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Estimation Issues in Disaggregate Gravity Trade Models*

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Abstract

French (2011) can analytically show that the standard Anderson and van Wincoop (2003) gravity trade model is only correctly specified for disaggregate data; gravity trade model analysis should be done at product level and then estimation results should be reaggregated. If however gravity trade model analysis is to be done at product level then also estimation issues in disaggregate gravity trade models should come to the fore. As is shown, previous estimators suffer under different statistical problems. This paper proposes a zero-inflated Poisson Quasi-Likelihood (PQL) and a Gamma Two-Part Model (G2PM) as reliable alternatives. Estimated within a Generalised Estimating Equation (GEE) framework, both estimators are consistent and have more or less conservative test statistics. Further, for model selection a Quasi-Likelihood under the Independence Model Criterion (QIC) is recommend since this statistic is conform with GEE approaches. Both estimators PQL and G2PM and the model selection technique QIC should become standard tools for disaggregate gravity trade model estimation.

Keywords: Gravity Model, Excess Zeros, Poisson Quasi-Likelihood, Gamma Two-Part Model, Generalised Estimating Equation Approach

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1 Introduction

Recently research focus in gravity trade model analysis shifted from an aggregate to a disaggregate gravity trade model. This shift was first empirically motivated, policy evaluation is better done at a disaggregate than at an aggregate level but now there is also a statistical interest. In a recent paper Anderson and Yotov (2010) hint at the significant downward aggregation bias which is immanent when comparing disaggregate with aggregate gravity trade model estimates.[1] An analytical explanation therefor is given by French (2011) who analytically shows that aggregation of disaggregate gravity trade models over all product categories does not converge to the standard aggregate Anderson and van Wincoop (2003) (AvW) gravity trade model. It turns out that the outward multilateral resistance term of the AvW Model is wrongly specified; it should be non-constant varying by importer. French's results emphasise the importance to do gravity trade model analysis always at product level and then to reaggregate estimation results.

If however gravity trade model analysis is to be done at product level then also estimation issues in disaggregate gravity trade models, in particular the appropriate treatment of excess zeros should come to the fore. Although there are applications of gravity trade models to disaggregate data there are only few papers which explicitly deal with estimation issues. A notable exemption is the paper by Burger, van Oort, and Linders (2009). Here, the authors partly follow Santos Silva and Tenreyro (2006) that logarithmising leads to biased gravity trade model estimates but for disaggregate gravity trade models the authors instead recommend a zero-inflated Poisson / Negative Binomial Pseudo Maximum Likelihood (ZIPPML / ZINBPML). Contrary to the standard approach, i.e. Poisson Pseudo Maximum Likelihood (PPML) former approaches deal with the problem of excess zeros (and overdispersion).[2]

Despite being state of the art, there are still some shortcomings with ZIPPML / ZINBPML why a further discussion of alternative estimators is worthwhile. In the literature two different kinds of statistical models are distinguished which deal with excess zeros: (1) zero-inflated Count Data Models and (2) Two-Part Models. Each of these models itself encompasses a set of different estimators. A potential new estimator belonging to the former class of zero-inflated Count Data Models is a zero-inflated Poisson Quasi-Likelihood (PQL) (Staub and Winkelmann, 2011). This estimator is not only consistent in the presence of excess zeros but also practically unaffected by unobserved heterogeneity (Staub and Winkelmann, 2010, pg. 10); additionally, PQL is not faced with a scale dependence problem. Another potential new estimator belonging to the latter class of Two-Part Models is a Gamma Two-Part Model (G2PM) (Lee, Xiang, and Hirayama, 2010). This estimator is insofar promising as it overcomes major weaknesses of standard Tobit models and compared to other Two-Part Models it flexible adjusts to different right-skew distri-

[1] The potential aggregation bias in gravity trade model estimation is extensively discussed in Anderson and van Wincoop (2004).

[2] For statistical details on excess zeros and overdispersion see below.

butions and deals appropriately with heteroskedasticity. So far, both new estimators are not applied to (disaggregate) gravity trade model analysis.

For the empirical part two additional aspects are to be considered: (1) in practise not Pseudo Maximum Likelihood (PML) approaches are applied but Generalised Estimating Equation (Liang and Zeger, 1986) (GEE) approaches, PML approaches are too restrictive to fully account for heteroskedasticity (Santos Silva and Tenreyro, 2006), and (2) for model selection a Quasi-Likelihood under the Independence Model Criterion (Pan, 2001) (QIC) is to be calculated not a standard Akaike Information Criterion (AIC), the latter is based on a Likelihood function whereas a Quasi-Likelihood function is provided by a GEE approach. Implicitly, all this is already done in practice but the GEE approach is only mentioned in a few papers, the QIC statistic is not even mentioned in a single paper. These methodological aspects are of importance as well since significance levels of estimators and model selection results are affected hereof; in end effect economic inference is affected.[3]

As indicated above disaggregate gravity trade model analysis becomes more important, thus also estimation issues connected herewith should become more important. Given the shortcomings of previous estimators, this paper proposes PQL and G2PM as reliable alternatives; here, both new estimators PQL and G2PM are applied to disaggregate data (i.e. intra-European piglet trade) to evaluate their empirical performance and applicability. The analysis is done in a GEE framework and model selection is based on QIC.

Since the focus of this paper is methodological, so for the theoretical model homogeneous firms trade models (Felbermayr and Kohler, 2010; Egger and Larch, 2011) are chosen, but not further discussed. Homogeneous firms trade models have the advantage to share the same properties as heterogeneous firms trade models (Helpman, Melitz, and Rubinstein, 2008), but not to require firm heterogeneity. For many applications these simpler models should suffice (Felbermayr and Kohler, 2010).

This paper is organised as follows. The first section deals with the appropriate specification of the theoretical model; here, homogeneous firms trade models are compared with heterogeneous firms trade models and one-part models with two-part models. In the second section then methodological aspects of disaggregate gravity trade model estimation are discussed. The advantages of PQL and G2PM are sketched. The next section then applies both new estimators to intra-European piglet trade. The paper concludes with some recommendations for future disaggregate gravity trade model estimation.

[3]GEE approaches should also be relevant in other applications, e.g. production economics. Recently, Sun, Henderson, and Kumbhakar (2011) argue that production functions should better be estimated multiplicative than log-linear; the authors recommend PML approaches. However, if the variance structure is wrongly specified a PML approach would lead to biased variance estimates; instead, GEE estimates would be asymptotically consistent.

2 Model Specification

Starting point of every gravity trade model analysis is the specification of an appropriate theoretical model. Here the Anderson and van Wincoop (2003) (AvW) Model is standard for aggregate data.[4] For disaggregate data however the AvW Model does not fit perfectly. The AvW Model neither deals with zero trade flows which are manifold at product level nor it deals with asymmetric trade flows which are caused by different degrees of specialisation (Helpman, Melitz, and Rubinstein, 2008). Helpman, Melitz, and Rubinstein instead propose a heterogeneous firms trade model which simultaneously deals with zero and asymmetric trade flows. However, given that firm heterogeneity is only significant for products with low elasticities of substitution (Belenkiy, 2010)[5], for many applications heterogeneous firms trade models are overspecified, i.e. simpler models should suffice. Recently, Felbermayr and Kohler (2010) and Egger and Larch (2011) develop homogeneous firms trade models.[6] These models have the advantage not only to deal with zero and asymmetric trade flows but also not to require firm heterogeneity.

Homogeneous firms trade models consist of two parts. The first part deals with the extensive trade margin whereas the second part deals with the intensive trade margin. In other words, the first part asks the question whether trade occurs (yes or no), and the second part discusses the question to which extent trade takes place. The two parts can either be estimated together or separately.

To specify the corresponding stochastic models, first in advance following definitions are to be made: $\mathrm{X_{ij}}$ denotes the import value of importer j from exporter i and β_0 a constant which also captures the effect of total sector production Y; $\lambda_\mathrm{i} = \mathrm{y_i} + (\sigma - 1)\,\pi_\mathrm{i}$ and $\chi_\mathrm{j} = \mathrm{e_j} + (\sigma - 1)\,\mathrm{p_j}$ are exporter and importer fixed effects which capture the effects of exporter i's production $\mathrm{Y_i}$ and outward multilateral resistance Π_i and importer j's expenditure $\mathrm{E_j}$ and inward multilateral resistance $\mathrm{P_j}$, respectively (Anderson, 2010); and $\mathbf{d_{ij}}$ denotes the gravitational distance.[7]

The stochastic model for the non-separate model then looks as follows

$$\text{[1]} \qquad \mathrm{E}\left(\mathrm{X_{ij}} | \lambda_\mathrm{i}, \chi_\mathrm{j}, \mathbf{d_{ij}}\right) = \exp\left(\beta_0 + \lambda_\mathrm{i} + \chi_\mathrm{j} + \mathbf{d_{ij}}\right)$$

and the one for the separate model as

[4]See French (2011) for a general discussion why gravity trade models should not even be estimated at an aggretate level but at a disaggregate level with subsequent reaggregation of estimation results. Aggregation leads to a downward aggregation bias (Anderson and Yotov, 2010).

[5]Belenkiy (2010) can analytically show that as the Helpman, Melitz, and Rubinstein Model is constructed the significance of the firm heterogeneity term is inversely related to the size of the elasticity of substitution; so, for manufacturing firm heterogeneity should be significant whereas for agriculture firm heterogeneity should be insignificant.

[6]Felbermayr and Kohler (2010) develop a Corner Solutions Model specification of the homogeneous firms trade model and Egger and Larch (2011) a Two-Part Model specification.

[7]All small roman (greek) letters indicate logarithms and **bold** letters vectors.

[2] $$\Pr\left(X_{ij} > 0 | \lambda_i, \chi_j, \mathbf{d_{ij}}\right) = \Phi\left(\beta_0 + \lambda_i + \chi_j + \gamma\, \mathbf{d_{ij}}\right)$$

[3] $$E\left(X_{ij} > 0 | \lambda_i, \chi_j, \mathbf{d_{ij}}\right) = \exp\left(\beta_0 + \lambda_i + \chi_j + \gamma\, \mathbf{d_{ij}}\right)$$

where equation [2] corresponds to the extentive trade margin and equation [3] to the intensive trade margin.

3 Implementation and Estimation Issues

The second step in gravity trade model analysis is the econometric implementation of the theoretical model and its appropriate estimation. For disaggregate gravity trade model analysis, the problems of excess zeros, overdispersion, and heteroskedasticity are often existent. Excess zeros correspond to the empirical observation that there are more zeros in the data than predicted by the statistical model. Overdispersion is existent when the observed variance is higher than the variance of the statistical model, and heteroskedasticity when the observed variance is non-constant. Non-consideration of each would lead to inconsistent and / or inefficient estimates.

In their seminal paper Santos Silva and Tenreyro (2006) argue gravity trade models should not be estimated in log-linear form but in multiplicative form. Taking logarithms could lead to inconsistent estimates. If heteroskedasticity is present, Jensen's Inequality (i.e. $\ln[E(x)] \neq E[\ln(x)]$) would apply which then would render estimates inconsistent. They instead propose a Poisson Pseudo Maximum Likelihood (PPML), i.e. the endogenous y is to be modeled by a Poisson Model

[4] $$f^P\left(y|\lambda\right) = \frac{\exp\left(-\lambda\right) \lambda^y}{y!} \qquad , \lambda > 0$$

where the mean parameter is defined as $\lambda = \exp(x'\beta)$. PPML is consistent even in the presence of heteroskedasticity and it has the appeal to deal with zero trade flows.

Burger, van Oort, and Linders (2009) extend this framework for disaggregate data. The authors partly follow Santos Silva and Tenreyro (2006) that logarithmising leads to biased gravity trade model estimates but they claim that for disaggregate gravity trade models PPML is not appropriate. PPML suffers under the problems of excess zeros and overdispersion. These problems have to be treated separately since they are caused by different reasons; excess zeros is caused by disaggregation which naturally increases the number of zero trade flows and overdispersion is caused by unobserved heterogeneity which usually corresponds to an omitted variable problem (Greene, 1994).

Following Burger, van Oort, and Linders the problem of excess zeros alone can be tackled by a zero-inflated Poisson Pseudo Maximum Likelihood (ZIPPML). In the additional presence of overdispersion a zero-inflated Negative Binomal Pseudo Maximum Likelihood (ZINBPML) is appropriate. It is important to mention here that Burger, van Oort, and Linders do not develop an asymptotic theory!

An asymptotic theory is just recently developed by Staub and Winkelmann (2011). Utilising the framework of Gourieroux, Monfort, and Trognon's (1984a; 1984b) seminal papers on Pseudo Maximum Likelihood (PML) Staub and Winkelmann can show that ZIPPML / ZINBPML are inconsistent if not the underlying model is correctly specified, i.e. the empirical distribution fits with the assumed distribution of the statistical model. This finding is not totally unexpected so the second theorem of Gourieroux, Monfort, and Trognon's (1984a) paper already states that a necessary condition for consistency of a PML estimator is its membership in the linear exponential family (LEF). Since both distributions zero-inflated Poisson and zero-inflated Negative Binomial are not included in the LEF inconsistency of their PML estimators is expected. For value data ZINBPML is even inappropriate suffering under a scale-dependence problem (Bosquet and Boulhol, 2010).[8] Staub and Winkelmann further show that PPML is still consistent even in the presence of excess zeros, but the variance covariance matrices are invalid. In their paper the authors instead recommend a zero-inflated Poisson Quasi-Likelihood (PQL).

PQL is a Poisson Model shifted by a constant zero-inflation parameter π.[9] A comparison of the corresponding conditional expectation functions (CEF) exemplifies this statistical relation. Shifting the CEF of a Poisson Model $\mathrm{E}\left(\mathrm{y}|\mathrm{x}\right) = \lambda = \mathrm{x}'\beta$ by following constant term $\ln\left(1-\pi\right)$ yields the CEF of a PQL

$$[5] \qquad \mathrm{E}\left(\mathrm{y}|\mathrm{x}\right) = \left(1-\pi\right)\lambda = \exp\left(\ln\left(1-\pi\right) + \mathrm{x}'\beta\right).$$

Here it is important to consider that the zero-inflation parameter π is not separately identifiable. It is only estimable in conjunction with the constant term β_0 of the Poisson Model, i.e. $\tilde{\beta}_0 = \ln\left(1-\pi\right) + \beta_0$. This however is of minor importance as the interpretations of the other semi-elasticities $\partial\left[\mathrm{E}\left(\mathrm{y}|\mathrm{x}\right)/\mathrm{E}\left(\mathrm{y}|\mathrm{x}\right)\right]/\partial \mathrm{x}_\mathrm{k}$ are not affected hereof (Staub and Winkelmann, 2011).[10]

Table 1 once again exemplifies the reasons why PQL is preferable. Contrary to other estimators PQL is consistent even under model misspecifications and beyond that prac-

[8] Bosquet and Boulhol (2010) show that in dependence of the value unit NBPML either converges against a PPML or a Gamma Pseudo Maximum Likelihood.

[9] In their paper Staub and Winkelmann (2011) develop two zero-inflated Poisson Quasi-Likelihood one with a constant zero-inflation parameter and the other one with a non-constant zero-inflation parameter. Here only the constant zero-inflated Poisson Quasi-Likelihood is applied given convergence problems of the other estimator.

[10] One important property of PQL is that its estimates are idential with those of PPML only the variance covariance matrices are different.

Table 1: **Comparison Pseudo / Quasi Maximum Likelihood Estimators**

	PPML	**ZIPPML**	**ZINBPML**	**PQL**
Excess Zeros	0	+	+	+
Heteroskedasticity	+	+	+	+
Overdispersion	0	−	+	+
Model Misspecification	+	−	−	+
Scale Dependence	+	+	−	+

Notes: + = robust; − = vulnerable; 0 = robust but invalid variance covariance matrix.

tically unaffected by unobserved heterogeneity (Staub and Winkelmann, 2010, pg. 10). Also PQL is scale-independent (Bosquet and Boulhol, 2010). As other estimators PQL deals properly with excess zeros and heteroskedasticity.

Staub and Winkelmann's (2011) findings are important since they question Burger, van Oort, and Linders's (2009) statements!

Another strand in the literature, also dealing with excess zeros focuses on Two-Part Models and Tobit Models. For moderately disaggregate data standard Tobit estimators are appropriate. In the presence of excess zeros, Two-Part Models however are statistically more reliable; the relaxation of any left tail-probability constraint renders these models superior to Tobit Models. For Tobit Models the assumed left tail-probabilities do not fit with excess zeros, the actual sample proportions of zeros significantly exceed the theoretical predicted proportions (Chai and Bailey, 2008). In consequence corresponding Tobit estimators are inconsistent.

In trade literature Hillberry (2002) is the first proposing a standard log-normal Two-Part Model (2PM). Due to log-transformation this model however is also faced with the critique of Jensen's Inequality (i.e. $\ln[E(x)] \neq E[\ln(x)]$); hence, in the presence of heteroskedasticity corresponding log-linearised estimators are inconsistent (Santos Silva and Tenreyro, 2006). A more general Two-Part Model is looked for, in particular the problematic log-transformation is to be circumvented. A Gamma Two-Part Model (G2PM) (Lee, Xiang, and Hirayama, 2010) is here a promising alternative; the properties of the Gamma Distribution, flexible to adjust to different right-skew distributions and to deal with heteroskedasticity are important criteria.[11]

As with other Two-Part Models, the first part of a G2PM is estimated via a Binary Model (i.e. Logit or Probit Model) and the second part via a Gamma Model. The corresponding statistical model of the latter is

[11] Mullahy (1998) proposes another generalized Two-Part Model, the so called Modified Two-Part Model (M2PM). Here, the first part is to be estimated via a Binary Model (i.e. Logit or Probit Model) and the second part via a Poisson Model.

[6] $$f\left(y|k,\theta\right)=y^{k-1}\frac{e^{-y/\theta}}{\theta^{k}\Gamma(k)}\quad \text{for}\, y\geq 0\,;\, k,\theta>0$$

where y again indicates an endogenous and Γ a Gamma function. k and θ are the corresponding shape and scale parameters of a Gamma Distribution.

As PQL so G2PM deals with afore mentioned weaknesses of other models. By construction G2PM naturally deals with excess zeros and heteroskedasticity, but it is also scale-independent (Bosquet and Boulhol, 2010) and its PML estimators are consistent as well given that the Gamma Distribution belongs to the LEF.

Another aspect, most important for the empirical part is that both estimators PQL and G2PM can be nested in a Generalised Estimating Equation (Liang and Zeger, 1986) (GEE) framework. This is insofar important as in practise not PML approaches are applied but GEE approaches. This is done since the assumption of the proportionality of the variance and the expectation value (i.e. $V\left[y_i|x\right]\propto E\left[y_i|x\right]$) underlying each PML approach is too restrictive to fully account for heteroskedasticity (Santos Silva and Tenreyro, 2006). GEE approaches are insofar different to PML approaches that no specific variance covariance structures are specified. Under GEE approaches just working variance covariances matrices[12] are specified whose property it is to lead to variance covariance estimators not smaller than their true counterparts (i.e. $\widehat{cov(\beta)}\geq cov(\beta)$). This contrasts with PML approaches where the predefined variance covariance structures can either lead to smaller or greater variance covariance estimators (i.e. $\widehat{cov(\beta)}\gtreqless cov(\beta)$). GEE approaches lead to consistent estimators and more or less conservative test statistics.

Likewise, for model selection standard techniques as the Akaike Information Criterion (AIC) and its extensions do not apply. These techniques are based on likelihood functions and hence not applicable to GEE approaches (Pan, 2001). Pan instead recommends a Quasi-Likelihood under the Independence Model Criterion (QIC), an approach mimicking the AIC but basing on quasi-likelihood functions. The corresponding test statistic is calculable as follows

[7] $$QIC=-2Q\left(\hat{\mu}|I\right)+2p$$

where Q represents a quasi-likelihood function and I the corresponding assumed variance covariance structure. Further $\hat{\mu}=g^{-1}\left(X'\beta\right)$ where $g^{-1}\left(\right)$ indicates an inverse link function.

[12]GEE approaches belong to the class of semiparametric estimators. So, for variance covariance estimation sandwich estimators are applied which lead to consistent estimates; the price payed for this consistency is an increase in variance (Kauermann and Carroll, 2001).

4 Application: Intra-European Piglet Trade

The previous section discusses the statistical superiority of PQL over ZIPPML / ZINBPML and G2PM over 2PM, respectively. PQL and G2PM are now applied to intra-European piglet trade to illustrate their empirical performance and applicability.[13] The data set consists of roughly 80 % zero trade flows so a problem of excess zeros is immanent.

Estimation is done within a GEE framework; the corresponding estimation results are presented in Table 2.[14] The homogeneous firms trade model is once estimated via PQL and once via G2PM. PQL is applied to a one-part model framework and G2PM to a two-part model framework. The benchmark model (i.e. the standard AvW gravity trade model (Anderson and van Wincoop, 2003)) is estimated via Ordinary Least Squares (OLS). A fixed effects structure with importer, exporter and time fixed effects is assumed for each model.

Import data (i.e. CN8-Code 01039110) are extracted from the Statistical Office of the European Union (Eurostat); physical distance data from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII); all other data are self-constructed. The data frequency is annual, starting from 2000 to 2009. Following Marquer (2010) the trade flow analysis concentrates on the eight most important exporters and importers, i.e. Austria, Germany, Denmark, Spain, Italy, The Netherlands, Poland and Romania (see Figure 1).

Gravitational distance is approximated by physical distance (DIST), presence of a common border (CONTIG), presence of a common language (COMLANG), a binary indicator for trade between member states and new member states before EU enlargement (NMS_inter) and a binary indicator for trade between new member states before EU enlargement (NMS_intra).[15]

Main signs of all models are in accordance. Market characteristics and market developments are adaquetely represented by estimation results. Striking at first are only the estimation results of physical distance (DIST) and common border (CONTIG); these estimates do not have the usual signs. This contradiction however is explainable if one considers the market structure of the European pig sector. As Figure 1 reveals the main exporters (i.e. Denmark and The Netherlands) are located in the middle of Europe whereas, except for Germany the main importers (i.e. Spain, Italy and Romania) are located at the southern or southeastern European periphery; location of hog production is not only explained by piglet prices but also by other factors like environmental regulations, land availability etc.. This explains why physical distance and also common border do not have the expected signs.

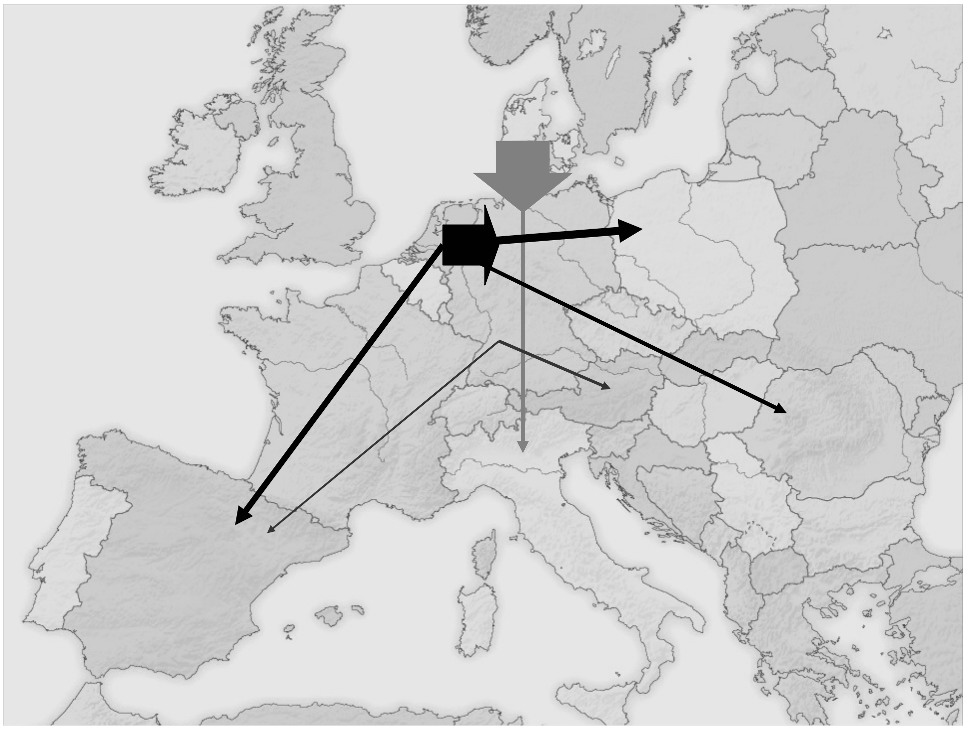
All other signs are in accordance. The downturn in trade indicated by the indicator NMS_inter fits well with market developments. After the EU enlargement large com-

[13] For details on European pig farming and recent developments see Marquer (2010).

[14] All estimations are done in STATA; for gravity trade model estimation the function xtgee is used. Program code is available on request.

[15] 1 indicates trade before EU enlargement and 0 afterwards.

Figure 1: **Intra-European Piglet Trade Flows (Major Exporters / Importers)**



Source: Own representation leant on Marquer (2010).

mercial hog producers as Smithfield Foods, Inc. opened up commercial hog plants in Easteurope what decreases exports to member states of the EU15 as indicated. The other indicator NMS_intra indicates that piglet trade between new member states decreases after EU enlargement. This decrease can be explained by a large decrease in sow stocks in Easteuropean member states after 2005 (Marquer, 2010). The time fixed effects also seem reasonably to capture global market developments. The time fixed effects follow in tendency hog price developments lagged by one year (see Figure 2).[16] That piglet producers can not immediately adjust their production to hog price developments seems obvious. 2006 is an exemption; good hog prices of 2005 were not immediately passed through which then caused a more restrained piglet production (Ernährungswirtschaft, 2010). Also the 2007 price bubble is immanent. The time fixed effect of 2008 has even a negative sign. In consequence of the high feed prices in 2007 many piglet producers closed business which decreases supply.

One question is still open the choice of the most appropriate model. Here, as discussed above for model selection QIC statistics are appropriate. The calculated QIC statistics[17], as presented in Table 2 indicate that a two-part model specification which is estimated via

[16]Price charts can be found under `http://www.bordbia.ie/industryservices/pig/pages/prices.aspx`

[17]The size of QIC statistics is scale-dependent but not the ordering; so for the conclusion it is irrelevant in which unit the endogenous is measured as long as the same unit is used for each model.

Table 2: **Overview Gravity Trade Model Estimation Results**

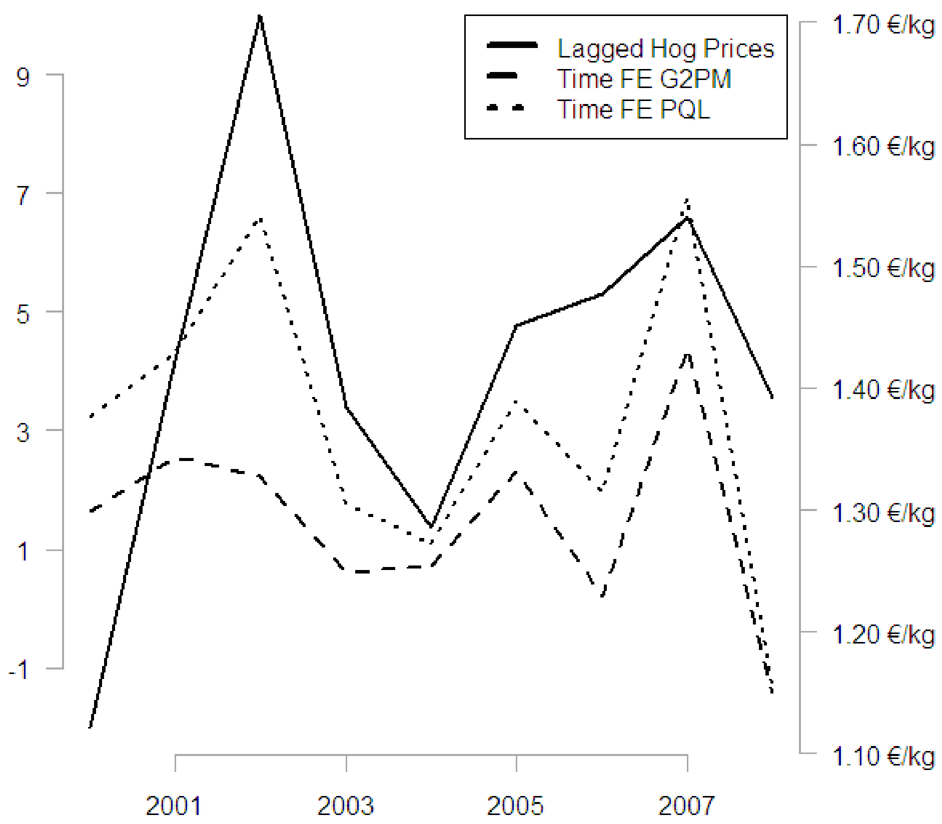
	OLS	**PQL**	**G2PM**	
			PART 1	**PART 2**
INTERCEPT	10.170*** (4.465)	−0.031 (6.076)	−12.022*** (2.450)	5.657** (2.862)
log(DIST)	−0.008 (0.494)	0.263 (0.715)	1.016*** (0.273)	0.584* (0.350)
CONTIG	− 0.024 (0.539)	−0.153 (0.599)	1.161*** (0.233)	−0.695** (0.284)
COMLANG	3.320*** (1.113)	1.330* (0.759)	−1.237*** (0.286)	1.427** (0.713)
NMS_inter	1.212 (1.298)	4.316*** (1.015)	2.624*** (0.731)	2.716*** (0.596)
NMS_intra	0.090 (1.393)	5.125*** (1.040)	3.363*** (0.705)	1.484*** (0.555)
FE_2000	0.556 (0.831)	3.222*** (0.771)	1.045 (0.665)	1.628*** (0.439)
FE_2001	2.683** (1.136)	4.303*** (0.695)	1.334* (0.716)	2.554*** (0.577)
FE_2002	1.356 (1.203)	6.618*** (0.878)	1.606*** (0.567)	2.236*** (0.678)
FE_2003	0.739 (1.166)	1.777** (0.730)	0.223 (0.603)	0.595 (0.601)
FE_2004	0.500 (1.591)	1.104 (0.765)	0.158 (0.690)	0.716 (0.614)
FE_2005	1.601 (1.262)	3.506*** (0.669)	0.472 (0.635)	2.315*** (0.800)
FE_2006	− 0.370 (0.916)	1.958** (0.859)	0.158 (0.595)	0.212 (0.512)
FE_2007	4.037*** (1.194)	6.923*** (0.749)	0.858 (0.586)	4.386*** (0.502)
FE_2008	− 1.643 (1.010)	−1.274 (0.916)	−0.254 (0.761)	−1.429** (0.572)
No. of Obs.	114	560	560	114
QIC	–	1.423e+09	524.98	3427.16

Notes: Importer, exporter, and time fixed effects. (Semi-) Robust standard errors (clustering by country pair).
Signif. levels: 0 '***' 0.01 '**' 0.05 '*' 0.1 ' ' 1

G2PM is the best choice.[18] So, in conclusion intra-European piglet trade is best modeled by means of a two-part model estimated via G2PM!

[18] The QIC statistic of the alternative Modified Two-Part Model (M2PM) (see footnote 11) is 5.398e+08. Hence, G2PM is also preferable to M2PM.

Figure 2: **Comparison Time Fixed Effects vs. Lagged Hog Prices**



Source: Own representation.

5 Conclusions

Recently research focus in gravity trade model analysis shifted from an aggregate to a disaggregate gravity trade model. This shift was first empirically motivated, but now there is also a statistical interest. In a recent paper French (2011) analytically shows that the standard aggregate AvW Model is misspecified; the outward multilateral resistance term is misspecified. Gravity trade model analysis should be done at product level and then estimation results should be reaggregated. If however gravity trade model analysis is to be done at product level then also estimation issues in disaggregate gravity trade models should come to the fore. This paper therefore deals with estimation issues in disaggregate gravity trade models.

It is shown that previous estimators, when applied to disaggregate data suffer under different statistical problems; in end effect the estimators are inconsistent. This paper therefore proposes PQL and G2PM as reliable alternatives. Both estimators appropriately deal with statistical problems as excess zeros, heteroskedasticity and model misspecification. Estimated within a GEE framework, both estimators are consistent and have more or less conservative test statistics. For model selection standard techniques are not applicable as these techniques are based on Likelihood functions. However, QIC statistics are appropriate alternatives as these statistics are conform with GEE approaches. Both methods are based on Quasi-Likelihood functions.

To evaluate the empirical performance and applicability here both estimators PQL and G2PM are applied to intra-European piglet trade; a data set where with 80 % zero trade flows a problem of excess is immanent. The empirical application favours G2PM over PQL. This result however is not to be generalised rather research should always follow statistical testing procedures and exclude step by step different model alternatives. Both estimators PQL and G2PM and the model selection technique QIC should become standard tools for disaggregate gravity trade model estimation!

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Department für Agrarökonomie und Rurale Entwicklung
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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwis-senschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Professuren mit folgenden Themenschwerpunkten:

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- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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