulate the pest/disease status of agricultural imports, whereas the bilateral measures implemented by China target US imports and EU imports nearly to the same extent. For EU imports, the measures mostly relate again to the pest and disease status whereas for US imports, nearly all areas of regulatory activity are affected with a slight focus on requirements for microbiological testing (64 out of 112 measures). Trade partners of the EU seam to be rather uniformly affected by bilateral measures with the US, AUS, and CAN still facing the most measures. Most of these bilateral measure focus on the regulation of the use of GMO and biotechnology and hormones in the growth of animals.

Table 8 Number of bilateral SPS measures

	USA	CAN	CHN	EU15	HKG	JPN	KOR	RUS	MEX
USA	n.p.	14	112	73		3	20		3
ARG	16	7	8	42		10	2		10
AUS			10	59			13		
BRA		2	10	13			4		
CAN	4	n.p.	8	63	2	1	20		3
CHN				23		7		6	
EU15	97	30	99	n.p.	20	17	21		20
HKG			15	3	n.p.				
NZL			1	20			9		
POL		2	1				2		10

Note: in rows: exporters, in columns: importers.
Source: Own compilation.

3.2 Other model data

HS 4-digit data on trade in meat products originates from the United Nations Conference on Trade and Development (UNCTAD) Comtrade database (UNCTAD 2009a) for the years 1996 to 2007. Those ten importing (Canada, China, EU15, Hong Kong, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, and the United States) and ten exporting (Argentina, Australia, Brazil, Canada, China, EU15, Hong Kong, New Zealand, Poland, and the United States) countries which have the highest average aggregated meat trade flow in value terms over the sample period are included in the analysis.

Table 9 Mean and Variance of Model Variables

Variable	Mean	Variance
Trade value/10,000,000	2.078	86.066
ln production exporter	22.542	2.718
ln consumption importer	22.538	2.027
ln distance	9.005	0.45
Tariff	4.204	251.82
Aggregate of regulations	9.102	186.687
Disease prevention measures	0.358	1.1638
Pest/disease status	0.256	0.623
Quarantine	0.097	0.205
Regionalization	0.005	0.005
Requirements for microbiological testing	0.36	1.295
E.coli	0.1	0.154
Listeria monocytogens	0.118	0.139
Salmonella	0.142	0.213
Tolerance limits for residues and contaminants	3.418	52.102
Dioxin	0.174	0.457
Food additives	0.393	0.81
Pesticides	0.217	0.672
Drugs	0.478	2.239
Other toxins	2.122	35.329
Retained water content	0.034	0.033
Production process requirements	1.057	3.672
GMO/biotechnology	0.323	1.198
Hormones	0.594	1.915
Other production processes	0.14	0.338
Conformity assessment and information requ.	2.617	15.795
Certification	0.296	0.434
Inspection and approval procedure	0.826	1.901
HACCP	0.452	1.86
Harmonization	0.185	0.198
Labeling	0.373	0.768
Traceability	0.091	0.121
Risk assessment	0.172	0.398
Sanitary requirements for meat establishments	0.222	0.417
Handling of meat after slaughtering	1.29	4.9
Irradiation	0.313	0.755
Meat/bone separation	0.011	0.017
Packaging	0.207	0.267
Storage	0.185	0.223
Technical barriers to trade	0.318	0.578
Transportation	0.256	0.296
Food safety	9	184.484
Animal health	1.546	6.379
Plant health	2.122	35.329
Protect humans from animal/plant pests or diseases	3.234	51.766

Source: Own calculations.

Zero trade flows between country pairs are included. Consumption of domestic meat is not considered. Altogether, there are $n = 11400$ observations on trade flows[5] of which 51 percent are non-zero. Mean and variance of the trade flow and explanatory variables are depicted in table 1.

Meat production and consumption quantities result from the statistical webpage of the Food and Agricultural Organization (FAO 2009) and from the webpage of Indexmundi (2009).

Bilateral data on the explanatory variable geographic distance originates from the Centre d'Etudes Prospectives et d'Informations Internationales homepage (CEPII 2009). Weighted distance is chosen as the distance variable, where the EU15 is centered on Germany.

A time dummy variable is included. Tariff data stems from UNCTAD TRAINS database (UNCTAD 2009b). If available, the bilateral effectively applied tariff is chosen; otherwise, the most-favored-nations tariff is incorporated.

4 Results and Specification Tests

Table 2 presents outcomes of four different models estimated by PPML. The common base of the four models is the exponential regression function (3). The models differ with respect to the differentiation of regulatory measures $\sum_k \beta_k r_{ijt}^k$. The model Aggregate in the first column of table 2 includes one overall aggregate of regulatory instruments being the sum of all counts for a particular country-pair and HS-line within one year. The model Classes in the second column of table 2 includes the six pre-defined classes of regulatory measures. The third column presents parameter estimates for the Instruments model, which captures the individual 29 specific regulatory measures. The parameter estimates of the Goals model are presented in the fourth column, which considers regulatory measures aggregated by the four safety objectives listed above.

---

[5] (95 country pairs) * (12 years) * (10 HS 4-digit codes).

Table 10 Parameter Estimates of Model Variants

	Aggregate	Classes	Instruments	Goals
ln production exporter	1.526***	1.736***	3.425***	1.653***
ln consumption importer	1.678***	1.986***	4.156***	1.804***
ln distance	-0.931***	-0.964***	-1.063***	-0.967***
Tariff	0.010***	0.009***	0.010***	0.009***
Aggregate of regulatory measures	0.015***	-	-	-
Disease prevention measures	-	0.122***	-	-
Pest/disease status	-	-	0.096	-
Quarantine	-	-	-0.2	-
Regionalization	-	-	-0.153	-
Requ. for microbiological testing	-	0.087	-	-
E.coli	-	-	-0.092	-
Listeria monocytogens	-	-	-0.573	-
Salmonella	-	-	0.760***	-
Tolerance limits for residues	-	0.015**	-	-
Dioxin	-	-	0.416***	-
Food additives	-	-	-0.102	-
Pesticides	-	-	-0.067***	-
Drugs	-	-	0.200***	-
Other toxins	-	-	-0.456***	-
Retained water content	-	-	0.597	-
Production process requirements	-	-0.091***	-	-
GMO/biotechnology	-	-	0.03	-
Hormones	-	-	-0.447**	-
Other production processes	-	-	-0.146**	-
Conformity assessment	-	0.050**	-	-
Certification	-	-	0.018	-
Inspection/approval proced.	-	-	0.449***	-
HACCP	-	-	0.360***	-
Harmonization	-	-	0.267	-
Labeling	-	-	0.007	-
Traceability	-	-	0.161	-
Risk assessment	-	-	-0.639	-
Requ. for meat establishm.	-	-	-0.869***	-
Handling of meat after slaught.	-	-0.128**	-	-
Irradiation	-	-	-0.662***	-
Meat/bone separation	-	-	-0.412	-
Packaging	-	-	0.117	-
Storage	-	-	-0.06	-
Technical barriers to trade	-	-	0.192	-
Transportation	-	-	0.879***	-
Food safety	-	-	-	0.012
Animal health	-	-	-	0.080***
Plant protection	-	-	-	0.016
Protect humans	-	-	-	-0.01
Wald test	r.***	r.***	r.***	r.***
RESET	n.r.***	n.r.***	r.***	n.r.***

Note: *** and ** denote significance level of 1 percent and 5 percent, respectively. r.: rejected. n.r.: not rejected.

Source: Own calculations.

All models are tested on the independence of the conditional mean from the explanatory variables (Wald-test) and on the correct specification of the functional form of the conditional mean expectation (Ramsey's Regression Equation Specification Error Test (RESET)). The tests are carried out using standard errors that are robust to distributional misspecifications imposed by restrictions of the Poisson assumption (Wooldridge 1999).

The Wald-test rejects the hypothesis that the conditional mean $E\left[m \mid x\right]$ is independent of the explanatory variables for all four models. The heteroscedasticity-robust RESET tests the null hypothesis that the additional regressors $\left(x\hat{\beta}\right)^2$ and $\left(x\hat{\beta}\right)^3$ do not help to explain the dependent variable by using the auxiliary regression $m = \exp\left(x\beta + \delta_1\left(x\hat{\beta}\right)^2 + \delta_2\left(x\hat{\beta}\right)^3\right)$; thus δ_1 and δ_2 are not significantly different from zero (Wooldridge 1999; Silva and Tenreyro 2006). The test suggests a correct specification of the models Aggregate, Classes, and Goals but fails for the Instruments model.

The parameter estimates of the four traditional gravity explanatory variables are rather similar in the four models with the exception that the estimates of economic size of exporter and importer diverge in the Instruments model. The outcomes are all significant at the 1 percent significance level. The signs of the covariates' economic size and geographic distance are as expected: distance negatively affects trade, while the economic size fosters trade flows. The slightly positive tariff coefficient's estimate of $\exp\left(0.01\right) \approx 1.01$ suggests a minor influence of tariffs on today's meat trade. However, this result has to be read with caution since no distinction between imports under preferential tariff rate quotas and imports under tariffs has been made. The first column of table 2 additionally reports the estimate for the aggregate regulatory instruments variable. The estimate's value of $\exp\left(0.015\right) \approx 1.015$ affirms the ambiguous impact of regulatory measures on trade: regulations may be trade-restricting or trade-facilitating or may have no trade impact at all – a strong tendency cannot be determined from the result of the aggregate variable. The more disaggregated Classes model gives first evidence on the differing implied trade effects of regulatory measures. Five of the six estimates are significant. Whereas the classes (1) Disease prevention measures, (3) Tolerance limits for residues and contaminants, and (5) Conformity assessment and information requirements are trade-promoting, the trade impact of the classes (4) Production process requirements and (6) Requirements for handling of meat after slaughtering is negative.

The third column of table 2 goes further into the analysis and presents the specific regulatory instruments' influence on trade. The negative impact of the class (4) Production process requirements is caused by measures regulating the application of hormones and by other production processes, while the impact of regulations on genetically modified organisms (GMO) and biotechnology is not significant. The irradiation measures' sign in class (6) Requirements for handling of meat after slaughtering is significantly negative, while the negative trade effect of meat/bone separation and storage measures is not significant. The fourth column of table 2 shows that only animal health is significant among the policy objectives potentially underlying the regulations. The corresponding parameter estimate of $\exp(0.080)$ confirms the necessity of measures providing a good animal health status for an active global trade in meat.

5 Conclusions

Using a non-linear panel data gravity model, this article analyzes the trade effects of different regulatory measures that are imposed in the meat sector in order to achieve a desired national level of SPS health. The dataset used is specifically compiled for this study and is new and unique with respect to the detail of information on the applied sector specific national regulatory instruments and with respect to the applied classification of measures into SPS areas and political objectives they serve. The disaggregated analysis of the trade effects of regulatory instruments reveals the theoretically well-known ambiguous trade impact of many of these measures: at the class level we find that regulations imposed to achieve a desired level of SPS health differ in their implied trade impact. The even further disaggregated estimation at the level of the single regulation shows that there are specific measures which have a substantial positive impact and others with a significant negative impact. These effects can offset each other within a class. When grouping the regulations according to underlying policy goals, policy measures ensuring animal health are identified as being significantly trade-enhancing. These results add more detail to the findings of recent research by Disdier, Fontagné, and Mimouni (2008), who estimate an overall negative impact of SPS and technical barriers to trade measures on meat trade using a log-linear fixed effects gravity model with HS 2-digit data.

Limitations that apply to this article result from the fact that a frequency count is used to characterize the importance of the measures. This does not allow a comparison of the SPS safety level achieved by a specific measure to the trade restriction that it imposes. For this, more theoretical work on how to compare and quantify the potential SPS safety levels that are achievable with single measures or sets of measures is necessary.

6 References

Anderson, J.E. 1979. "A Theoretical Foundation of the Gravity Equation." *The American Economic Review* 69(1):106-116.

CEPII. 2009. Distances. http://www.cepii.fr/anglaisgraph/bdd/distances.htm. 2009-30-04.

Deardorff, A.V. 1998. "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?" In J.A. Frankel, ed. *The Regionalization of the World Economy*. Chicago IL: University of Chicago Press, pp. 7-32.

Disdier, A.-C., Fontagné, L., and M. Mimouni. 2008. "The Impact of Regulations on Agricultural Trade: Evidence from the SPS and TBT Agreements." *American Journal of Agricultural Economics* 90(2):336-350.

FAO. 2009. FAOSTAT. http://faostat.fao.org/site/339/default.aspx. 2009-30-04.

Gourieroux, C., Monfort, A., and A. Trognon. 1984. "Pseudo Maximum Likelihood Methods: Applications to Poisson Models." *Econometrica* 52(3):701-720.

Indexmundi. 2009. Hong Kong Yearly Meet, Beef and Veal. http://www.indexmundi.com/agriculture/?country=hk&commodity=beef-and-veal-meat&graph=domestic-consumption. 2009-30-04.

IPFSAPH. 2009. International Portal on Food Safety, Animal & Plant Health. http://www.ipfsaph.org/En/default.jsp. 2009-30-04.

Josling, T., Roberts, D., and D. Orden (2004). *Food Regulations and Trade,* Washington DC: Institute for International Economics, pp. 232.

Otsuki, T., Wilson, J.S., and M. Sewadeh. 2001. "Saving Two in a Billion: Quantifying the Trade Effect of European Food Safety Standards on African Exports." *Food Policy* 26(5):495-514.

Peterson, E.B., and D. Orden. 2008. "Avocado Pests and Avocado Trade." *American Journal of Agricultural Economics* 90(2):321-335.

Silva, J.M.C.S., and S. Tenreyro. 2006. "The Log of Gravity." *The Review of Economics and Statistics* 88(4):641-658.

UNCTAD. 2009a. UNCTAD Comtrade Database. http://comtrade.un.org/db/default.aspx. 2009-30-04.

——. 2009b. UNCTAD TRAINS Database. http://r0.unctad.org/trains_new/index.shtm. 2009-30-04.

Wilson, N.L., and J. Antón. 2006. "Combining Risk Assessment and Economics in Managing a Sanitary-Phytosanitary Risk." *American Journal of Agricultural Economics* 88(1):194-202.

Wooldridge, J.M. 1999. "Quasi-Likelihood Methods for Count Data." In M.H. Pesaran and P. Schmidt, eds. *Handbook of Applied Econometrics*. Oxford UK: Blackwell Publishers Ltd., pp. 352-406.

WTO. 1994. Agreement Establishing the World Trade Organization. Annex 1: Sanitary and Phytosanitary Measures. Geneva.

——. 2009. SPS Information Management System. http://spsims.wto.org/. 2009-30-04.