COMENIUS UNIVERSITY BRATISLAVA
FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS

Department of Applied Mathematics and Statistics

MODELLING THE IMPACT OF EU ACCESSION ON AGRICULTURE

Dissertation thesis

in 9.1.9 Applied Mathematics

Mgr. DÁŠA BARTOŠOVÁ

Supervisor: Prof. Dr. Ing. Jarko Fidrmuc

Bratislava 2009

Department of Applied Mathematics and Statistics
Faculty of Mathematics, Physics and Informatics
Comenius University
Mlynská dolina
842 48 Bratislava
Slovakia

Doctoral Thesis in Applied Mathematics 2009

Acknowledgement

I would like to thank my supervisor Jarko Fidrmuc for his help, advices and suggestions. I appreciate very much his expert guidance, and continuing motivation during our discussions. Further, I would like to thank Ľubica Bartová, Ján Pokrivčák, Dušan Drábik and once again to my supervisor Jarko Fidrmuc who initiated my participation on TradeAG project and thus provided me an opportunity to apply my theoretical knowledge in this project. I am also very grateful to all the members of the Department of Applied Mathematics and Statistics of Faculty of Mathematics, Physics and Informatics at the Comenius University, especially to Pavel Brunovský, Margaréta Halická, and Daniel Ševčovič, for the excellent working environment, friendly atmosphere, and collegiality which they provide to me. I would like to express my thanks to colleagues Michal Zákopčan, Ivana Bátorová, Jana Szolgayová, Soňa Kilianová, Beáta Stehlíková, and Zuzana Sziebertová for their help, support and friendship. Great thank belongs to my parents and my sister for their support and patience during my PhD studies. Thank you all!

Bratislava, April 2009 Dáša Bartošová

Abstrakt

BARTOŠOVÁ, Dáša: Modelovanie vplyvu vstupu do EÚ na poľnohospodárstvo [Dizertačná práca]. Univerzita Komenského v Bratislave, Fakulta Matematiky, Fyziky a Informatiky, Katedra Matematiky a Štatistiky. Školiteľ: Prof. Dr. Ing. Jarko Fidrmuc. Bratislava, 2009. Počet strán: 101.

V dizertačnej práci analyzujeme agropotravinársky obchod vstupujúcich krajín v období ich vstupu do EÚ. Prvá kapitola je analýzou dopadu rozšírenia EÚ na agropotravinársky sektor vo vstupujúcich krajinách a predstavením metód, ktoré sa používajú na modelovanie medzinárodného obchodu. Druhá a tretia kapitola je venovaná teoretickému základu dynamických panelových modelov a gravitačných modelov. Prehľad agropotravinárskeho obchodu vo vybraných krajinách je zhrnutý v štvrtej kapitole. Súčasťou piatej kapitoly je vytvorenie dynamického gravitačného panelového modelu pre import a export, na základe dostupných dát. Podstatné výsledky modelu sú zhrnuté v šiestej kapitole.

Kľúčové slová: *agropotravinársky obchod, rozšírenie EÚ, gravitačné modely, dynamické panelové modely.*

Abstract

BARTOŠOVÁ, Dáša: Modelling the Impact of EU Accession on Agriculture [Dissertation thesis]. Comenius University in Bratislava, Faculty of Mathematics, Physics and Informatics, Department of Mathematics and Statistics. Supervisor: Prof. Dr. Ing. Jarko Fidrmuc. Bratislava, 2009. Number of pages: 101.

In dissertation thesis we analyze the agriculture trade of Central and Eastern European countries in during their accession to the European Union. Chapter 1 introduces the implications of the EU enlargement in the agriculture sector in accession countries and the methods which are used for modeling the foreign trade. Chapter 2 and 3 is present the econometric theory of dynamic panel data models and economic theory behind gravity models, respectively. Chapter 4 shows a review of trade in the agriculture sector in selected accession countries. In Chapter 5 we estimate dynamic gravity panel data models for import and export of agriculture products for selected countries. The main results of our thesis are summarized in the last Chapter.

Key words: *agro-food, EU enlargement, gravity models, dynamic panel data models.*

Preface

The gravity models of trade are commonly used in the empirical analysis of bilateral trade because of its success in explaining trade flows among countries. However, the traditional method of estimation, which is using pooled data, causes biased results because it does not reflect the inherited heterogeneity among the countries. To solve this problem, panel estimators are used in recent studies because they permit general types of countries' heterogeneity. However, the majority of the earlier studies used static estimations, while we know that the economic data are usually characterized by their dynamic properties in time.

Gravity models estimate the trade flows of several countries as a function of demand and supply, transaction costs and integration effects in partners' countries in given time period. As macroeconomic data are often characterized by high dynamic properties, we include also the lagged levels of trade to gravity models. One of our goals is to create a model, which includes the dynamics of trade and the positives of gravity models. Even though we have only short time-series, another goal of our approach is to estimate the long-run effects, which are not feasible in static models.

In this thesis we apply dynamic augmented gravity models for panel data to model selected issues of EU accession in the agriculture sector. This approach is appropriate for our data set, which is characterized by relatively short time-series and a small cross-sectional dimension (that is, by a low number of analyzed countries) in comparison to other applications of gravity models. Furthermore, we compare several dynamic panel estimators for modeling the agriculture trade and use various bootstrap options to approximate the distribution of the sample estimator. According to our knowledge, our thesis represents the first application of these methods to trade and especially to the EU enlargement.

The thesis is structured as follows. We describe the implications of the EU enlargement in the agriculture sector in accession countries and introduce the methods which are used for modelling the foreign trade in Chapter 1. Chapter 2 introduces to the dynamic panel data and to the models which are used to estimate the regressions with them. Chapter 3 reviews the literature on gravity panel data models, which are now the most commonly applied method of analysis of foreign trade. Chapter 4 analyzes the development and trade in the agriculture sector in selected Central and Eastern European countries during their accession to the EU. In Chapter 5 we estimate several specifications of dynamic panel data models for selected agriculture products. The discussion compares the dynamic panel estimators and performs bootstrap experiments to estimate also the asymptotic distribution of the estimated parameters. Finally, the conclusions in the last chapter summarize the main results of the thesis. There are also several appendices, which include the details related to the theory discussed in the individual chapters.

Contents

Chapter 1

Introduction

After European Union (EU) enlargement, there is a question, what could the accession influenced the most in new Member States, how much responded theirs' trade and also prices (of import and export), labour market, socio economic and other sectors to admission to the EU. In this thesis we analyze possible issues of EU enlargement, especially on agro-food trade in new Member States.

Central and Eastern European countries (CEECs) received a preferential trade treatment already before the accession to the European Union (EU) as a result of bilateral agreements (especially Europe Agreements) with the EU. However, the level of liberalization of agro-food trade in these agreements was limited. The asymmetric preferences of associated agreements – preferential quotas for the benefit of CEECs have not brought expected growth of export of these countries to the EU. By contrast, the exports of agricultural and food commodities from EU15 to the CEECs increased. As further factors of the low performance of the agricultural exports of the CEECs, Frohberg and Hartmann [36] appointed the unsatisfactory level of export quality, insufficient sanitary and phytosanitary arrangements, uncompetitive food processing industry, insufficient marketing, and revaluation real exchange rate of individual CEECs currencies compared to the German Mark. According to authors serious barrier of CEECs' export to the EU were the way in which the Commission used to issue the licenses for imports within the frame of preferential quotas, the non-transparency of quotas utilization, and the distribution of market power, which have probably conferred the preferential advantages on importers. The Eastern enlargement of the EU has fully changed these conditions. All new member states have gained the full access to the common market of the agricultural commodities. Under these conditions, the distortions in the agricultural market are to be replaced by an efficient allocation of the resources. However, the outcome of this development is difficult to asses on the base of previous developments. In particular, the past weak development of the agricultural sector in the CEECs raises the question whether the agricultural products are competitive to utilize the liberalization of trade with the agricultural commodities.

Agriculture has an important function in the new Member States within the frame their economies. Agriculture in the new Member Sates is characterized by a wide range of different farming systems and cropping patterns. Small and middle private farms characterise the agriculture sector in Poland. Important specialized agriculture farms are especially in Hungary and Estonia. Agriculture of Hungary has double structure with large farms beside many small ineffective private farms. Developed private farms dominate in Slovenia. By contrast, large co-operative or joint stock holdings (successors to previous collective farms), dominate farm structure in the Czech Republic and particularly in Slovakia. In the Baltic States, Romania and to a lesser degree in Bulgaria and Hungary many new private farms have been established.

We analyze the Bulgarian, Czech, Latvian, Lithuanian, Romanian, Slovak, and Slovene imports and exports of selected agro-food commodities with selected countries and regions between 1996 and 2005. Moreover, the coverage of this thesis is broader because the partner countries analyzed in the thesis include the EU15, ten new Member States including Romania and Bulgaria, the Commonwealth of Independent States (CIS), the USA and the rest of world (ROW).

According to Deardorff [28], gravity models are consistent with several different theories of foreign trade. We derive dynamic panel data models, where we combine two approaches, which dominate the applied trade analysis - computable general equilibrium model (CGEM) and gravity model. Thus we make unique dynamic gravity panel data model. We use fixed effects (FE) model, Hausman-Taylor method (HT) and also generalized method of movements (GMM), especially Arellano and Bond application of GMM, where the lagged dependent and independent variables are used as instrumental variables. GMM is used to analyze the stability of the results because is less applicable for our data set. In our specification we follow Baldwin’s critique on several common mistakes in formulation of the gravity models. We also make bootstraping on FE and HT models of export and import, which is special technique to estimate the distribution of the estimators.

Chapter 2

The Panel Models

2.1 Introduction

The development of panel data modelling, especially of the range of economic and financial models, where the panel data model is applicable, expands in recent years. Numerous theoretical and applied studies have been published. For example in books by Hsiao [43], Baltagi [15] and Matyas and Sevestre [55] there are used different theoretical issues and summarized several applications.

Typical macro panel most likely contains all the individuals and not just a random subgroup of individuals, so in macroeconomic are often used non-random parameters, where only the individual effects are considered random. For a discussion on the choice between fixed or random effects used in model, see e.g. Mundlak [56] and Hsiao [43].

2.2 Regression model

2.2.1 Introduction

Panel data refers to data for N different entities observed at T different time periods. Panel data regression differs from a regular time-series or cross-section regression in that it has a double subscript on its variables to keep track of both the entity and time period.

Considering the regression model given by

$$y_{it} = \alpha + x_{it}^{'}\beta + \varepsilon_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{2.1}$$

where the *i* subscript denotes the cross-section dimension and *t* denotes the time-series dimension. α is a scalar, β is K x 1 and x_{it} is the *it*-th observation on K explanatory variables. The disturbances are defined as

$$\varepsilon_{it} = \mu_i + \lambda_t + \upsilon_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{2.2}$$

where μ_i denotes the unobservable individual effect, λ_t denotes the unobservable time effect, which is individual-invariant and accounts for any time-specific effect that is not included in regression and υ_{it} is the remainder stochastic disturbance term. This is known as the two-way error component regression model from Baltagi [15]. (2.2) can be write in matrix form

$$\varepsilon = Z_\mu \mu + Z_\lambda \lambda + \upsilon \tag{2.3}$$

where the matrix $Z_\mu = I_N \otimes \iota_T$, where I_N denotes an identity matrix of dimension N, ι_T denotes a vector of ones of dimension T. This means, that Z_μ is a matrix of individual dummies that one may include in the regression to estimate the μ_i if they are assumed to be fixed parameters. $Z_\mu Z'_\mu = I_N \otimes J_T$, where J_T is a matrix of ones of dimension T. The projection matrix on Z_μ reduces to $I_N \otimes \bar{J}_T$, where $\bar{J}_T = \frac{J_T}{T}$, is in the form $P = Z_\mu (Z'_\mu Z_\mu)^{-1} Z'_\mu$. P is a matrix which averages the observation across time for each individual and $Q = I_{NT} - P$ is a matrix which obtains the deviations from individual means. The properties of matrices P and Q are in Appendix B. $Z_\lambda = \iota_N \otimes I_T$ (the dimension is $NT \times T$) is the matrix of time dummies that one may include in regression to estimate the λ_t if they are fixed parameters, $\lambda^{'} = (\lambda_1, \lambda_2, ..., \lambda_T)$ and $\otimes$ denotes the Kronecker product[1].

[1] To see what The Kronecker product is, see Appendix A

2.2.2 The fixed effects model

Fixed effects regression is a method for controlling omitted variables in panel data when the omitted variables vary across the entities (e.g. countries) but do not change over time. Fixed effects regression can be used when there are two or more time observations for each entity.

The (2.2) represents a two-way fixed effects error component model in case the μ_i and λ_t assumed to bed fixed parameters to be estimate and the disturbances υ_{it} are stochastic with $\upsilon_{it} \sim \text{IID}(0,\sigma_\upsilon^2)$. The X_{it} are assumed to be independent of the υ_{it} for all i and t. The inference is conditional on the particular N individuals and over the specific time periods observed. If N or T is large, there will be [(N-1)+(T-1)] dummy variables in the regression, which is too many and this causes an enormous loss in degrees of freedom. This reduces the problem of multicollinearity among the regressors. The fixed effects estimates of β can be obtain by performing the within transformation given by Wallace and Hussain [68], rather than invert a large $(N+T+K-1)$ dimension matrix. The within transformation is in form

$$Q = E_N \otimes E_T = I_N \otimes I_T - I_N \otimes \bar{J}_T - I_T \otimes \bar{J}_N + \bar{J}_N \otimes \bar{J}_T \tag{2.4}$$

This transformation eliminates the μ_i and λ_t effects. The typical element of $\tilde{\varepsilon} = Q\varepsilon$ is $\tilde{\varepsilon}_{it} = (\varepsilon_{it} - \bar{\varepsilon}_{i.} - \bar{\varepsilon}_{.t} + \bar{\varepsilon}_{..})$, where $\bar{\varepsilon}_{..} = \sum_{i=1}^{N}\sum_{t=1}^{T}\frac{\varepsilon_{it}}{NT}$ and by performing the regression of $\tilde{y} = Qy$ on $\tilde{X} = QX$ it can be obtain the within estimator $\tilde{\beta} = (X'QX)^{-1}X'Qy$.

The simple regression in (2.1) by averaging over individuals and with disturbances given by (2.2) can be written as

$$\bar{y}_{.t} = \alpha + \beta \bar{x}_{.t} + \lambda_t + \bar{v}_{.t} \tag{2.5}$$

where the restriction $\sum_{i=1}^{N}\mu_i = 0$ has been utilized to avoid the dummy variable trap.

By averaging over time and using $\sum_{t=1}^{T}\lambda_t = 0$ (2.1) gives

$$\bar{y}_{i.} = \alpha + \beta \bar{x}_{i.} + \mu_i + \bar{v}_{i.} \tag{2.6}$$

Averaging across all observations (2.1) gives

$$\overline{y}_{..} = \alpha + \beta\,\overline{x}_{..} + \overline{v}_{..} \qquad (2.7)$$

where is utilized the restriction $\sum_{i=1}^{N}\mu_i = 0$ and $\sum_{t=1}^{T}\lambda_t = 0$. OLS[2] on this model gives the within estimator for the two-way model $\tilde{\beta}$. The within estimate of the intercept can be deduced from $\tilde{\alpha} = \overline{y}_{..} - \tilde{\beta}\overline{x}_{..}$ and those of μ_i and λ_t are given by

$$\tilde{\mu}_i = (\overline{y}_{i.} - \overline{y}_{..}) - \tilde{\beta}(\overline{x}_{i.} - \overline{x}_{..}) \qquad (2.7)$$

$$\tilde{\lambda}_t = (\overline{y}_{it} - \overline{y}_{..}) - \tilde{\beta}(\overline{x}_{.t} - \overline{x}_{..}) \qquad (2.8)$$

Because the Q transformation wipes out the time-invariant and individual-invariant variables, the within estimator cannot estimate theirs effect.

2.2.3 Heterogeneous panels with time-specific factors

Conventional double index panel data model can be expressed as

$$y_{it} = x_{it}^{'}\beta + z_i^{'}\gamma + \varepsilon_{it} \qquad i = 1,\ldots,N; \quad t = 1,\ldots,T \qquad (2.9)$$

$$\varepsilon_{it} = \mu_i + \lambda_t + \upsilon_{it} \qquad (2.10)$$

where the error term ε_{it} is composed of an individual effect μ_i that accounts for the effect of all possible time invariant determinants and might be correlated with some of the explanatory variables $x_{it}^{'}$ and $z_i^{'}$. The time-specific effect λ_t is common to all cross-section units that is meant to correct for the impact of all the individual invariant determinants. Zero mean and random disturbances υ_{it} is uncorrelated across cross-section units and over time periods and these three components are independent to each other.

By generalization that individual responses to variations of the common time-specific effects are heterogeneous, (2.10) can be extend to

[2] OLS – Ordinary Least Squares

$$\varepsilon_{it} = \mu_i + \theta_i f_t + \upsilon_{it} \tag{2.11}$$

where θ_i represent possible heterogeneous responses with respect to the time-specific common factors f_t between entities. The estimation of β and γ, which is more efficient with properly accommodating the error component structure given by (3.7), was used explicitly in panel studies by Ahn, Lee and Schmidt [1], Bai and Ng [10], Pesaran [60] and Phillips and Sul [61]. If some or all of the regressors in $x_{it}^{'}$ are likely to be correlated with f_t, the uncorrected estimator is severely biased. This approach allow for certain degrees of cross-section dependence through heterogeneous time-specific effects.

Under assumption that all of the time-specific common effects are observable, the combination of (2.9) and (2.11) can be written as

$$y_{it} = x_{it}^{'}\beta + z_i^{'}\gamma + f_t^{*'}\theta_i + \varepsilon_{it} \qquad i = 1,\dots,N; \quad t = 1,\dots,T \tag{2.12}$$

$$\varepsilon_{it} = \mu_i + \upsilon_{it} \tag{2.13}$$

where f_t^{*} are observed multiple time-specific factor. This model considers explicitly the impact of time-specific factors f_t^{*} instead of the fixed time effects and does not impose the homogeneous restrictions on the coefficients on f_t^{*}.

Following the pooled correlated common effect (PCCE) estimation[3] approached by Pesaran [60] in the case where observed and unobserved common time-specific effects are considered, the model (2.12) is extended to

$$y_{it} = x_{it}^{'}\beta + z_i^{'}\gamma + f_t^{'}\theta_i + \mu_i + \upsilon_{it} \qquad i = 1,\dots,N; \quad t = 1,\dots,T \tag{2.14}$$

under assumption there is a single unobserved time-specific common effect in ε_{it} and then $f_t^{'}$ is the augmented set including f_t^{*} and the cross-sectional averages of y_{it} and $x_{it}^{'}$, namely $\overline{y}_t = \sum_{i=1}^{N} \frac{y_{it}}{N}$ and $\overline{x}_t = \sum_{i=1}^{N} \frac{x_{it}^{'}}{N}$. Pesaran [60] showed that PCCE estimation provides the consistent estimator of β although it does not provide a consistent estimator of γ. The dimensions of vectors in model are as follows: $x_{it}^{'} = (x_{1,it}, x_{2,it}, \dots, x_{K,it})$ is 1 x K vector of variables that vary over individuals and

[3] PCCE - Pooled correlated common effect estimation is also called generalized within estimator of extend model.

time periods, $z_i^{'} = (z_{1,i}, z_{2,i}, ..., z_{L,i})$ is 1 x L vector of individual-specific variables, $f_t^{'} = (f_{1,t}, f_{2,t}, ..., f_{G,t})$ is 1 x G vector of time-specific variables, $\beta = (\beta_1, \beta_2, ..., \beta_K)^{'}$, $\gamma = (\gamma_1, \gamma_2, ..., \gamma_L)^{'}$ and $\theta = (\theta_1, \theta_2, ..., \theta_G)^{'}$ are conformably defined column vectors of parameters, respectively.

2.2.4 The Hausman-Taylor estimation in heterogeneous panels with time-specific factors

By following Hausman-Taylor model used by Serlenga and Shin [65], model specified in (2.14) can be written in form

$$y_{it} = x_{1it}^{'}\beta_1 + x_{2it}^{'}\beta_2 + z_{1i}^{'}\gamma_1 + z_{2i}^{'}\gamma_2 + f_t^{'}\theta_i + \mu_i + \upsilon_{it} \qquad i = 1, ..., N; \quad t = 1, ..., T \qquad (2.15)$$

where $x_{it}^{'} = (x_{1it}^{'}, x_{2it}^{'})$, while $x_{1it}^{'}$ and $x_{2it}^{'}$ are K_1- and K_2-vectors, $z_i^{'} = (z_{1i}^{'}, z_{2i}^{'})$, while $z_{1i}^{'}$ and $z_{2i}^{'}$ are L_1- and L_2-vectors, β_1, β_2, γ_1 and γ_2 are conformably defined column vectors.

<u>Assumption A:</u>

i. $\upsilon_{it} \sim iid(0, \sigma_\upsilon^2)$

ii. $\mu_i \sim iid(\mu, \sigma_\mu^2)$

iii. $E(\mu_i \upsilon_{jt}) = 0$ *for all i, j, t*

iv. $E(x_{it}\upsilon_{js}) = 0$, $E(f_t\upsilon_{is}) = 0$ *and* $E(z_i\upsilon_{jt}) = 0$ *for all i, j, s, t, so all the regressors are exogenous with respect to the idiosyncratic errors* υ_{it}

v. $x_{1it}^{'}$, $z_{1i}^{'}$ *and* $f_t^{'}$ *are uncorrelated with* μ_i *for all i, t, whereas* $x_{2it}^{'}$ *and* $z_{2i}^{'}$ *are correlated with* μ_i

vi. The dimension N and T are sufficiently large

This assumption is standard in the panel data literature. The prior information is important to distinguish columns of x and z which are correlated with the individual unobservable effect μ_i and those which are not. Assumption *vi* is necessary to consistently estimate heterogeneous parameters θ_i. According to estimation theory for all the parameters in (2.14) the consistent estimator of β is

$$\hat{\beta}_{FE} = \left(\sum_{i=1}^{N} x_i^{'} M x_i \right)^{-1} \left(\sum_{i=1}^{N} x_i^{'} M y_i \right) \tag{2.16}$$

where $\underset{(T\times 1)}{y_i} = \begin{pmatrix} y_{i1} \\ y_{i2} \\ \vdots \\ y_{iT} \end{pmatrix}$; $\underset{(T\times 1)}{\iota_T} = \begin{pmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{pmatrix}$; $\underset{(G\times T)}{f^{'}} = (f_1, f_2, \dots, f_T)$; $\underset{(K\times T)}{x_i^{'}} = (x_{i1}, x_{i2}, \dots, x_{iT})$,

$H_T = (\iota_T, f)$ is a T x (G+1) matrix and $M_T = I_T - H_T(H_T^{'}H_T)^{-1}H_T^{'}$. The consistent estimator of λ_i can be obtained from the regression

$$\tilde{y}_{it} = b_i + f_t^{'}\theta_i + \tilde{\upsilon}_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{2.17}$$

where $\tilde{y}_{it} = y_{it} - x_{it}^{'}\hat{\beta}_{FE}$ and $b_i = \mu_i + z_i^{'}\gamma$. Under assumption the underlying variables are stationary, in which case under standard conditions, the consistency and the asymptotic normality of the FE estimator of β can be easily established. However, the FE estimation above will wipe out any individual specific variables in Z_i from (2.15). In order to consistently estimate γ_1 and γ_2 on individual specific variables, firstly rewrite (2.16) to the form

$$d_{it} = \mu_i + z_{i1}^{'}\gamma_1 + z_{i2}^{'}\gamma_2 + \upsilon_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{2.18}$$

where $d_{it} = y_{it} - x_{it}^{'}\beta - f_t^{'}\theta_i$ for $i = 1,...,N$ and $t = 1,...,T$. (2.18) can be rewrite by using *ii* in Assumption A as

$$d_{it} = \alpha + z_{i1}^{'}\gamma_1 + z_{i2}^{'}\gamma_2 + \mu_i^{*} + \upsilon_{it} = \alpha + z_i^{'}\gamma + \varepsilon_{it}^{*} \qquad i = 1,...,N; \quad t = 1,...,T \tag{2.19}$$

where $\mu_i^{*} \sim (0, \sigma_\mu^2)$ and $\varepsilon_i^{*} = \mu_i^{*} + \upsilon_{it}$ is a zero mean process by construction. Equation (2.19) can be rewriting in matrix form

$$d = \alpha\iota_{NT} + Z_1\gamma_1 + Z_2\gamma_2 + \varepsilon^{*} \tag{2.10}$$

where $\underset{(NT\times 1)}{d} = \begin{pmatrix} d_1 \\ d_2 \\ \vdots \\ d_N \end{pmatrix}$; $\underset{(NT\times 1)}{\iota_{NT}} = \begin{pmatrix} \iota_T \\ \iota_T \\ \vdots \\ \iota_T \end{pmatrix}$; $\underset{(T\times L)}{Z_j} = \begin{pmatrix} z_{j1}\iota_T \\ z_{j2}\iota_T \\ \vdots \\ z_{jN}\iota_T \end{pmatrix}$, $j=1,2$ and $\underset{(NT\times 1)}{\varepsilon^*} = \begin{pmatrix} \varepsilon_1^* \\ \varepsilon_2^* \\ \vdots \\ \varepsilon_N^* \end{pmatrix}$.

Replacing d by its consistent estimate $\hat{d} = \left\{\hat{d}_{it}, i=1,...,N; t=1,...,T\right\}$, where $\hat{d}_{it} = y_{it} - x_{it}^{'}\hat{\beta} - f_t^{'}\hat{\theta}_i$ for $i=1,...,N$ and $t=1,...,T$, (2.19) can be write as

$$\hat{d} = \alpha\iota_{NT} + Z_1\gamma_1 + Z_2\gamma_2 + \varepsilon^* = C\delta + \varepsilon^* \tag{2.21}$$

where $C = (\iota_{NT}, Z_1, Z_2)$ and $\delta = (\alpha, \gamma_1\gamma_2)^{'}$. To deal with the nonzero correlation between Z_2 and α or α*, it has to be find the matrix of instrument variables $W = (\iota_{NT}, Z_1, W_2)$ with dimension $NT\times(1+L_1+H)$, where W_2 is an $NT\times H$ matrix of instrument variables for Z_2 with $H \geq L_2$ for identification. The advantage of HT estimation is that the instrument variables for Z_2 can be obtained withinside and that QX_1 is suggested to use as the instruments for Z_2. An alternative source of instrument variables can be used after rewriting (2.15) to

$$y_{it} = b_i + x_{it}^{'}\beta + f_{1t}\theta_{1i} + f_{2t}\theta_{2i} + \cdots + f_{Gt}\theta_{Gi} + \upsilon_{it} \tag{2.22}$$

where $b_i = \mu_i + z_i^{'}\gamma_i$. Specify $\hat{\theta}_{jit} = \hat{\theta}_{ji}f_{jt}$ for $j=1,...,G$, $i=1,...,N$ and $t=1,...,T$, where $\hat{\theta}_{ji}$ are consistent estimates of heterogeneous factor θ_{ji} and specify $NT\times 1$

dimension matrix $\hat{\Theta}_j = \begin{pmatrix} f_j\hat{\theta}_{j1} \\ f_j\hat{\theta}_{j2} \\ \vdots \\ f_j\hat{\theta}_{jN} \end{pmatrix}$, where $\underset{(T\times 1)}{f_j} = \begin{pmatrix} f_{j1} \\ f_{j2} \\ \vdots \\ f_{jN} \end{pmatrix}$ for $j=1,...,G$.

Assumption B:

Let θ_{ji} are correlated with z_{2i}, but not correlated with μ_i for $j=1,\dots,G_1$, while for θ_{ji} are correlated with both z_{2i} and μ_i for $j= G1+1,\dots,G$.

This assumption implies that some of individuals' heterogeneous responses are correlated with Z_2 with respect to common factors f_t, but not correlated with individual effects. The instrument matrix for Z_2 can be write as $NT \times H$ dimension (where $H = K_1 + G_1$) matrix $W_2 = \left(QX_1, \hat{\Theta}_1, \hat{\Theta}_2, ..., \hat{\Theta}_{G_1}\right)$ under Assumption A *v* and Assumption B. Estimation (2.21) by multiplying with W' is in the form

$$W'\hat{d} = W'C\delta + W'\varepsilon^* \tag{2.23}$$

and the consistent estimator of δ is obtained by the GLSIV[4] estimation by

$$\hat{\delta}_{GLS} = \left[C'WV^{-1}W'C\right]^{-1} C'WV^{-1}W'\hat{d} \tag{2.24}$$

where $V = Var(W'\varepsilon^*)$. The FGLS[5] estimation can be obtained by replacing V by its consistent estimator. An initial consistent estimation of $\hat{\delta}$ is obtained by the OLS estimator from (2.21) and it is constructed a consistent estimate of ε^* by $\hat{\varepsilon}^*_{OLS} = \hat{d} - C\hat{\delta}_{OLS}$, where $\hat{\varepsilon}^*_{OLS} = (\hat{\varepsilon}^*_{OLS,1}, \hat{\varepsilon}^*_{OLS,2}, ...\hat{\varepsilon}^*_{OLS,N})'$. The initial consistent estimate of V is then

$$\hat{V}_{(1)} = \sum_{i=1}^{N} w_i'\hat{\varepsilon}^*_{OLS,i}\hat{\varepsilon}^{*'}_{OLS,i}w_i \tag{2.25}$$

where w_i is the instrument matrix for individual *i* with $T \times (1 + L_1 + H)$ dimension, defined in $W = (w_1', w_2', ..., w_N')'$ and estimate the FGLS estimator of δ by

$$\hat{\delta}^{(1)}_{FGLS} = \left[C'W\hat{V}^{-1}_{(1)}W'C\right]^{-1} C'W\hat{V}^{-1}_{(1)}W'\hat{d}\,. \tag{2.26}$$

Under construction of GLS[6] residuals by $\hat{\varepsilon}^*_{GLS} = \hat{d} - C\hat{\delta}^{(1)}_{FGLS}$ the estimation of V is

$$\hat{V}_{(2)} = \sum_{i=1}^{N} w_i'\hat{\varepsilon}^*_{GLS,i}\hat{\varepsilon}^{*'}_{GLS,i}w_i \tag{2.27}$$

[4] GLSIV estimation - Generalized Least Squares Instrumental Variables
[5] FGLS - Feasible Generalized Least Squares
[6] GLS - Generalized Least Squares

and for δ is

$$\hat{\delta}_{FGLS}^{(2)} = \left[C'W\hat{V}_{(2)}^{-1}W'C\right]^{-1} C'W\hat{V}_{(2)}^{-1}W'\hat{d}. \tag{2.28}$$

2.3 Dynamic panel data models

2.3.1 Introduction

In case of dynamic panel data models, the asymptotic approximation can be for $T \to \infty$ or for $N \to \infty$ or for both, where N indicates the number of units in each cross-section of the sample and T indicates the number of time's dimension. In practice, T is often small and N is reasonably large. The accuracy and efficiency of various types of estimators in dynamic fixed effects models and in dynamic error-components models have been the central issue of a number of theoretical and Monte Carlo studies, e.g. Balestra and Nerlove [14], Nerlove [58], Maddala [51] and Arellano and Bond [4].

2.3.2 Dynamic regression

Dynamic relationships are characterized by the presence of lagged dependent variable among the regressors, i.e.

$$y_{it} = \delta y_{it-1} + x_{it}'\beta + \varepsilon_{it} \qquad i = 1,\ldots,N; \quad t = 1,\ldots,T \tag{2.29}$$

$$\varepsilon_{it} = \mu_i + \lambda_t + \upsilon_{it} \qquad i = 1,\ldots,N; \quad t = 1,\ldots,T \tag{2.30}$$

where δ is a scalar, x_{it} is 1 x K and β is K x 1, μ_i ~ IID(0, σ_μ^2) and ν_{it} ~ IID(0, σ_ν^2) independent of each other and among themselves and λ_t denotes the unobservable time effect, which is individual-invariant and accounts for any time-specific effect that is not included in regression. The dynamic panel data regressions described in (2.29) with condition above are characterized by two sources of persistence over time. Autocorrelation due to the presence of a lagged dependent variable among the regressors and individual effects characterizing the heterogeneity among the individuals. There are some basic problems introduced by the inclusion of lagged dependent variable. Since y_{it} is a function of μ_i, it immediately follow that y_{it-1} is also a function of μ_i. Therefore, y_{it-1} is correlated with the error term. This renders the OLS estimator biased and inconsistent even if the ν_{it} are not serially correlated. For the fixed effects (FE) estimator, the within transformation wipes out the μ_i, but $(y_{i,t-1} - \bar{y}_{i,-1})$, where $\bar{y}_{i,-1} = \sum_{t=2}^{T} \frac{y_{i,t-1}}{(T-1)}$ will still be correlated with $(\nu_{it} - \bar{\nu}_i)$ even if the ν_{it} are not serially correlated. This is because $y_{i,t-1}$ is correlated with $\bar{\nu}_i$ by construction. The latter average contains ν_{it-1} which is obviously correlated with y_{it-1}. In the fact, the within estimator will be biased of $O\left(\frac{1}{T}\right)$ and its consistency will depend upon T being large. Kiviet [46] derived an approximation for the bias of the within estimator in a dynamic panel data model with serially uncorrelated disturbances and strongly exogenous regressors. He proposes a corrected within estimator that subtracts a consistent estimator of bias from the original within estimator. For the typical panel where N is large and T is fixed, the within estimator is biased and inconsistent. It is worth emphasizing that only if $T \rightarrow \infty$ will the within estimator of δ and β be consistent for the dynamic error component model.

An alternative transformation that wipes out the individual effects is the first difference transformation. In this case, correlation between the predetermined explanatory variables and the remainder error is easier to handle. In fact, Anderson and Hsiao [8] suggest first differencing the model to get rid of the μ_i and then using $\Delta y_{i,t-2} = (y_{i,t-2} - y_{i,t-3})$ or simply $y_{i,t-2}$ as an instrument for $\Delta y_{i,t-1} = (y_{i,t-1} - y_{i,t-2})$. These instruments will not be correlated with $\Delta \nu_{it} = (\nu_{it} - \nu_{i,t-1})$, as long as the ν_{it} themselves are not serially correlated. This instrumental variable (IV) estimation method leads to consistent but not necessarily efficient estimates of the parameters in the model because it does not make use of all the available moment conditions (see Ahn, Schmidt [2]) and it does not take into account the differenced structure on the residual disturbances ($\Delta \nu_{it}$). Arellano [3] finds that for simple dynamic error components models, the estimator that uses differences $\Delta y_{i,t-2}$ rather than levels $y_{i,t-2}$ for instruments has a singularity point and very large variances over a significant range of parameter values. In contrast, the estimator that uses instruments in levels, i.e. $\Delta y_{i,t-2}$, has no singularities and much smaller variances and is therefore recommended. Arellano and Bond [4] propose a generalized method of moments (GMM) procedure that is more efficient than the Anderson and Hsiao [9] estimator.

2.3.2 The Arellano and Bond

Arellano and Bond [4] argue that additional instruments can be obtained in dynamic panel data model if one utilizes the orthogonality conditions that exist between lagged values of y_{it} and the disturbances ν_{it}. Let us illustrate this with the simple autoregressive model with no regressors:

$$y_{it} = \delta y_{i,t-1} + \varepsilon_{it} \qquad i = 1,\ldots,N; \quad t = 1,\ldots,T \tag{2.31}$$

with $\varepsilon_{it} = \mu_i + \nu_{it}$ with $\mu_i \sim \text{IID}(0,\ \sigma_\mu^2)$ and $\nu_{it} \sim \text{IID}(0,\ \sigma_\nu^2)$, independent of each other and among themselves. In order to get a consistent estimate of δ as $N \rightarrow \infty$ with T fixed, we first difference (2.31) to eliminate the individual effects:

$$y_{it} - y_{i,t-1} = \delta(y_{i,t-1} - y_{i,t-2}) + (\nu_{it} + \nu_{i,t-1}) \tag{2.32}$$

and note that $(\nu_{it} - \nu_{i,t-1})$ is MA(1)[7] with unit root. For $t = 3$, the first period we observe this relationship, we have

$$y_{i3} - y_{i2} = \delta(y_{i2} - y_{i1}) + (\nu_{i3} + \nu_{i2}) \tag{2.33}$$

In this case, y_{i1} is a valid instrument, since it is highly correlated with $(y_{i2} - y_{i1})$ and not correlated with $(\nu_{i3} - \nu_{i2})$ as long as the ν_{it} are not serially correlated. Note what happens for $t = 4$, the second period we observed is:

$$y_{i4} - y_{i3} = \delta(y_{i3} - y_{i2}) + (\nu_{i4} + \nu_{i3}) \tag{2.34}$$

In this case, y_{i2} as well as y_{i1} are valid instruments for $(y_{i3} - y_{i2})$, since both y_{i2} and y_{i1} are not correlated with $(\nu_{i4} - \nu_{i3})$. We can continue in this adding an extra valid instrument with each forward period, so that for period T the set of valid instruments becomes $(y_{i1}, y_{i2}, \ldots, y_{iT-2})$. This instrumental variable procedure still does not account for the difference error term in (2.32). In fact

[7] MA(1) – A moving average model uses lagged values of the forecast error to improve the current forecast. A first-order moving average term uses the most recent forecast error, a second-order term uses the forecast error from the two most recent periods, and so on. An MA(1) has the form: $u_t = \varepsilon_t + \theta_1 \varepsilon_{t-1}$.

$$E(\Delta\nu_i\ \Delta\nu_i') = \sigma_\nu^2\ (I_N \otimes G) \tag{2.35}$$

where $\Delta\nu_i' = (\nu_{i3} - \nu_{i2}, \ldots, \nu_{iT} - \nu_{i,T-1})$ and $G = \begin{pmatrix} 2 & -1 & 0 & \ldots & 0 & 0 & 0 \\ -1 & 2 & -1 & \ldots & 0 & 0 & 0 \\ : & : & : & \ldots & : & : & : \\ 0 & 0 & 0 & \ldots & -1 & 2 & -1 \\ 0 & 0 & 0 & \ldots & 0 & -1 & 2 \end{pmatrix}$

is $(T-2) \times (T-2)$, since $\Delta\nu_i$ is MA(1) with unit root. Define

$$W_i = \begin{bmatrix} [y_{i1}] & & & 0 \\ & [y_{i1}, y_{i2}] & & \\ & & \ddots & \\ 0 & & & [y_{i1}, \ldots, y_{i,T-2}] \end{bmatrix} \tag{2.36}$$

Then the matrix of instruments is $W = [W_1', \ldots, W_N']'$ and the moment equations described above are given by $E(W_i'\Delta\nu_i) = 0$. Premultiplying the differenced equation (2.32) in vector form by W', one gets

$$W'\Delta y = W'(\Delta y_{-1})\delta + W'\Delta\nu \tag{2.37}$$

Performing GLS on (2.37) one gets the Arellano and Bond [5] preliminary one-step consistent estimator

$$\hat{\delta}_1 = [(\Delta y_{-1})'W(W'(I_N \otimes G)W)^{-1}W'(\Delta y_{-1})]^{-1} \times [(\Delta y_{-1})'W(W'(I_N \otimes G)W)^{-1}W'(\Delta y)] \tag{2.38}$$

The optimal GMM estimator of δ_1 according to Hansen [40] for $N \to \infty$ and T fixed using only the above moment restrictions yields the same expression as in (2.38) except that $W'(I_N \otimes G)W = \sum_{i=1}^{N} W_i'GW_i$ is replaced by $V_N = \sum_{i=1}^{N} W_i'(\Delta\nu_i)(\Delta\nu_i)'W_i$. This GMM estimator requires no knowledge concerning the initial conditions or distributions of ν_i and μ_i, where $\Delta\nu$ is replaced by differenced residuals obtained from the preliminary consistent estimator $\hat{\delta}_1$. The resulting estimator is the two-step Arellano and Bond [4] GMM estimator

$$\hat{\delta}_2 = [(\Delta y_{-1})' W(W'\hat{V}_N^{-1}W)^{-1}W'(\Delta y_{-1})]^{-1} \times [(\Delta y_{-1})' W(W'\hat{V}_N^{-1}W)^{-1}W'(\Delta y)] \quad (2.39)$$

2.3.2.1 Models with exogenous variables

If there are additional strictly exogenous regressors x_{it} as in (2.29) with $E(x_{it}v_{it}) = 0$ for all t, s = 1, 2, . . . , T, but where all the x_{it} are correlated with μ_i, then all the x_{it} are valid instruments for the first-differenced equation of (2.29). Therefore, $[x_{i1}', x_{i2}', ..., x_{iT}']$ should be added to each diagonal element of W_i in (2.36). In this case, (2.24) becomes

$$W'\Delta y = W'(\Delta y_{-1})\delta + W'(\Delta X)\beta + W'\Delta \nu \quad (2.40)$$

where ΔX is the stacked N(T – 2) x K matrix of observations on Δx_{it}. One and two step estimators of (δ, β’) can be obtained from

$$\begin{pmatrix} \hat{\delta} \\ \hat{\beta} \end{pmatrix} = ([\Delta y_{-1}, \Delta X]' W\hat{V}_N^{-1}W'[\Delta y_{-1}, \Delta X])^{-1}([\Delta y_{-1}, \Delta X]' W\hat{V}_N^{-1}W'\Delta y) \quad (2.41)$$

as in (2.38) and (2.39). If x_{it} are predetermined rather than strictly exogenous with $E(x_{it}v_{it}) \neq 0$ for s < t and zero otherwise, then only $[x_{i1}', x_{i2}', ..., x_{i(s-1)}']$ are valid instruments for the differenced equation at period s. This can be illustrated as follows:

for t = 3, the first differenced equation of (2.29) becomes

$$y_{i3} - y_{i2} = \delta(y_{i2} - y_{i1}) + (x_{i3}' - x_{i2}')\beta + (\nu_{i3} - \nu_{i2}) \quad (2.42)$$

For this equation, x_{i1}' and x_{i2}' are valid instruments, since both are not correlated with $(\nu_{i3} - \nu_{i2})$. For t = 4, the next period we observe this relationship

$$y_{i4} - y_{i3} = \delta(y_{i3} - y_{i2}) + (x_{i4}' - x_{i3}')\beta + (\nu_{i4} - \nu_{i3}) \quad (2.43)$$

and we have additional instruments since now x_{i1}', x_{i2}' and x_{i3}' are not correlated with $(\nu_{i4} - \nu_{i3})$. Continuing in this fashion, we get

$$W_i = \begin{bmatrix} [y_{i1}, x'_{i1}, x'_{i2}] & & & 0 \\ & [y_{i1}, y_{i2}, x'_{i1}, x'_{i2}, x'_{i3}] & & \\ & & \ddots & \\ 0 & & & [y_{i1}, ..., y_{i,T-2}, x'_{i1}, ..., x'_{i,T-1}] \end{bmatrix} \tag{2.44}$$

and one and two step estimators are again given by (2.41) with this choice of W_i. In empirical studies, a combination of both predetermined and strictly exogenous variables may occur rather than the above two extreme cases, and the researcher can adjust the matrix of instruments W accordingly.

2.4 Stationarity and Panel unit root test

The finding that many macro time series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Engle and Grange [32] point out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated.

Choi and Chue [26] study subsampling hypothesis tests for panel data that may be non-stationary, cross-sectionally correlated and cross-sectionally cointegrated. The subsampling approach provides approximations to the finite sample distribution of the tests without estimating nuisance parameters. The number of cross-sectional units is assumed to be finite and that of time-series observations infinite. Choi and Chue [26] show that subsampling provides asymptotic distributions that are equivalent to the asymptotic distributions of the panel tests. The panel unit root tests considered are e.g. Levin, Lin and Chu's [48] and Im, Pesaran and Shin's [44].

Consider following autoregressive process for panel data:

$$y_{it} = \delta_i y_{it-1} + x'_{it}\beta_i + \varepsilon_{it} \qquad i = 1, ..., N; \quad t = 1, ..., T \tag{2.45}$$

where x_{it} represent the exogenous variables including any fixed effects or individual trends, δ_i are the autoregressive coefficients and ε_{it} are assumed to be mutually independent idiosyncratic disturbances. If $|\delta_i| < 1$, y_{it} is said to be weakly (trend-) stationary and if $\delta_i = 1$, y_{it} contains a unit root.

There are two natural assumptions that can be made about the δ_i. One can assume that the persistence parameters are common across cross-sections so that $\delta_i = \delta$ for all *i*. The Levin,Lin and Chu's (LLC), Breitung's t-stat and Hadri's tests all employ this assumption. One can allow δ_i to vary across cross-sections. The Im, Pesaran and Shin's (IPS), Fisher-ADF and Fisher-PP[8] tests are of this form.

2.4.1 Tests with common unit root process

The basic assumption for these kind of tests is that δ_i is identical across cross-section so that $\delta_i = \delta$ for all *i*. LLC and Breitung consider the following basic ADF specification:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{d_i} \varphi_{ij} \Delta y_{it-j} + x_{it}^{'} \beta_i + \varepsilon_{it} \qquad i = 1,..., N; \quad t = 1,..., T \qquad (2.46)$$

where a common α is assumed to be $\alpha = \delta - 1$ and allow the lag order for the difference terms, d_i, to vary across cross-sections. The null and alternative hypotheses for the tests can be written as:

- H_0: $\alpha = 0$
- H_1: $\alpha < 0$ (2.47)

Under the null hypothesis, there is a unit root, while under the alternative, there is no unit root. Hadri's unit root test uses the null hypothesis of no unit root.

2.4.1.1 Levin, Lin and Chu

The LLC method derives estimates of α from proxies for Δy_{it} and y_{it} that are standardized and free autocorrelations and deterministic components. Consider $\Delta \overline{y}_{it}$ and $\overline{y}_{it}$ defined by taking Δy_{it}, y_{it-1} and removing the autocorrelations and deterministic components using two sets of auxiliary estimates $(\hat{\varphi}, \hat{\beta})$ and $(\tilde{\varphi}, \tilde{\beta})$[9]:

[8] ADF – Augmented Dickey-Fuller and PP – Phillips-Perron tests for unit root in the series

[9] The coefficients $(\hat{\varphi}, \hat{\beta})$ and $(\tilde{\varphi}, \tilde{\beta})$ are estimated from additional equations, regressing Δy_{it} and y_{it-1} on the lag terms Δy_{it-i} for j = 1, . . ., d_i and the exogenous variables x_{it}.

$$\Delta\bar{y}_{it} = \Delta y_{it} - \sum_{j=1}^{d_i} \hat{\varphi}_{ij}\Delta y_{it-j} - x'_{it}\hat{\beta} \tag{2.48}$$

$$\bar{y}_{it-1} = y_{it-1} - \sum_{j=1}^{d_i} \tilde{\varphi}_{ij}\Delta y_{it-j} - x'_{it}\tilde{\beta} \tag{2.49}$$

The proxies can be obtained by standardizing (2.48) and (2.49), dividing by the regression standard error:

$$\Delta y^*_{it} = \frac{\Delta\bar{y}_{it}}{s_i} \tag{2.50}$$

$$y^*_{it-1} = \frac{\bar{y}_{it-1}}{s_i} \tag{2.51}$$

where s_i are the estimated standard errors from estimating each ADF in (2.46). An estimate of the coefficient α can be obtained from the pooled proxy equation

$$\Delta y^*_{it} = \alpha y^*_{it-1} + \eta_{it} \tag{2.51}$$

LLC shows that under the null hypothesis, a modified t-statistics for the resulting α^* is asymptotically normally distributed[10].

2.4.2 Tests with individual unit root processes

The tests are characterized by the combining of individual unit root tests to derive a panel-specific result.

[10] That means, the modified t-statistics $t^*_\alpha = \dfrac{t_\alpha - (NT^*)S_N\sigma^{*-2}se(\alpha^*)\mu_{m\bar{T}^*}}{\sigma_{m\bar{T}^*}} \to N(0,1)$, where t_α is the standard t-statistics for $\alpha^*=0$, σ^{*2} is the estimated variance of the error term η, se(α^*) is the standard error of α^* and $T^* = T - \dfrac{\sum_i d_i}{N} - 1$. The average standard deviation S_N is defined as the mean of the ratios of the long-run standard deviation to the innovation standard deviation for each individual. and μ_{mT^*} and σ_{mT^*} are adjustment terms for the mean and standard deviation.

2.4.2.1 Im-Pesaran and Shin

Im-Pesaran-Shin's unit root test estimates the t-test for unit root in heterogeneous panels and it allows for individual effects, time trends and common time effects. By considering a separate ADF regression for each cross-section (2.46), the null and alternative hypotheses can be written as:

- H_0: $\alpha_i = 0$, for all i
- H_1: $\begin{cases} \alpha_i = 0, \text{ for } i = 1, 2, \ldots, N_1 \\ \alpha_i < 0, \text{ for } i = N_1+1, N_1+2, \ldots, N \end{cases}$ (2.52)

where i may to be reordered as necessary. This can be interpreted as non-zero fraction of the individual process in stationary. IPS is based on the mean of the individual Dickey-Fuller t-statistics of each unit in the panel. Lags of the dependent variable may be introduced to allow for serial correlation in the errors. After estimating the separate ADF regressions, the average of the t-statistics for α_i from the individual ADF regressions, $t_{iTi}(d_i)$

$$t_{NT} = \frac{\left(\sum_{i=1}^{N} t_{iT_i}(d_i)\right)}{N} \tag{2.53}$$

is then adjusted to arrive at the desired test statistics[11].

[11] In the general case where the lag order in (2.46) may be non-zero for some cross-sections, IPS shoe that a properly standardized t_{NT} has an asymptotic standard normal distribution $W_{t_{NT}} = \dfrac{\sqrt{N}\left(t_{NT} - N^{-1}\sum_{i=1}^{N} E(t_{iT}(d_i))\right)}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(t_{iT}(d_i))}} \rightarrow N(0,1)$.The expressions for the expected mean $E(t_{iT}(d_i))$ and variance $Var(t_{iT}(d_i))$ of the ADF regression t-statistics are provided by IPS for various values of T and d.

2.5 Bootstrapping

2.5.1 Introduction

The technique of bootstrapping which was developed by Efron [29] has been the subject of much research in statistics. The results of this research are concatenated in books and journals for example in by Beran and Ducharme [19], Davison and Hinkley [27], Efron and Tibshirani [30], Horowitz [42], Maddala and Jeong [52], Mammen [53], Vinod [67] and many others, who provide reviews with an econometric orientation.

2.5.2 The bootstrap method

Typical assumptions underlying traditional panel data models are absence of serial error correlation and homoscedasticity over the time and cross section dimension. For extend applications of panel models, however, (neglected) dynamic features might show up in autocorrelated error terms. Neglecting such forms of heterogeneity may invalidate conclusions obtained under a modelling method. Deriving first order asymptotic approximations is often cumbersome in presence of nuisance parameters. Under such circumstances bootstrap approaches are in widespread use to obtain robust critical values for a particular test statistic. The estimates of mean and standard deviation can be calculated by using of many different methods, but the unknown of the sampling distribution causes the difficultness. Bootstrapping, which is characterized by many repetitions of the regression with randomly selected subsamples, estimates the asymptotic distribution of samples (the sample mean and the sample variance) and the confidence interval for the mean by using the data. Each bootstrap subsample is a simple random sample selected with replacement from the original observations. According to this fact, some of the original observations are repeated more than once in bootstrap subsample and others are omitted from an individual bootstrap subsample.

The technique of bootstrapping which is based on resampling observations from the data is used to estimate the sample mean and sample variance of computed estimations of regression. When we consider simple regression in form

$$y_{it} = \alpha + x_{it}^{'}\beta + u_{it} \qquad i = 1,\ldots,N; \quad t = 1,\ldots,T \tag{2.54}$$

$$u_{it} = \mu_i + \nu_{it} \qquad (2.55)$$

where the *i* subscript denotes the cross-section dimension and *t* denotes the time-series dimension. α is a scalar, β is K x 1 and x_{it} is the *it*-th observation on K explanatory variables, with one-way error component model for the disturbances, where μ_i denotes the unobservable individual specific effect which is time-invariant for any individual-specific effect that is not included in the regression and ν_{it} denotes the reminder disturbances. In vector form (2.54) can be written as

$$y = \alpha\iota_{NT} + X\beta + u = Z\delta + u \qquad (2.56)$$

where y is NT x 1, X is NT x K, Z = [ι_{NT}, x], δ' = (α' , β') and ι_{NT} is a vector of ones of dimension NT.

If we derive an estimate $\hat{\delta}$ from Z in regression (2.56), we can derive a bootstrap estimate of its precision by generating a sequence of bootstrap estimators. Bootstrap takes M ≤ N random observations of (y, Z) to derive an estimate of regression of these M random observations. Let us denote this estimate by $\hat{\delta}_1$. Bootstrap makes many replications (say R) of regression with M random observations and generates a sequence of bootstrap estimators ($\hat{\delta}_1, \hat{\delta}_2, ..., \hat{\delta}_R$). The sample mean of coefficient δ is then

$$E[\delta] = \hat{\delta} = \frac{\hat{\delta}_1 + \hat{\delta}_2 + ... + \hat{\delta}_R}{R} \qquad (2.57)$$

and estimated asymptotic sample variance may be computed from the sequence of bootstrap estimates and the original estimator as follows

$$Var[\delta] = \frac{\sum_{r=1}^{R} (\hat{\delta}_r - \hat{\delta})(\hat{\delta}_r - \hat{\delta})'}{R} \qquad (2.53)$$

where the formula is written to allow $\hat{\delta}$ to be a vector of estimated parameters. The square root of variance Var[δ] is known as the bootstrap standard errors of $\hat{\delta}$.

Relevant number of replications, which are generally adequate for estimates of standard error and thus adequate for fixed effect and Hausman-Taylor estimators approximation confidence intervals is between 50 and 250.

2.5.2.1 The bootstrap method used by STATA 9

The conditions depend on the method which is used in econometric software where the bootstrap is made. We use STATA 9, where the bootstrap method chooses randomly the subsample from the whole sample with iteration. That means one observation can be occurred more than once, so it has a reason to use the same dimension of subsample as the dimension of whole sample. Various options that we use to compare the results are:

<u>mse:</u> We use this option, which indicates that bootstrap compute the variance using deviations of the replicates from the observed value of the statistics based on the entire dataset. By default, bootstrap in STATA 9 computes the variance using deviations from the average of the replicates.[12]

<u>strata:</u> We use this bootstrap command in a half of all bootstraps regressions to make a comparison if it is relevant or not to use it in our data. If this option is specified, bootstrap samples are taken independently within each stratum. As we have dynamic panel data model, we use time and home country as stratum.

[12] In STATA 9 option “bca“ requests that bootstrap estimate the acceleration of each statistics in exp_list and this estimate is used to construct BCa confidence intervals.

Chapter 3

The Gravity Models

3.1 Introduction

Gravity models of foreign trade are advanced from simple gravity model begin with Newton's Law for the gravitational force between two objects i and j:

$$GF_{ij} = \frac{M_i M_j}{D_{ij}} \qquad i \neq j \tag{3.1}$$

where GF denotes force of gravity, M_i and M_j are the masses of the objects and D_{ij} is the distance between M_i and M_j. In general, the gravity models are estimated in terms of natural logarithms, so (3.1) can be written as

$$\ln GF_{ij} = \ln M_i + \ln M_j - \ln D_{ij} \qquad i \neq j \tag{3.2}$$

In trade, the force of gravity is replaced with the value of bilateral trade and the masses M_i and M_j with GDP of home and trade partner's country.

3.2 Theory of gravity models

Gravity model as a tool of explaining the bilateral trade are first applied to foreign trade by Tinbergen [66], Poyhonen [62] and Linnemann [49] who devise that the trade volume could be estimated as an increasing function of the national incomes of the trading partners and a decreasing function of the distance between them. Early general gravity equations are in form

$$\ln M_{ij} = \alpha_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \gamma_1 \ln P_i + \gamma_2 \ln P_j + \delta \ln D_{ij} + u_{ij} \qquad (3.3)$$

where M_{ij} denotes the import from country *i* to *j*, Y_x and P_x denote the aggregate income and the population of country x = *i, j* and D_{ij} is the geographical distance between *i* and *j*. In empirical studies the coefficients β_1 and β_2 are expected to be positive, while γ_1, γ_2 and δ are expected to be negative. The equation (3.3) suggests that the gravity equation was developed for cross-sectional analysis, which is very likely to suffer from omitted variable bias because of the unobserved country specific effects and since it completely neglects the temporal aspects and dynamics of foreign trade, which is the main reason for preferring panel data analysis.

The first basic assumption is that, the trade flows in several countries are estimated as a function of demand and supply in partner countries, transporting and transaction costs and integration effects in specific time period. Baldwin [11] and Hamilton and Winters [39] present the first applications of this approach. Anderson [6] is the first, who applies utility function[13] to derive more sophisticated model. He remarks that the disequilibrium of balance-of-payments may appear in the regression's residuals, which in case of theirs correlation with any of the regressors, may lead to biased estimates. Deardorff [28] and Bergstrand [20] apply CES utility function to generalize the gravity model by introducing prices. Another important contribution is made by Helpman [41] and Krugman [47] who derive the gravity model under the assumption of increasing returns to scale in production. Following this path, Evenett and Keller [33] derive gravity model under perfect and imperfect product specialization. Although Deardorff [28] is quite critical about the application of gravity equation for the justification of any of the trade theories that an empirical model, which can be derived from any of the conflicting theories, is not the right tool of the selection among them, it still remains an important tool for

[13] He applies Cobb-Douglas and also Constant Elasticity of Substitution (CES – see in Appendix D)

foreign trade modeling because of its convenience, empirical success and high degree of flexibility.

Anderson and van Wincoop [7] show that all prices appearing in Bergstrand's derivation[14] can be summarized by just two price indices – one for exporter and one for importer.

3.2.1 Anderson and van Wincoop

Anderson and van Wincoop [7] derive theoretically consistent gravity model from the earlier models applied by Anderson [6] and Deardorff [28], which contain complicated export price index term in denominator. They consider that all goods are differentiated by place of origin and following Deardorff [28] they assume that each region is specialized in the production of only one good and the supply of each good is fixed. They assume CES utility function, which approximated the identical, homothetic preferences.

If c_{ij} denotes the consumption by region j consumers of goods from region i, consumers in region j maximize

$$\left(\sum_i \psi_i^{\frac{1}{\sigma}} c_{ij}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{3.5}$$

subject to the budget constraint

$$\sum_i p_{ij} c_{ij} = y_j \tag{3.6}$$

where σ denotes the elasticity of substitution between all goods, ψ_i is a positive distribution parameter, y_j denotes the nominal income of region j residents and p_{ij} denotes the price of region i goods from region j consumers. Prices differ between locations due to trade costs that are not directly observable so let p_i denote the exporter's supply price, net of trade costs and t_{ij} denote the trade cost factor between i and j, then $p_{ij} = p_i t_{ij}$.

[14] Bergstrand [20] argues that gravity equation can be derived from general equilibrium model, where the exporters' and importers' incomes are excluded, only if several assumptions are made. The assumptions are summarized in Appendix E.

Anderson and van Wincoop [7] assume that for each good shipped from *i* to *j*, the exporter incurs export costs equal to $t_{ij} - 1$ of country *i* goods and the exporter passes on these trade costs to the importer. If the nominal value of exports from *i* to *j* is $x_{ij} = p_{ij}c_{ij}$, where $p_{ij}c_{ij}$ is the sum of the value of production at the origin and $(t_{ij} - 1)\, p_i c_{ij}$ are the trade costs that the exporter passes on to the importer, then total income of region *i* is $y_i = \sum_j x_{ij}$ .Then the nominal demand for region *i* goods by region *j* consumers satisfying maximization of (3.5) subject to (3.6) is

$$x_{ij} = y_j \left(\frac{\psi_i p_i t_{ij}}{P_j} \right)^{(1-\sigma)} \tag{3.7}$$

where P_j denotes the consumer price index of *j*, given by

$$P_j = \left[\sum_i (\psi_i p_i t_{ij})^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{3.8}$$

Anderson and van Wincoop [7] refer to this price as multilateral trade resistance as it depends positively on trade barriers with all trading partners. Market clearance implies, that

$$y_i = \sum_j x_{ij} = \sum_j y_j \left(\frac{\psi_i t_{ij} p_i}{P_j} \right)^{1-\sigma}; \quad \forall i . \tag{3.9}$$

Under symmetry of the trade barriers, that is $t_{ij} = t_{ji}$, which Anderson and van Wincoop [7] assume, it can be shown that the implicit solution to

$$\psi_j p_i P_j = \theta_i^{\frac{1}{1-\sigma}} \tag{3.10}$$

with the *i*-th region's share in the world income $\theta_i = \frac{y_i}{y^w}$, is a solution to (3.8) and (3.9). An implicit normalization is imposed, because (3.10) is solved not only for relative prices, but also for absolute prices.

Substituting (3.10) into the export demand system (3.7) and price indexes as a function of trade barriers (3.8) yields the Anderson and van Wincoop's gravity model:

$$x_{ij} = \frac{y_i y_j}{y^w}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma} \tag{3.11}$$

$$P_j^{1-\sigma} = \sum_i P_i^{\sigma-1}\theta_i t_{ij}^{1-\sigma}; \qquad \forall j \tag{3.12}$$

$$P_i^{1-\sigma} = \sum_j P_j^{\sigma-1}\theta_j t_{ij}^{1-\sigma}; \qquad \forall i. \tag{3.13}$$

This gravity model shows that bilateral trade depends on relative trade barriers, that means the bilateral barrier t_{ij} divided by multilateral resistance variables P_i and P_j, which are related to average trade barriers of the exporter and importer with all their trading partners.

3.2.2 Baldwin's medal mistakes

Baldwin and Taglioni [13] identify three common errors, which can be often seen in literature on gravity models. Discussing the earlier models by Rose [63], Anderson and van Wincoop [7] and others, Baldwin and Taglioni [13] illustrate the biases caused by these errors.

Gold-medal error

Many researchers omit the multilateral resistance factor. Following Rose and van Wincoop [64] and other authors, Baldwin and Taglioni [13] propose country dummies in cross-section data and country-pair FE in panel data to solve this mistake. However, country-pair dummies are time-invariant and consequently can only in part resolve the error, because serial correlation remains. In some applications, country-specific time dummies can be added to the estimations. It should be added that pair dummies capture all fixed variables, e.g. including distance, making it impossible to distinguish among parameters of various time-invariant variables. The inclusion of lagged trade is similar to the inclusion of country-specific time dummies. Thus, our approach is not subject to this source of bias.

Silver-medal error

Many authors work with averaged bilaterally trade instead of direction-specific trade as the theory asserts, that the gravity models holds for each and every uni-directional trade flow. In their approach, gravity equation is derived from a modified CES expenditure function, it is naturally multiplicative, that means the averaging of two trade flows should be geometric (the sum of the logs), but most authors take the arithmetic average (log of the sums). Baldwin and Taglioni [13] evaluate this bias in case of Rose [63] and any other authors' specification. As far as we estimate dynamic panel models separately for exports and imports, our approach is not biased by the inappropriate aggregation of export and import data.

Bronze-medal error

The use of real trade flows instead of nominal values of trade causes another common mistake, which is done in the majority of studies. Since there are global trends in inflation rates, the inclusion of this term probably creates biases via spurious correlations. Rose [63] and other papers offset this error by including time dummies. Since bilateral trade flows are divided by the same price index, the time dummies correct the false deflation procedure. We reflect also this remark of the authors and use nominal variables for our estimations.

3.3 Double index gravity panel data model of trade

Double index-based panel data specification in which case explanatory variables are expressed as a combination of characteristics of trading partners have been applied for example by Glink and Rose [37]. The double indexed gravity model is used also per country *i* and *j* by Matyas [54]. The double index panel data model can be written as

$$y_{it} = x_{it}^{'}\beta + z_{i}^{'}\gamma + \mu_i + \lambda_t + \upsilon_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{3.14}$$

where an index *i* represents each country-pair. The variables x_{it} embrace explanatory variables with variation in the country-pair (from one to another country[15]) and time dimension and variables that vary only with one partner of trade and time, respectively, z_i variables denote time invariant regressors.

[15] Triple index version of the gravity model is in Appendix C.

The fixed effect model along with Hausman-Taylor is the most commonly used estimation technique in the analysis of gravity model of foreign trade, because they deal with unobserved heterogeneous individual effects and its correlation with both time-varying and time-invariant regressors to avoid any potential bias.

Chapter 4

The EU enlargement implications on the new Member States' agro-food trade

4.1 Short general agriculture review

Agriculture in the new Member States is characterising by larger diversification of natural and economic conditions. Small private farms have always characterised the agricultural sector in Poland and Slovenia. By contrast, large co-operative or joint stock holdings (successors to previous collective farms), dominate farm structure in the Czech Republic and particularly in Slovakia. In the Baltic States, Romania and to lesser degree in Bulgaria and Hungary many new private farms have been established.

The 2005 agricultural year was marked by a slight decrease in crop production and production of livestock products, combined with favorable prices for livestock products and lower prices for crops. Input prices were substantially higher in 2005 in most Member States mainly due to increased prices for energy and fertilizers. However, price developments were highly variable across sectors and countries. The first estimates sent by Member States show a sharp decline in agricultural income by – 6.3% in real terms as compared to 2004 in the European Union as a whole1. Agricultural income dropped by – 6.6% in the old Member States and by – 3.8% in the new Member States. The actual range by country varied from – 19.3% for Hungary to +25.9% for Lithuania.[16]

4.1.1 Agriculture review of selected countries

Bulgaria

Agriculture has become an important sector within the Bulgarian economy. After the financial crisis of 1996, agriculture was the only sector that grew.

There are various reasons for the important decline in the agricultural output in the post-reform period. Since price liberalisation, agricultural producers have been affected by a large increase in input prices, a reduced demand, and by a government intervention aimed at slowing down the increase of consumer prices of the main foods and at ensuring food security by limiting exports. In addition, serious policy mismanagement during 1995 and 1996 and poor weather conditions gave rise to a grain shortage in those years with very negative effects for the agricultural sector and the food industry. The decline in production was accompanied by a drop in domestic demand and a change in consumption patterns, mainly from animal products to cereals, due to the general loss of purchasing power and the high share of incomes spent on food.

The main exported commodities are tobacco, wine, processed fruit and vegetables and animal products (mainly dairy products). In 1997 the main imported commodities were sugar and cereals. OECD countries import about 32% of the Bulgarian agricultural exports and the EU import about 23%. Trade with the EU has significantly developed. Like other CECs, Bulgaria signed an Association Agreement with the EU in late 1993 in order to benefit from trade with western markets.

Bulgaria is a GATT[17] and WTO[18] contracting party since 1997. It has also become a CEFTA[19] member on 17 July 1998.

[16] The source see [69]

[17] GATT - The General Agreement on Tariffs and Trade was the outcome of the failure of negotiating governments to create the International Trade Organization (ITO). GATT was formed in 1947 and lasted until 1994, when it was replaced by the World Trade Organization.

Czech Republic

In volume terms agricultural output has dipped further in 1997 according to the latest estimates. After a certain stabilisation in 1995 and 1996 it reached its lowest point of the pre-transition level, in particular due to a further drop in livestock production, which has been most affected and stood. Crop output seems to have stabilised in recent years, after hitting a low in 1994.

In addition to the reduction in quantities produced agriculture has suffered from a worsening terms of trade. Input prices have tended to increase faster than producer prices, increasing the cost-price squeeze and leading to a negative income situation for the agricultural sector.

While agro-food exports have stagnated, imports have continued to rise in recent years, leading to a rapidly increasing deficit, the largest part of which is with the EU. The EU is the Czech Republic's biggest trading partner with a share in Czech imports of around 50% and in Czech exports of around 35%, although with a declining tendency for both in the last three years.

The main import items are (tropical) fruit and animal feed, while the main export items are dairy products, beverages and oilseeds.

Latvia

Following liberalisation, trade patterns changed dramatically. Over the 5 years, Latvia changed from a net-exporter of agricultural commodities to net-importer, while the share of agricultural trade in total trade is still significant.

Agricultural exports and imports in 1997 increased as compared to 1996. The rise in imports of food products gathered momentum in 1995, notably for products such as fruit, sugar, tropical beverages and cocoa. By the end 1997, it was estimated that grain imports, which had in the past accounted for one quarter of total agro-food imports, had fallen to around 3,7% of the total value. The main imports were alcoholic beverages, juices and mineral water, fish, sugar, and fruit and vegetables. Traditional export commodities like meat and live animals reached a remarkable share of 5%.

As far as imports of agricultural and food products are concerned, the Member States of the European Union have become the largest partners. In 1997, the EU share in Latvian agricultural imports accounted for 53%. The CEECs have

[18] WTO - The World Trade Organization is an international organization designed to supervise and liberalize international trade. The WTO came into being on 1 January 1995, and is the successor to the General Agreement on Tariffs and Trade and continued to operate for almost five decades as a de facto international organization.

[19] CEFTA - The Central European Free Trade Agreement is a trade agreement between Non-EU countries in Central and South-Eastern Europe.

become the second ranking source of agricultural imports. Showing high fluctuations in recent years, their share more than doubled between 1990 and 1997.

Lithuania

In the pre-reform period, agriculture and food production were the second largest sectors of the Lithuanian economy. This share fell dramatically during the transition period. In 1995, however, the decline in production was reversed, and the upward trend in agricultural output continued in 1996. Such a significant growth in agricultural output has to be solely attributed to the good improvement in crop production. Livestock sector output continued to decline slightly mainly due to meat production decline.

Imports of food products have been growing rapidly. These are mainly high value-added products. Livestock products in general and meat and milk products in particular, are still the largest components of agro-food exports. The principal source of imports over the last years has been Europe, and this increased from 53% in 1993 to around 65% in each of the last years. A close third and gaining in import share are the other CECs.

Romania

Romanian agriculture has undergone at least three dramatic changes over the last 100 years, nearly one per generation. As in most CECs, the share of livestock in agricultural output fell over the same period.

The regional breakdown of agro-food trade flows shows that the most important market for Romanian exports is the EU with 55%. On the import side, the EU is the major trading partner. Surprisingly, the CECs are at present minor economic partners.

The structure of agro-food trade is dominated by foodstuffs and beverages, which are mainly responsible for the agro-food deficit, while the trade balance for animal products has been consistently positive since 1993. The improvement in the agricultural trade balance is almost exclusively due to cereals, which returned to achieving a positive balance in 1995.

Slovakia

The strong recovery of the general economy led to an overall decrease in the importance of agriculture in the general economy. The low importance also reflects the industry- and service-oriented character of Slovakia’s economy.

The bottleneck of economic recovery in the Slovak agro-food sector is the low competitiveness of the food-industry and the absence of efficient marketing structures in the downstream-sector.

The present level of border protection in the Slovak Republic is based on GATT commitments, in which Slovakia agreed on a relatively low level of protection for agriculture. This also influenced the arrangements of subsequent trade agreements as with the EU and CEFTA. However, the sectors, which at present suffer the greatest backlog in restructuring such as beef, pork and dairy, enjoy rather high border protection.

Slovakia is traditionally a net importer of agricultural products. Agro-food imports have about twice the value of Slovak exports. Both imports and exports of agro-food commodities increased since 1994. Whereas the overall value of agro-food trade is rising, its relative share on all trade of the economy is decline, which is in line with the decline in relative importance of agriculture in economy.

The most important trade partner both for imports and exports remained the Czech Republic. The second most important trade partner is the EU, which is like the Czech Republic a net exporter of agro-food products to Slovakia. Within the CEFTA trade (excluding the CR) Slovakia has a net exporter position.

The biggest share of agro-food imports embraced commodities which can not be produced in Slovakia. The second predominant group comprised commodities, which can compete with domestic primary production as dairy products, meat, cereals, sugar and bakery products. In the third group are commodities such as coffee, alcoholic beverages, cocoa and cigarettes. Slovak exports are based on live animals, dairy products, confectionery and bakery products and beverages. Cereal exports are rather volatile.

Slovenia

The apparent economic importance of Slovenian agriculture is low – and tending to decline. The relative share of crops and livestock in agricultural output has not changed substantially. Although agriculture is declining in macro-economic terms, during the first years of independence it played and continues to play an important role in maintaining social and territorial equilibrium.

The regional breakdown of the agro-food trade flows shows that the most important markets for Slovenian export are the EU and the republics of former Yugoslavia. On the import side, the EU is the major trading partner with CEFTA countries. The structure of agro-food exports is dominated by processed products, mainly meat and meat preparations, beverages and dairy products. Imports are mainly of unprocessed products: fruit and vegetables, cereals, sugar.

Chapter 5

Application on trade analysis

5.1 Data description

We use a unique database collected for the TradeAG[20] project of bilateral agro-food trade flows of Bulgaria, Czech Republic, Latvia, Lithuania, Romania, Slovakia, and Slovenia with the EU15, the new Member States in Central and Eastern Europe (Bulgaria, Czech Republic, Poland, Hungary, Latvia, Lithuania, Estonia, Romania, Slovakia, Slovenia), the Commonwealth of Independent States as a total (CIS), the USA and with the rest of the world (all other countries).

Our database includes quarterly data (1996-2005) for exports and imports of the following agro-food commodities[21]: Meat of bovine animals (HS 0201-0202), Meat of swine (HS 0203), Meat of poultry (HS 0207), Meat total (HS 0201-0210), Milk and cream (HS 0401-0402), Cheese and curd (HS 0406), Milk and diary total (HS 0401-0406), Cereals without rise (HS 1001-1005+1007-1008), Oilseeds (HS 1201-1207), Sugar (HS 1701-1702), and finally the total agricultural import and export (see Figure 2), which is also divided in two parts – HS 01-14, HS 15-24. All trade flows were available both in its nominal value (Euro) and physical units

[20] Agriculture TRADE Agreements, see http://www.tradeag.eu/

[21] HS – The Harmonized System Codes, HS 01-14 – animals and vegetables, HS 15-24 – animal and vegetable fat, oils, waxes and foodstuffs.

(kilograms). This allows us to compute trade prices (see Figure 1) and terms of trade for all commodities and partner countries.

Figure 1: Import and export prices per kilogram

The data set for the reporting countries includes also annual trade flow data for Hungary, Estonia, and Poland, which were not used for the estimations. Nevertheless, we used these data for comparison of the overall development, which do not show any significant deviation of these three countries pattern from the pattern of countries with available quarterly data.

Figure 2: Total agro-food import and export trade flows in millions Euro

In addition, we use income data for the individual reporting and partner countries. The time series for the gross domestic product (GDP) are influenced by seasonality, so we work with seasonally adjustment data using the U.S. Census Bureau's X12 ARIMA procedure. We use also the consumer price index either in the home or in the partner countries (CPI). Furthermore, we include seasonal variables and a dummy variable for the membership in the EU (which equals 1 if the both reporting and partner countries are member states of the EU and 0 otherwise). In our data set, this variable shows mainly the effects of the EU enlargement in May 2004, because we do not have trade flows between the earlier member states.

In our sensitivity analysis, we control also for outliers. Following Burstaller and Landesmann [23], we drop all observations deviated more than a specific margin from the long-term trend. As far as the results did not change, we present only non-adjusted results here.

We test if the data are stationary, although non-stationary data is not problem in case of panel data model, because the data are cointegrated. We use several tests to make panel unit root test, which results are in Tables 11a and 11b in Annex. We find out, that all the data are stationary except the GDP. According to tests results we cannot reject the null hypothesis that the data are stationary. In case of GDP, we do not reject the null hypothesis of unit root and test, that GDP is integrated of 1^{st} order (GDP is I(1) process). For export's and import's prices of Milk and curd (pmilkcr) and Total milk (pmilkt), two tests[22] do not reject the null hypothesis of unit root, but three another does. The GMM method has no problem with stationarity of the data, because used the differences of regressors.

5.2 Models of trade

In general, two approaches dominate the applied trade analysis. First, aggregate or more or less disaggregate trade flows of individual countries are related to the income of export markets and price (competitiveness). Baldwin, Francois and Portes [12] presented a computable general equilibrium model (CGEM) analyzing the Eastern enlargement of the EU. The advantage of CGEM approach is that it includes relatively detailed sectoral information of the analyzed economies.

Besides few models of the world economy (see e.g. Neck, Haber and MacKibbin [57]), foreign trade development enters the model on the assumptions level. These assumptions of trade effects are often based on gravity models, which estimate trade flows of several countries in specific time period as a function of demand and supply in partner countries, transporting and transaction costs and integration effects (e.g. membership in EU). These models were used in analyses of the Eastern European countries trade. Hamilton and Winters [39] and Baldwin [11] presented the first applications of this approach. Bussière, Fidrmuc,

[22] Levin, Lin and Chu's and Im, Pesaran and Shin's tests do not reject the null hypothesis of unit root.

and Schnatz [24] presented the statement of literature and analysis of accession of the new Member States to the EU.

The disadvantage of the gravity models is however, that they include usually a detailed geographic structure (high number of reporting and partner countries) but only aggregate trade flows. Thus, these analyses do not provide information on the integration effects by economic sectors. Nevertheless, some authors use these models also for analysis of the integration effects in selected sectors, usually using a shorter cross-country dimension. Brenton and Di Mauro [21] and Fidrmuc, Huber and Michalek [35] use gravity models for sensitive commodities including several agro-food products. Olper and Raimondi [59] estimate gravity model for the agro-food trade.

Reflecting the properties of our data set, we combine both approaches used in the literature. We consider both country and product specific variables and overall macroeconomic data in our estimations. Following standard demand equation, we consider the overall income and the relative prices (product price related to the overall price level) as the major determinants of trade in specific commodities with selected countries. Because we have only short time series, we use also the cross-sectional dimension, which is however smaller than in typical gravity models. This approach can be expressed in log-linear form[23] as

$$m_{it} = \alpha_i + \theta_t + \rho m_{it-1} + \beta_1 y_t^{home} - \beta_2 (e_t p_{it}^m - cpi_t^{home}) + \gamma EU + \varepsilon_{it}^m \tag{5.1}$$

$$x_{it} = \alpha_i + \theta_t + \rho x_{it-1} + \beta_1 y_{it} - \beta_2 (p_{it}^x - cpi_{it}) + \gamma EU + \varepsilon_{it}^x \tag{5.2}$$

where α denotes fixed effects, θ time effects, m import and x export of a particular commodity and countries i at the time t, y denotes income – GDP in home country (y_{home}) and in partner countries (y_i), p denotes the price of product (price is calculated as division between agro-food trade by value in Euro and trade by quantity in kg), e stands for the exchange rate (home currency per 1 Euro). Variable cpi denotes the consumer price index either in the home or in the partner countries, dummy variable EU denotes the membership in the EU (which equals 1 if the both reporting and partner countries are member states of the EU and 0 otherwise) and we included also seasonal variables (*seas*2, *seas*3, *seas*4).

Thus, the model stated by equations (6.1) and (6.2) is a dynamic version of gravity models, where the domestic supply factors are fully covered by the time

[23] To know the short version for Slovakia, see Bartošová, Bartová and Fidrmuc [16], short version for accession countries is available in Bartošová, Bartová and Fidrmuc [17], Bartošová, Bartová and Fidrmuc [18].

effects θ. In addition, this model includes the elements of a standard demand function (relative price effects). The comparison of effects for particular agro-food commodities is also a new contribution in trade models. We present the estimates for ten broad agro-food commodities and for the aggregate of the agro-food trade.

Equations (6.1) and (6.2) present model with fixed effects α_i, which we use as our basic specification. The least square method estimation of model can be biased, because fixed effects, which are part of dependent variable (m_{it} and x_{it}) as well as of the lagged dependent variable ($m_{it\text{-}1}$ a $x_{it\text{-}1}$) on the right side of equation, cause an autocorrelation of dependent variable. Baltagi [15] presents that bias is strong, if the cross-sectional dimension (number of countries) is relatively high and time dimension (number of observations for individual countries) is low. Because in our database the cross-sectional dimension is relatively small (11 countries or groups) and time dimension is relatively long (40 observations), the bias range should be rather limited.

To use Hausman-Taylor method we have to specify special exogenous variable, namely distance (D) as time invariant variable, which value is the distance between the capital cities of the country-pair. We also define time invariant endogenous dummy variable border (B) denotes the neighbourhood of countries (which equals 1 if the reporting and partner countries are neighbouring and 0 otherwise, in the case of neighbouring with EU15 equals 1 if reporting country is in neighbourhood with at least one of the countries of the EU15). The seasonal variables (*seas*2, *seas*3, *seas*4) we also defined as time variant exogenous variables. Thus the model can be written in form:

$$m_{it} = \alpha_i + \theta_t + \rho m_{it-1} + \beta_1 y_t^{home} - \beta_2 (e_t p_{it}^m - cpi_t^{home}) + \gamma EU + \varphi B + \phi D + \varepsilon_{it}^m \quad (5.3)$$

$$x_{it} = \alpha_i + \theta_t + \rho x_{it-1} + \beta_1 y_{it} - \beta_2 (p_{it}^x - cpi_{it}) + \gamma EU + \varphi B + \phi D + \varepsilon_{it}^x \quad (5.4)$$

Arellano and Bond [4] and Arellano and Bover [5] propose an alternative approach. By differentiation of equations (6.1) and (6.2) we eliminate fixed effects from the estimated equation. The estimation equation can be expressed as

$$\Delta m_{it} = \rho \Delta m_{it-1} + \beta_1 \Delta y_t^{home} - \beta_2 (\Delta p_{it}^m - \Delta cpi_t^{home}) + \gamma EU + \Delta \varepsilon_{it}^m \quad (5.5)$$

$$\Delta x_{it} = \rho \Delta x_{it-1} + \beta_1 \Delta y_{it} - \beta_2 (\Delta p_{it}^x - \Delta cpi_{it}) + \gamma EU + \Delta \varepsilon_{it}^x \quad (5.6)$$

However, this data transformation causes autocorrelation of transformed errors. Therefore, Arellano and Bond propose the estimation method based on generalized method of moments (GMM), where the lagged dependent and independent variables are used as instrumental variables. This method is recommended for data with relatively large cross-sectional dimension and relatively small number of observations. This method is however, less applicable for our data set and mainly is used to analyze the stability of the results.

We compare all three estimation methods of dynamic panel model. The inclusion of dynamic effects in trade flows was discussed by Bun and Klaassen [22]. The dynamic effects allow us to differ between short-run and long-run integration effects. The structure of autoregressive part of model has been selected on the base of information criteria (Akaike information criterion). In most of models the optimal lag structure includes only one lag. By the reason of comparability of the estimations, we present the first order autoregressive model for all commodities.

We make a bootstrap to our models with 50 and 250 replications, which are generally adequate for estimates of standard error and thus adequate for approximation confidence intervals. We compare the results for fixed effect and Hausman-Taylor estimators. The strata function was also used because we made a dynamic panel data model and the option of strata means that the bootstrap samples are taken independently within each stratum[24]. We compare the results of bootstrap technique with utilization of strata option with two stratums and no strata option. We prefer the bootstrap computation of the variance using deviations of the replicates from the observed value of the statistics based on the entire dataset.

5.3 Estimation Results

The core part of the demand for agro-food imports in the new Member States behaves slightly differently than the agricultural exports (see Table 1, Table 2, Table 3 and Table 4 in Annex). The income elasticities are significant only for few products. However, it seems that mainly meet and milk products depend heavily on the income development in these countries.

Similarly, price elasticities are larger (up to 1.4 for sugar) than those found on the export side. Price elasticities for meat products are again insignificant, but those for cereals are important now. On the contrary the autoregressive parameters are of similar size to those estimated for the exports.

[24] We used two strata variables, particularly time and home country, because of dynamic panel data model.

The agro-food imports, except for cereals, are significantly influenced by the past import performance. The autoregressive coefficients are usually between 0.2 and 0.6.

Finally, the EU effects are largely different for imports. We can see that only imports of the sensitive products (milk products, oilseeds, and sugar) have significant EU effects, which are only slightly larger than on the export side. This means that with the exception of sugar and oilseeds, the Eastern enlargement of the EU has had largely positive effects on the new Member States with the positive net effects. This confirms the early analysis of the EU accession effects on the agricultural sector in the new Member States by e.g. Lukas and Mládek [50]. However, the effects remain rather moderate.

However results for total agro-food imports are subject to possible aggregation bias, specific the large differences between the parameters estimated for the individual agro-food commodities. We can see that the income elasticity is low but significant in average, while the price elasticities remain relatively large.
In short brief table with selected commodities we show how the results of two dynamic panel modelling methods (fixed effect model and Hausman-Taylor model) of agrarian import are largely comparable with small differences.

Table 6.4.1: Comparison of fixed effect and Hausman-Taylor method for import:

Import	m_{it-1}		p_t		y_t		EU	
	FE	HT	FE	HT	FE	HT	FE	HT
Meat total	0.527***	0.534***	-0.155**	-0.137*	0.853***	0.926***	0.085	0.043
	(22.00)	(21.10)	(-2.20)	(-1.81)	(5.74)	(5.48)	(0.90)	(0.42)
Milk and dairy	0.406***	0.469***	-0.398***	-0.404***	0.452***	0.500***	0.306***	0.220**
total	(15.39)	(18.03)	(-5.77)	(-6.08)	(3.02)	(3.41)	(3.06)	(2.38)
Cereals	0.008	0.021	-0.727***	-0.686***	-0.288	0.437	0.617*	0.306
without rice	(0.16)	(0.39)	(-3.73)	(-3.21)	(-0.66)	(0.93)	(1.69)	(0.83)
Oilseeds	0.274***	0.312***	-0.340***	-0.375***	0.302	0.253	0.616***	0.588***
	(8.85)	(8.70)	(-3.48)	(-3.21)	(1.57)	(1.00)	(4.05)	(3.31)
Sugar	0.228***	0.242***	-1.411***	-1.518***	-0.266	-0.320	2.532***	2.518***
	(5.85)	(5.54)	(-6.80)	(-5.88)	(-0.61)	(-0.59)	(7.97)	(7.03)
Total agrarian	0.281***	0.283***	-0.674***	-0.665***	0.179**	0.218***	0.112**	0.096*
import	(16.66)	(16.02)	(-17.50)	(-16.42)	(2.56)	(2.81)	(2.40)	(1.94)

Only several export commodities of the new Member States do actually depend on the income development of their trading partners, which implies that the developed import markets are already saturated. GDP of the partner country is a significant determinant only for sugar export. This commodity have possibly partially a luxury character, which is consistent then with the other results.

Relative price level is an important determinant for the exports of nearly all agro-food commodities from the new Member States. Examples are cereals and meat products in general. The former commodity trade pattern may be possibly explained by the homogeneity of the traded products. Thus, prices may be rather an indication for different quality of the product, and do not enter the demand function directly. The latter product trade pattern may be a result of various factors, including BSE effects and the recent orientation on fresh and local products. For the remaining products, price elasticities are relatively large, ranging between one half and three quarters. The exception in commodities is cheese and curd (cheese), for which the price elasticity is positive but significant. The same results we obtain from fixed effect, Hausmal-Taylor method and also from GMM, where the coefficient is not significant, but still positive. We can suppose that cheese products are kind of luxury commodities, which demand rises in relation to price growth.

The agro-food exports are significantly influenced by the past export performance. The autoregressive coefficients are usually between 0.3 and 0.6.

Finally, we can see that the membership in the EU has large and positive effects on the majority of the export commodities. The estimated coefficients are between 0.25 (cheese) and 1.3 (sugar). After we reflect that the estimation equation is defined in logs, we get EU[25] effects between 30% and 200%.

Furthermore, the long-run effects are much larger because we have to reflect also the autoregressive parameter.[26] Some commodities, especially those with already high short-run effects (sugar) increase by 3 times in comparison the short-run effects.

We report also the results for total agro-food exports. These results however, are subject to possible aggregation bias, given the large differences between the parameters estimated for the individual agro-food commodities. Nevertheless, we can see that the income elasticity is low but significant in average, while the price elasticities remain relatively large. The EU effects are again large and statistically significant for the individual agro-food commodities.

Our analysis could be significantly biased by important country-specific effects. Therefore, we estimate all specifications for the individual reporting

[25] The EU effects are computed as exp(γ).

[26] We get the long-run effect as the sum of a geometric row, $\gamma/(1-\rho)$. This expression has then been transformed, exactly as the short-run effects, in order to discus their absolute size.

countries. While we can find some slight differences between these results, the overall picture remains the same.[27]

The results comparison of FE and HT methods of agrarian export modelling for several commodities is shown in next table.

Table 6.4.2: Comparison of fixed effect and Hausman-Taylor method for export:

Export	x_{it-1}		p_t		y_t		EU	
	FE	**HT**	**FE**	**HT**	**FE**	**HT**	**FE**	**HT**
Meat total	0.549***	0.555***	-0.092	-0.059	-0.071	0.114	0.657***	0.590***
	(18.09)	(18.59)	(-0.92)	(-0.61)	(-0.39)	(0.72)	(4.66)	(4.35)
Milk and dairy total	0.502***	0.503***	-0.149**	-0.146**	0.213	0.225*	0.425***	0.421***
	(23.38)	(23.79)	(-2.05)	(-2.05)	(1.64)	(1.76)	(4.14)	(4.17)
Cereals without rice	0.462***	0.461***	-0.518	-0.517	1.632	1.655*	-0.003	-0.007
	(5.47)	(5.57)	(-1.47)	(-1.49)	(1.63)	(1.70)	(-0.01)	(-0.01)
Oilseeds	0.294***	0.294***	-0.733***	-0.739***	0.334	0.308	0.376	0.383*
	(8.03)	(8.15)	(-4.67)	(-4.88)	(1.20)	(1.32)	(1.57)	(1.65)
Sugar	0.391***	0.392***	-0.775***	-0.789***	2.294***	2.201***	1.334***	1.356***
	(8.74)	(9.29)	(-3.78)	(-4.09)	(4.65)	(4.84)	(3.69)	(3.99)
Total agrarian export	0.400***	0.400***	-0.533***	-0.535***	0.296***	0.284***	0.232***	0.236***
	(21.24)	(21.47)	(-12.71)	(-12.89)	(3.98)	(3.93)	(4.40)	(4.51)

Finally we compare these estimations with the Arellano and Bond dynamic panel data estimator (see Table 5 and Table 6 in Annex). In general, the results are similar to the previous results, although fewer coefficients are significant. This is especially true for the EU dummy, which is significant only for the imports of swine meat. The autoregressive coefficient is also lower than in the corresponding estimations by fixed effect models with lagged variables.

Furthermore, the Sargan test of over-identifying restrictions in the homoscedastic version of the estimations (not reported here) rejects the null hypothesis that the over-identifying restrictions are valid. However, this is likely to be due to heteroscedasticity because the Sargan test over-rejects under this condition. As the heteroscedasticity is likely in our set of countries, we use only the robust estimators. In turn, the Arellano-Bond test rejects the null of no autocovariance in differenced residuals of order 2 in nearly all specifications (exceptions include the exports of various kind of meat and total agro-food

[27] The detailed country results are available upon request from authors.

exports), while the presence of the first-order autocovariance does not pose any problems for the estimations.

The results of computed mean and standard error of the estimators for particular samples are in Annex, for import regression in Tables 7a - 7d by fixed effect model, Tables 8a - 8f by Hausman-Taylor model and for export regression in Tables 9a - 9d by fixed effect model and Tables 10a - 10f by Hausman-Taylor model.

Generally, bootstrapping shows that samples *distance* and *border* for import regression are more significant for any commodities after 50 or 250 replications with and also without strata option. For example for Meat of poultry, Total agrarian import HS01-14 and Cereals without rise, against the import regression by Hausman-Taylor method. As we have small dynamic gravity panel data model with 7 countries only, the replications made our data set more extensive, so the significance of *distance* and *border* means that these two samples are important for import of the mentioned commodities. Similar results we have got for Meat of poultry and Total agrarian import for *EU*, which was more significant for bootstrap than in contrary the results from regression.

For Hausman-Taylor export regression *distance* and *border* are more significant mainly for Milk and cream and Milk and diary total, which means that for milk commodities could be *distance* and *border* more important, than our results from export regression showed us. For *EU* the bootstrap confirms the results from regression.

For the others commodities (import/export, prices and GDP) the results from bootstrapping, whether with strata option, or no strata option for 50 and 250 replications, confirmed our first results for import and export, which means that our models were suitable for modelling bilateral trade for panel of 7 countries.

Chapter 6

Conclusions

In May 2004, eight Central and Eastern European countries joined the EU and gained thus a full access to the single market. This has liberalized also trade in sensitive products. Especially the effects on the agro-food trade have been a source of concern of policy makers and agricultural producers because of wage and land cost differentials.

In this thesis we analyze trade flows of the agro-food commodities between selected countries (Bulgaria, the Czech Republic, Latvia, Lithuania, Romania, Slovakia, and Slovenia) and a broad group of trading partners (EU15, the new Member States in Central and Eastern Europe, CIS, USA and the rest of the world). Our analysis does not include Estonia, Hungary and Poland directly, because we have only annual data for them, but we include this countries as the partners of the analyzed countries.

As we have a small panel of 7 countries and short time-series, we use dynamic gravity panel data model and we use several techniques to estimate it. Firstly we use fixed effect within estimator, secondly Hausman-Taylor method and thirdly generalized method of movements by Arellano-Bond for analyzing long-run effects. We compare the results and come to the conclusion, that results from these methods are comparable.

We show that dynamic panel data models are appropriate tools for modelling of agricultural trade flows. The lagged levels of the agricultural trade are significant determinants of contemporaneous trade level, which underlines the importance of history in this market. The application of dynamic models enable us to make inference on the long-run effects of EU accession despite short time series.

In general, we find low income but high price elasticities of demand for agricultural imports. Thus, the agricultural market is already saturated and highly sensitive to price changes.

Despite many limitations behind our analysis, our results show slightly positive implications for the new Member States. We analyze possible effects of EU enlargement on agro-food trade in new Member States in this thesis. We find positive and significant EU enlargement effects especially for exports of the new Member States, which vary strongly between agricultural commodities.

Furthermore, the long-run effects are much higher (in general twice to three times higher). On the other hand the agro-food imports of the new Member States show lower growth dynamic after the Eastern enlargement of the EU. As a result, it seems that the new Member States gained significantly from the liberalization of the agricultural trade, although the effects remained rather moderate.

In our approach, we avoid the common mistakes in gravity models, as the so-called Baldwin's gold-, silver- and bronze-medal mistakes. We use dynamic panel data models, where we include the lagged trade and in addition to common determinants. The models are specified for relatively disaggregate commodity groups (exports and imports) reflecting also the panel structure of the data. The estimates are robust across different commodity groups and also with respect to estimation methods (fixed effect model, Hausman-Taylor estimator, Arellano and Bond estimator).

Finally we use bootstrapping, which is special technique to estimate the distribution of sample estimators, if the distribution is likely to be different from standard asymptotic distribution. We use various options and find out, that for small dynamic gravity panel data model as ours, it is appropriate to use 50 or 250 replications for which the results are comparable. We show, that the bootstrap errors, especially for variables *distance*, *border* and *EU* are smaller than the asymptotic values.

Appendix A

The Kronecker product denoted by $\otimes$ is an operation on two matrices of arbitrary size resulting in a block matrix.

Definition:
Let A is a matrix of M x N dimension and B is a matrix of P x R dimension as follows

$$A_{M\times N} = \begin{pmatrix} a_{11} & \cdots & a_{1N} \\ \vdots & \ddots & \vdots \\ a_{M1} & \cdots & a_{MN} \end{pmatrix} \text{ and } B_{P\times R} = \begin{pmatrix} b_{11} & \cdots & b_{1R} \\ \vdots & \ddots & \vdots \\ b_{P1} & \cdots & b_{PR} \end{pmatrix} \tag{A.1}$$

then the <u>Kronecker product</u> $A \otimes B$ is matrix K of MP x NR dimension, which can be written as

$$A \otimes B = K_{MP\times NR} = \begin{pmatrix} a_{11}b_{11} & \cdots & a_{11}b_{1R} & \cdots & a_{1N}b_{11} & \cdots & a_{1N}b_{1R} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ a_{11}b_{P1} & \cdots & a_{11}b_{PR} & \cdots & a_{1N}b_{P1} & \cdots & a_{1N}b_{PR} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ a_{M1}b_{11} & \cdots & a_{M1}b_{1R} & \cdots & a_{MN}b_{11} & \cdots & a_{MN}b_{1R} \\ \vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\ a_{M1}b_{P1} & \cdots & a_{M1}b_{PR} & \cdots & a_{MN}b_{P1} & \cdots & a_{MN}b_{PR} \end{pmatrix} \tag{A.2}$$

or in simple form $K = A_{M\times N} \otimes B_{P\times R} = \begin{pmatrix} a_{11}B & \cdots & a_{1N}B \\ \vdots & \ddots & \vdots \\ a_{M1}B & \cdots & a_{MN}B \end{pmatrix}$.

Fundamental properties:
Let A, B and C are matrices and k is a scalar, then the Kronecker product is

- <u>bilinear:</u>

$A \otimes (B + C) = A \otimes B + A \otimes C$
$(A + B) \otimes C = A \otimes C + B \otimes C$
$(kA) \otimes B = A \otimes (kB) = k(A \otimes B)$

- <u>associative:</u>

$(A \otimes B) \otimes C = A \otimes (B \otimes C)$

- <u>commutative:</u>

In general, $A \otimes B$ and $B \otimes A$ are different matrices, but are permutation equivalent, that means there exist permutation matrices F and G such that $A \otimes B = F(A \otimes B)G$. If A and B are square matrices, then for permutation matrices exists such relation, that $F = G^T$.

- If A and B are invertible, then:

$(A \otimes B)^{-1} = A^{-1} \otimes B^{-1}$

- If A and B are squared matrices, then for transpose:

$(A \otimes B)^T = A^T \otimes B^T$

- If A and B are squared matrices ($M = N$ and $P = R$), then:

$\det(A \otimes B) = (\det A)^P(\det B)^M$

$\mathrm{rank}(A \otimes B) = \mathrm{rank}(A)\mathrm{rank}(B)$

$\mathrm{trace}(A \otimes B) = \mathrm{trace}(A)\mathrm{trace}(B)$

More about theory of Kronecker product see Eves [34] or Kailath [45].

Appendix B

Matrices P and Q are:

- <u>symmetric and idempotent:</u>

$P^T = P$ and $Q^T = Q$

$P^2 = P$ and $Q^2 = Q$

This means, that

$\mathrm{rank}(P) = \mathrm{tr}(P) = N$

$\mathrm{rank}(Q) = \mathrm{tr}(Q) = N(T - 1)$

- <u>orthogonal:</u>

$PQ = 0$

- The sum of P and Q is an identity matrix:

$P + Q = I_{NT}$

The typical element of Pu is $\bar{u}_{i.} = \sum_{t=1}^{T} \frac{u_{it}}{T}$ repeated T times for each individual and Qu has a typical element $(u_{it} - \bar{u}_{i.})$. For more information see Graybill [38].

Appendix C

Triple index gravity model for foreign trade

The typical gravity equation for the foreign trade is triple index model expressed as

$$y_{jkt} = \alpha_0 + \theta_t + x'_{jkt}\beta_{1t} + x'_{jt}\beta_{2t} + x'_{kt}\beta_{3t} + z'_{jk}\gamma_t + u_{jkt} \qquad \text{(C.1)}$$

for j = 1, . . . , N, k = 1, . . . , N, $j \neq k$, t = 1, . . . , T, where y_{jkt} is the dependent variable (volume of trade from home country j to target country k at time t), x_{jkt} is explanatory variable with variation in all three dimensions (e.g. exchange rate between local currencies), x_{jt} and x_{kt} are explanatory variables which vary in j, k and t (e.g. GDP), z_{jk} is explanatory variable with variation in j and k (e.g. distance) but not with variation in t, and the disturbance terms u_{jkt} are assumed to be IID~$(0,\sigma_u^2)$, where σ_u^2 is constant across all j, k, t. The equation (C.1) is estimated by the cross-section OLS for each time, where α_0 and θ_t cannot be separately identified. This cross-section OLS estimation ignores any of heterogeneous characteristics related to bilateral trade relationship, which is likely to suffer from substantial heterogeneity bias.

In order to bargain with heterogeneity issues a panel-based approach is more suitable, because the effects of such determinants can be modeled by including country-pair individual effects. Setting $\beta_{.t} = \beta_{.}$, $\gamma_t = \gamma$ and $\theta_t = 0$ for all t in (C.1), the pooled panel data[28] model is obtained, which has the form

$$y_{jkt} = \alpha_0 + x'_{jkt}\beta_1 + x'_{jt}\beta_2 + x'_{kt}\beta_3 + z'_{jk}\gamma + u_{jkt} \qquad \text{(C.2)}$$

But the pooled OLS estimator obtained from (C.2) does not still bargain with the issue of heterogeneity bias. The gravity model based on the pooled specification in (C.2) has according to Matyas [54] miss specification and he proposed that the proper econometric specification of the gravity model should be a three-way model as

$$y_{jkt} = \alpha_0 + \varphi_j + \varphi_k + \theta_t + x'_{jkt}\beta_1 + x'_{jt}\beta_2 + x'_{kt}\beta_3 + z'_{jk}\gamma + u_{jkt} \qquad \text{(C.3)}$$

[28] Pooled data are combination of cross-section and time-series data.

where it is assumed that time-specific effect (θ_t) and the other two time invariant country-specific effects (φ_j and φ_k) are unobservable and thus specified as fixed effects. Estimating both models (C.2) and (C.3), he found a statistically significant evidence against restrictions $\varphi_j = \varphi_k = \theta_t = 0$.

Egger and Pfaffermayr [31] demonstrate that when the Matayas's model (C.3) is extended to include bilateral trade interaction effects such as

$$y_{jkt} = \alpha_0 + \varphi_j + \varphi_k + \varphi_{jk} + \theta_t + x'_{jkt}\beta_1 + x'_{jt}\beta_2 + x'_{kt}\beta_3 + z'_{jk}\gamma + u_{jkt} \qquad \text{(C.4)}$$

then this generalized three-way specification is in fact identical to a two-way model with time and bilateral effects only. This implies that the Matayas's model (C.3) has also miss specification, since it does not span the whole vector space of possible treatments of explaining variations in bilateral trade and ignoring such bilateral trade interactions, which may lead to bias in estimation. In general, the bilateral effect accounts for any time invariant bilateral influences which would lead to deviations from country-pair's trade tendency.

Cheng and Wall [25] focus on the issue of heterogeneity bias and proposed the following fixed effects model

$$y_{jkt} = \alpha_0 + \varphi_{jk} + \theta_t + x'_{jkt}\beta_1 + x'_{jt}\beta_2 + x'_{kt}\beta_3 + z'_{jk}\gamma + u_{jkt} \qquad \text{(C.5)}$$

It is claimed that the fixed effects are a result of ignorance because it is not known which variables are responsible for heterogeneity bias. They suggested allowing each pair of countries to have its own dummy variable that may be correlated with both the bilateral trade and explanatory variables. The main feature that distinguishes it from Matyas's (C.3) model is the inclusion of country-pair effects which are allowed to differ accordingly with the direction of trade ($\varphi_{jk} \neq \varphi_{kj}$). Cheng and Wall [25] also consider the symmetric fixed effects and the difference fixed effects models. Based on the statistical finding that the restrictions imposed in (C.2), the symmetry restriction on the country-pair effects and those needed to obtain the difference fixed effects model specification are all significantly rejected, they concluded that the fixed effects model (C.5) will be the most robust econometric specification of the gravity model of foreign trade.

Appendix D

Consider general gravity equations in log-linear form

$$\ln M_{ij} = \alpha_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \gamma_1 \ln P_i + \gamma_2 \ln P_j + \gamma_3 \ln D_{ij} + u_{ij} \qquad \text{(D.1)}$$

where M_{ij} denotes the import from country *i* to *j*, Y_x and P_x denote the aggregate income and the population of country x = *i*, *j* and D_{ij} is the geographical distance between *i* and *j*. In empirical studies the coefficients β_1 and β_2 are expected to be positive, while γ_1, γ_2 and γ_3 are expected to be negative. The consumers' utility function in country *j* – CES (Constant Elasticity of Substitution) is in form:

$$U_j(x_{ij},\ldots,x_{Nj}) = \left\{ \left[\left(\sum_{\substack{s=1 \\ s\neq j}}^{N} x_{sj}^{\beta_j} \right)^{\frac{1}{\beta_j}} \right]^{\alpha_j} + x_{jj}^{\alpha_j} \right\}^{\frac{1}{\alpha_j}} \qquad j = 1,\ldots,N \qquad \text{(D.2)}$$

$$\alpha_j = \frac{(\mu_j - 1)}{\mu_j}, \qquad 0 \le \mu_j \le \infty$$

$$\beta_j = \frac{(\sigma_j - 1)}{\sigma_j}, \qquad 0 \le \sigma_j \le \infty$$

where x_{sj} is the amount of goods produced in country *s*, demanded by the consumers in country *j*. x_{jj} is the demanded amount of domestically produced goods. The constant elasticity of substitution between domestic and importable goods is denoted by μ_j and among the importable goods by σ_j. If μ_j and σ_j are equal, equation (D.1) reduces to a simple CES.

Appendix E

Bergstrand [20] argues that gravity equation can be derived from general equilibrium model only if several assumptions are made. We mention the assumptions only in short order:

- The aggregate trade flow from country *i* to *j* is small relatively to the other markets. This causes that the changes in amounts (amounts of goods produced in country *i* demanded by the consumers in country *j*) and prices (currency price of country *i* of country *i*'s product sold in country *j*) will have only negligible impact on the incomes of *i* and *j* and will not affect the prices in any countries of the world.

- Identical utility and production functions across countries.

- Perfect substitutability of goods internationally both in production and consumption.

- Perfect commodity arbitrage, which means the price differences are immediately eliminated and a unique price prevails in all countries.

- Zero tariffs.

- Zero transport costs.

Annex

Table 1: Dynamic fixed effect (FE) models for import of selected agro-food commodities

Variable	Meat of bovine	Meat of swine	Meat of poultry	Meat total	Milk and cream	Cheese and curd	Milk and dairy total
HS code	**0201-0202**	**0203**	**0207**	**0201-0210**	**0401-0402**	**0406**	**0401-0406**
m_{it-1}	0.427***	0.611***	0.505***	0.527***	0.444***	0.307***	0.406***
	(11.08)	(18.91)	(18.13)	(22.00)	(12.11)	(10.86)	(15.39)
p_t	-0.569***	-0.206*	-0.135	-0.155**	-0.700***	-0.094	-0.398***
	(-3.79)	(-1.65)	(-1.61)	(-2.20)	(-5.76)	(-0.91)	(-5.77)
y_t	0.613*	1.028***	0.732***	0.853***	0.019	1.161***	0.452***
	(1.80)	(4.25)	(3.97)	(5.74)	(0.06)	(7.00)	(3.02)
EU	0.085	0.045	0.242**	0.085	0.001	0.363***	0.306***
	(0.38)	(0.30)	(3.97)	(0.90)	(0.01)	(3.21)	(3.06)
R^2	0.45	0.64	0.60	0.68	0.61	0.43	0.71
N	536	651	829	1073	536	705	975

Variable	Cereals without rice	Oilseeds	Sugar	Total agrarian import	Total agrarian import HS01-14	Total agrarian import HS15-24
HS code	**1001-1005, 1007-1008**	**1201-1207**	**1701-1702**	**01-24**	**01-14**	**15-24**
m_{it-1}	0.008	0.274***	0.228***	0.281***	0.231***	0.348***
	(0.16)	(8.85)	(5.85)	(16.66)	(12.85)	(18.64)
p_t	-0.727***	-0.340***	-1.411***	-0.674***	-0.712***	-0.561***
	(-3.73)	(-3.48)	(-6.80)	(-17.50)	(-13.36)	(-13.10)
y_t	-0.288	0.302	-0.266	0.179**	0.148	0.288***
	(-0.66)	(1.57)	(-0.61)	(2.56)	(1.48)	(3.72)
EU	0.617*	0.616***	2.532***	0.112**	0.266***	0.008
	(1.69)	(4.05)	(7.97)	(2.40)	(3.76)	(0.15)
R^2	0.37	0.55	0.53	0.82	0.79	0.83
N	300	807	388	1781	1273	1835

Notes: *t*-statistics are in parentheses
*, **, *** denote significance at the 10, 5 and 1 per cent level

Table 2: Dynamic fixed effect (FE) models for export of selected agro-food commodities

Variable	Meat of bovine	Meat of swine	Meat of poultry	Meat total	Milk and cream	Cheese and curd	Milk and dairy total
HS code	**0201-0202**	**0203**	**0207**	**0201-0210**	**0401-0402**	**0406**	**0401-0406**
x_{it-1}	0.348***	0.577***	0.542***	0.549***	0.393***	0.470***	0.502***
	(7.59)	(13.81)	(13.70)	(18.09)	(13.33)	(20.07)	(23.38)
p_t	-0.401*	0.113	-0.512***	-0.092	-0.310**	0.335***	-0.149**
	(-1.91)	(0.68)	(-4.05)	(-0.92)	(-2.51)	(3.17)	(-2.05)
y_t	-0.511	-0.172	-0.028	-0.071	-0.539	0.767***	0.213
	(-1.32)	(-0.60)	(-0.12)	(-0.39)	(-2.52)	(5.43)	(1.64)
EU	0.850***	0.208	0.629***	0.657***	0.764***	0.255**	0.425***
	(3.36)	(1.00)	(3.74)	(4.66)	(4.32)	(2.16)	(4.14)
R^2	0.25	0.41	0.44	0.39	0.22	0.45	0.38
N	315	380	468	730	917	845	1295

Variable	Cereals without rice	Oilseeds	Sugar	Total agrarian import	Total agrarian import HS01-14	Total agrarian import HS15-24
HS code	**1001-1005, 1007-1008**	**1201-1207**	**1701-1702**	**01-24**	**01-14**	**15-24**
x_{it-1}	0.462***	0.294***	0.391***	0.400***	0.293***	0.467***
	(5.47)	(8.03)	(8.74)	(21.24)	(14.18)	(26.42)
p_t	-0.518	-0.733***	-0.775***	-0.533***	-0.647***	-0.660***
	(-1.47)	(-4.67)	(-3.78)	(-12.71)	(-11.06)	(-15.12)
y_t	1.632	0.334	2.294***	0.296***	0.141	0.281***
	(1.63)	(1.20)	(4.65)	(3.98)	(1.24)	(3.75)
EU	-0.003	0.376	1.334***	0.232***	0.247***	0.166***
	(-0.01)	(1.57)	(3.69)	(4.40)	(3.03)	(3.17)
R^2	0.37	0.25	0.54	0.41	0.29	0.49
N	144	594	357	1771	1330	1968

Notes: *t*-statistics are in parentheses
*, **, *** denote significance at the 10, 5 and 1 per cent level

Table 3: Dynamic Hausman-Taylor (HT) model for import of selected agro-food commodities

Variable	Meat of bovine	Meat of swine	Meat of poultry	Meat total	Milk and cream	Cheese and curd	Milk and dairy total
HS code	**0201-0202**	**0203**	**0207**	**0201-0210**	**0401-0402**	**0406**	**0401-0406**
m_{it-1}	0.434***	0.620***	0.513***	0.534***	0.498***	0.333***	0.469***
	(10.51)	(18.86)	(17.14)	(21.10)	(13.48)	(10.52)	(18.03)
p_t	-0.580***	-0.216*	-0.124	-0.137*	-0.612***	-0.055	-0.404***
	(-3.78)	(-1.66)	(-1.36)	(-1.81)	(-5.29)	(-0.52)	(-6.08)
y_t	0.388	0.906***	0.765***	0.926***	0.065	1.295***	0.500***
	(1.12)	(3.40)	(3.66)	(5.48)	(0.24)	(6.95)	(3.41)
EU	0.180	0.093	0.216*	0.043	-0.026	0.267**	0.220**
	(0.82)	(0.59)	(1.82)	(0.42)	(-0.15)	(2.33)	(2.38)
dist	0.326	0.231	0.877**	0.313	0.609	0.591	-0.016
	(0.70)	(0.25)	(2.00)	(0.55)	(0.57)	(2.00)	(-0.00)
bord	1.659	0.449	2.958**	1.671	1.808	3.620	1.073
	(0.70)	(0.14)	(2.11)	(0.89)	(0.46)	(1.42)	(0.09)
N	474	583	688	910	484	592	837

Variable	Cereals without rice	Oilseeds	Sugar	Total agrarian import	Total agrarian import HS01-14	Total agrarian import HS15-24
HS code	**1001-1005, 1007-1008**	**1201-1207**	**1701-1702**	**01-24**	**01-14**	**15-24**
m_{it-1}	0.021	0.312***	0.242***	0.283***	0.231***	0.352***
	(0.39)	(8.70)	(5.54)	(16.02)	(12.34)	(18.33)
p_t	-0.686***	-0.375***	-1.518***	-0.665***	-0.710***	-0.544***
	(-3.21)	(-3.21)	(-5.88)	(-16.42)	(-12.66)	(-12.11)
y_t	0.437	0.253	-0.320	0.218***	0.213*	0.346***
	(0.93)	(1.00)	(-0.59)	(2.81)	(1.85)	(4.13)
EU	0.306	0.588***	2.518***	0.096*	0.239***	-0.015
	(0.83)	(3.31)	(7.03)	(1.94)	(3.16)	(-0.29)
dist	0.986	1.423	2.093	1.381	1.562	0.384
	(1.25)	(1.06)	(1.19)	(0.69)	(0.24)	(0.48)
bord	1.470	4.548	13.096	8.768	9.240	3.222
	(0.40)	(0.67)	(1.15)	(0.79)	(0.27)	(0.87)
N	248	610	312	1649	1102	1701

Notes: *t*-statistics are in parentheses
*, **, *** denote significance at the 10, 5 and 1 per cent level

Table 4: Dynamic Hausman-Taylor (HT) model for export of selected agro-food commodities

Variable	Meat of bovine	Meat of swine	Meat of poultry	Meat total	Milk and cream	Cheese and curd	Milk and dairy total
HS code	**0201-0202**	**0203**	**0207**	**0201-0210**	**0401-0402**	**0406**	**0401-0406**
x_{it-1}	0.355***	0.585***	0.546***	0.555***	0.393***	0.470***	0.503***
	(7.98)	(13.78)	(14.08)	(18.59)	(13.70)	(20.51)	(23.79)
p_t	-0.355*	0.134	-0.499***	-0.059	-0.309**	0.335***	-0.146**
	(-1.77)	(0.80)	(-4.03)	(-0.61)	(-2.57)	(3.24)	(-2.05)
y_t	-0.328	-0.014	0.024	0.114	-0.536***	0.767***	0.225*
	(-0.96)	(-0.05)	(0.11)	(0.72)	(-2.58)	(5.55)	(1.76)
EU	0.760***	0.148	0.605***	0.590***	0.763***	0.255**	0.421***
	(3.22)	(0.70)	(3.68)	(4.35)	(4.44)	(2.21)	(4.17)
dist	1.133	0.964	1.159	-0.281	2.908	-0.023	0.708
	(0.77)	(0.065)	(0.83)	(-0.46)	(0.63)	(-0.03)	(1.28)
bord	2.577	3.965	4.810	1.501	13.570	1.239	3.409*
	(1.11)	(1.15)	(1.58)	(1.06)	(0.83)	(0.51)	(1.79)
N	315	380	468	730	917	845	1295

Variable	Cereals without rice	Oilseeds	Sugar	Total agrarian export	Total agrarian export HS01-14	Total agrarian export HS15-24
HS code	**1001-1005, 1007-1008**	**1201-1207**	**1701-1702**	**01-24**	**01-14**	**15-24**
x_{it-1}	0.461***	0.294***	0.392***	0.400***	0.292***	0.468***
	(5.57)	(8.15)	(9.29)	(21.47)	(14.46)	(26.73)
p_t	-0.517	-0.739***	-0.789***	-0.535***	-0.644***	-0.666***
	(-1.49)	(-4.88)	(-4.09)	(-12.89)	(-11.22)	(-15.40)
y_t	1.655*	0.308	2.201***	0.284***	0.150	0.243***
	(1.70)	(1.32)	(4.84)	(3.93)	(1.35)	(3.35)
EU	-0.007	0.383*	1.356***	0.236***	0.243***	0.177***
	(-0.01)	(1.65)	(3.99)	(4.51)	(3.04)	(3.43)
dist	0.292	0.556	-0.196	0.414	0.692	-0.033
	(0.14)	(0.48)	(-0.10)	(1.20)	(1.16)	(-0.10)
bord	-2.235	2.032	3.513	2.923*	5.259*	0.594
	(-0.27)	(0.64)	(0.38)	(1.76)	(1.77)	(0.38)
N	144	594	357	1771	1330	1968

Notes: *t*-statistics are in parentheses

*, **, *** denote significance at the 10, 5 and 1 per cent level

Table 5: Dynamic GMM models for import of selected agro-food commodities

Variable	Meat of bovine	Meat of swine	Meat of poultry	Meat total	Milk and cream	Cheese and curd	Milk and dairy total
HS code	**0201-0202**	**0203**	**0207**	**0201-0210**	**0401-0402**	**0406**	**0401-0406**
$LD.m_{it-1}$	0.172***	0.120	0.136**	0.180***	-0.012	0.121**	0.109
	(2.80)	(1.52)	(2.56)	(5.07)	(-0.23)	(1.99)	(1.43)
Dp_t	-1.321**	-0.259	-0.489**	-0.061	-1.246***	0.161	-0.535*
	(-2.30)	(-0.77)	(-2.06)	(-0.22)	(-4.31)	(0.57)	(-1.90)
Dy_t	-0.410	0.190	0.171	0.644	0.922	0.738	0.947*
	(-0.32)	(0.27)	(0.33)	(1.06)	(1.02)	(1.07)	(1.65)
EU	0.083	0.141**	0.064	0.016	0.062	0.00	0.025
	(0.83)	(2.29)	(1.13)	(0.35)	(0.74)	(0.07)	(0.54)
N	440	566	747	972	432	607	858
ARM1	-2.27**	-3.47***	-3.09***	-3.40***	-2.57**	-3.26***	-2.77***
ARM2	-1.49	-0.54	-0.06	-1.58	-0.36	-1.10	-0.94

Variable	Cereals without rice	Oilseeds	Sugar	Total agrarian import	Total agrarian import HS01-14	Total agrarian import HS15-24
HS code	**1001-1005, 1007-1008**	**1201-1207**	**1701-1702**	**01-24**	**01-14**	**15-24**
$LD.m_{it-1}$	-0.127**	-0.033	-0.076	-0.068	0.030	0.028
	(-2.27)	(-0.66)	(-0.76)	(-1.36)	(0.51)	(0.45)
Dp_t	-0.711***	-0.150	-1.394**	-0.924***	-0.824***	-0.945***
	(-2.91)	(-0.49)	(-2.06)	(-10.60)	(-5.76)	(-10.45)
Dy_t	2.325	1.447*	3.224	0.174	0.119	0.002
	(0.84)	(1.82)	(1.60)	(0.91)	(0.32)	(0.01)
EU	-0.401	-0.101	-0.024	0.033	0.038	0.023
	(-1.15)	(-0.97)	(-0.12)	(1.21)	(0.91)	(0.84)
N	147	623	256	1476	920	1573
ARM1	-2.09**	-3.14***	-1.61	-2.65***	-2.60***	-3.53***
ARM2	-1.34	-0.67	-1.03	-2.41**	-0.75	-0.47

Notes: t-statistics are in parentheses

ARM1 and ARM2 denote the Arellano-Bond test that the average autocovariance in residuals of order 1 and 2 is 0 with H_0 of no autocorrelation

*, **, *** denote significance at the 10, 5 and 1 per cent level

Table 6: Dynamic GMM models for export of selected agro-food commodities

Variable	Meat of bovine	Meat of swine	Meat of poultry	Meat total	Milk and cream	Cheese and curd	Milk and dairy total
HS code	**0201-0202**	**0203**	**0207**	**0201-0210**	**0401-0402**	**0406**	**0401-0406**
LD.x_{it-1}	-0.067	0.228**	0.063***	0.280***	0.131	0.185**	0.190
	(-0.69)	(2.04)	(0.73)	(3.48)	(1.54)	(2.44)	(1.47)
Dp_t	0.124	-1.152*	-1.313	-0.769**	-0.407	0.103	-0.397*
	(0.24)	(-1.96)	(-4.31)	(-2.14)	(-1.05)	(0.63)	(-1.84)
Dy_t	-0.701	1.705***	0.470	1.028***	0.246	1.399***	0.843*
	(-0.48)	(3.27)	(0.59)	(2.72)	(0.46)	(2.72)	(1.91)
EU	0.244**	0.156	0.104	0.122**	0.138*	0.070	0.085
	(2.21)	(1.40)	(1.13)	(2.00)	(1.66)	(1.29)	(1.23)
N	213	288	381	579	757	718	1124
ARM1	-2.10**	-2.75***	-2.01**	-2.60***	-2.92***	-3.50***	-2.88***
ARM2	1.03	0.27	-2.41**	-1.69*	-1.99**	-0.36	0.21

Variable	Cereals without rice	Oilseeds	Sugar	Total agrarian import	Total agrarian import HS01-14	Total agrarian import HS15-24
HS code	**1001-1005, 1007-1008**	**1201-1207**	**1701-1702**	**01-24**	**01-14**	**15-24**
LD.x_{it-1}	0.189	0.123*	0.023	0.088	0.041	0.255***
	(1.19)	(1.82)	(0.26)	(1.21)	(0.72)	(2.91)
Dp_t	0.459	-0.915***	-1.223*	-0.936***	-0.892***	-0.977***
	(0.49)	(-2.78)	(-1.76)	(-8.18)	(-7.03)	(-7.43)
Dy_t	5.288	-0.270	3.333***	-0.510	0.461	-0.210
	(1.27)	(-0.47)	(7.58)	(-1.23)	(1.83)	(-0.78)
EU	-1.356*	0.015	-0.186	0.029	0.044*	0.002
	(-1.85)	(0.14)	(-1.25)	(1.02)	(1.05)	(0.06)
N	60	414	205	1486	1001	1707
ARM1	-0.91	-2.72***	-0.81	-3.64***	-3.03***	-3.55***
ARM2	-0.75	-1.31	-0.56	-1.88*	-2.78***	-0.63

Notes: t-statistics are in parentheses

ARM1 and ARM2 denote the Arellano-Bond test that the average autocovariance in residuals of order 1 and 2 is 0 with H_0 of no autocorrelation

*, **, *** denote significance at the 10, 5 and 1 per cent level

Table 7a: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***import***

Variable	HS code	m_{it-1}				
Number of replications			50		250	
model/Bootstrap		FE	strata	no strata	strata	no strata
Meat of bovine	**0201-0202**	**0.427*** (11.08)**	0.427*** (7.35) 0.05810	0.427*** (7.85) 0.05440	0.427*** (7.08) 0.06033	0.427*** (7.35) 0.05808
Meat of swine	**0203**	**0.611*** (18.91)**	0.611*** (15.65) 0.03905	0.611*** (19.74) 0.03096	0.611*** (16.93) 0.03611	0.611*** (15.31) 0.03993
Meat of poultry	**0207**	**0.505*** (18.13)**	0.505*** (9.54) 0.05292	0.505*** (12.39) 0.04074	0.505*** (11.17) 0.04519	0.505*** (10.87) 0.04647
Meat total	**0201-0210**	**0.527*** (22.00)**	0.527*** (10.55) 0.0499	0.527*** (11.53) 0.04571	0.527*** (11.73) 0.04492	0.527*** (11.89) 0.04433
Milk and cream	**0401-0402**	**0.444*** (12.11)**	0.444*** (7.96) 0.05581	0.444*** (8.40) 0.05288	0.444*** (7.48) 0.05933	0.444*** (7.28) 0.06101
Cheese and curd	**0406**	**0.307*** (10.86)**	0.307*** (4.37) 0.07026	0.307*** (4.62) 0.06640	0.307*** (4.41) 0.06966	0.307*** (4.16) 0.07375
Milk and dairy total	**0401-0406**	**0.406*** (15.39)**	0.406*** (6.38) 0.06367	0.406*** (6.38) 0.063675	0.406*** (6.86) 0.05920	0.406*** (6.24) 0.06513
Cereals without rice	**1001-1005, 1007-1008**	**0.008 (0.16)**	0.008 (0.14) 0.05334	0.008 (0.17) 0.04328	0.008 (0.15) 0.04860	0.008 (0.17) 0.04485
Oilseeds	**1201-1207**	**0.274*** (8.85)**	0.274*** (4.73) 0.05782	0.274*** (5.54) 0.04946	0.274*** (5.31) 0.05153	0.274*** (4.50) 0.06083
Sugar	**1701-1702**	**0.228*** (5.85)**	0.228*** (5.52) 0.04132	0.228*** (4.02) 0.05673	0.228*** (4.28) 0.05337	0.228*** (4.57) 0.04991
Total agrarian import	**01-24**	**0.281*** (16.66)**	0.281*** (7.65) 0.03677	0.281*** (6.12) 0.04599	0.281*** (6.03) 0.04666	0.281*** (5.97) 0.04718
Total agrarian import HS01-14	**01-14**	**0.231*** (12.85)**	0.231*** (9.50) 0.02432	0.231*** (8.49) 0.02723	0.231*** (8.82) 0.02620	0.231*** (7.86) 0.02924
Total agrarian import HS15-24	**15-24**	**0.348*** (18.64)**	0.348*** (7.36) 0.04726	0.348*** (7.99) 0.04355	0.348*** (7.36) 0.04724	0.348*** (7.05) 0.04937

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 7a: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***prices***

Variable	HS code	p_t				
Number of replications			**50**		**250**	
model/Bootstrap		**FE**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**-0.569*** (-3.79)**	-0.569*** (-3.71) 0.15353	-0.569*** (-4.33) 0.13130	-0.569*** (-3.89) 0.14621	-0.569*** (-3.73) 0.15234
Meat of swine	**0203**	**-0.206* (-1.65)**	-0.206 (-1.26) 0.16294	-0.206 (- 1.30) 0.15781	-0.206 (-1.31) 0.15744	-0.206 (- 1.44) 0.14323
Meat of poultry	**0207**	**-0.135 (-1.61)**	-0.135 (-1.47) 0.09157	-0.135 (-1.52) 0.08885	-0.135 (-1.54) 0.08780	-0.135 (-1.51) 0.08934
Meat total	**0201-0210**	**-0.155** (-2.20)**	-0.155** (-2.15) 0.07199	-0.155** (-1.99) 0.07769	-0.155* (-1.76) 0.08817	-0.155* (-1.73) 0.08939
Milk and cream	**0401-0402**	**-0.700*** (-5.76)**	-0.700*** (-4.99) 0.14024	-0.700*** (-4.85) 0.14442	-0.700*** (-5.19) 0.13493	-0.700*** (-4.90) 0.14283
Cheese and curd	**0406**	**-0.094 (-0.91)**	-0.094 (-0.74) 0.12653	-0.094 (- 0.80) 0.11820	-0.094 (-0.69) 0.13584	-0.094 (- 0.77) 0.12221
Milk and dairy total	**0401-0406**	**-0.398*** (-5.77)**	-0.398*** (-4.74) 0.08402	-0.398*** (-4.26) 0.09346	-0.398*** (-4.47) 0.08914	-0.398*** (-4.12) 0.09676
Cereals without rice	**1001-1005, 1007-1008**	**-0.727*** (-3.73)**	-0.727** (-2.41) 0.30117	-0.727*** (-2.97) 0.24437	-0.727*** (-2.90) 0.25091	-0.727*** (-2.90) 0.25056
Oilseeds	**1201-1207**	**-0.340*** (-3.48)**	-0.340** (-2.50) 0.13583	-0.340*** (-2.60) 0.13084	-0.340*** (-2.77) 0.12303	-0.340** (-2.55) 0.13341
Sugar	**1701-1702**	**-1.411*** (-6.80)**	-1.411*** (-4.57) 0.30849	-1.411*** (-4.76) 0.29678	-1.411*** (-5.06) 0.27872	-1.411*** (-4.94) 0.28574
Total agrarian import	**01-24**	**-0.674*** (-17.50)**	-0.674*** (-13.82) 0.04877	-0.674*** (-12.52) 0.05383	-0.674*** (-12.14) 0.05548	-0.674*** (-13.58) 0.04961
Total agrarian import HS01-14	**01-14**	**-0.712*** (-13.36)**	-0.712*** (-10.06) 0.07080	-0.712*** (-10.43) 0.06824	-0.712*** (-11.05) 0.06443	-0.712*** (-9.91) 0.07184
Total agrarian import HS15-24	**15-24**	**-0.561*** (-13.10)**	-0.561*** (-12.74) 0.04406	-0.561*** (-9.49) 0.05917	-0.561*** (-10.20) 0.05502	-0.561*** (-10.39) 0.05402

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 7c: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***GDP***

Variable	HS code	y_t				
Number of replications			**50**		**250**	
model/Bootstrap		**FE**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.613* (1.80)**	0.613 (1.57) 0.39121	0.613 (1.50) 0.40915	0.613* (1.87) 0.32721	0.613* (1.76) 0.34770
Meat of swine	**0203**	**1.028*** (4.25)**	1.028*** (4.55) 0.22590	1.028*** (4.36) 0.23567	1.028*** (4.11) 0.25019	1.028*** (4.34) 0.23660
Meat of poultry	**0207**	**0.732*** (3.97)**	0.732*** (3.53) 0.20745	0.732*** (3.97) 0.18424	0.732*** (3.83) 0.19108	0.732*** (3.72) 0.19650
Meat total	**0201-0210**	**0.853*** (5.74)**	0.853*** (5.26) 0.16210	0.853*** (5.07) 0.16835	0.853*** (5.96) 0.14325	0.853*** (5.72) 0.14920
Milk and cream	**0401-0402**	**0.019 (0.06)**	0.019 (0.05) 0.34806	0.019 (0.05) 0.38488	0.019 (0.06) 0.31877	0.019 (0.06) 0.33758
Cheese and curd	**0406**	**1.161*** (7.00)**	1.161*** (6.06) 0.19166	1.161*** (4.75) 0.24451	1.161*** (5.80) 0.20011	1.161*** (5.08) 0.22846
Milk and dairy total	**0401-0406**	**0.452*** (3.02)**	0.452** (2.21) 0.20432	0.452** (2.17) 0.20809	0.452** (2.29) 0.19775	0.452** (2.22) 0.20383
Cereals without rice	**1001-1005, 1007-1008**	**-0.288 (-0.66)**	-0.288 (-0.62) 0.46696	-0.288 (-0.63) 0.45493	-0.288 (-0.55) 0.52748	-0.288 (-0.62) 0.46054
Oilseeds	**1201-1207**	**0.302 (1.57)**	0.302 (1.47) 0.20578	0.302 (1.41) 0.21485	0.302 (1.56) 0.19331	0.302 (1.44) 0.20949
Sugar	**1701-1702**	**-0.266 (-0.61)**	-0.266 (-0.47) 0.56669	-0.266 (-0.46) 0.57894	-0.266 (-0.48) 0.54944	-0.266 (-0.46) 0.57787
Total agrarian import	**01-24**	**0.179** (2.56)**	0.179*** (2.75) 0.06524	0.179** (2.48) 0.07232	0.179** (2.24) 0.07997	0.179** (2.46) 0.07288
Total agrarian import HS01-14	**01-14**	**0.148 (1.48)**	0.148 (1.47) 0.10119	0.148 (1.48) 0.10034	0.148 (1.61) 0.09252	0.148 (1.49) 0.09963
Total agrarian import HS15-24	**15-24**	**0.288*** (3.72)**	0.288** (2.47) 0.11671	0.288** (2.24) 0.12858	0.288** (2.57) 0.11235	0.288** (2.39) 0.12089

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 7d: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***EU***

Variable	HS code	EU				
Number of replications			**50**		**250**	
model/Bootstrap		**FEl**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.085 (0.38)**	0.085 (0.37) 0.23132	0.085 (0.36) 0.23606	0.085 (0.39) 0.21867	0.085 (0.37) 0.23135
Meat of swine	**0203**	**0.045 (0.30)**	0.045 (0.33) 0.13515	0.045 (0.33) 0.13762	0.045 (0.30) 0.14838	0.045 (0.33) 0.13528
Meat of poultry	**0207**	**0.242** (3.97)**	0.242** (2.06) 0.11716	0.242** (2.14) 0.11278	0.242** (2.28) 0.10633	0.242** (2.19) 0.11069
Meat total	**0201-0210**	**0.085 (0.90)**	0.085 (1.01) 0.08423	0.085 (0.79) 0.10739	0.085 (0.94) 0.09037	0.085 (0.97) 0.08784
Milk and cream	**0401-0402**	**0.001 (0.01)**	0.001 (0.01) 0.18105	0.001 (0.00) 0.23187	0.001 (0.01) 0.18196	0.001 (0.01) 0.19757
Cheese and curd	**0406**	**0.363*** (3.21)**	0.363*** (3.05) 0.11911	0.363** (2.53) 0.14355	0.363*** (3.09) 0.11754	0.363*** (2.91) 0.12468
Milk and dairy total	**0401-0406**	**0.306*** (3.06)**	0.306*** (3.38) 0.09062	0.306*** (3.04) 0.10067	0.306*** (3.15) 0.09712	0.306*** (3.17) 0.09651
Cereals without rice	**1001-1005, 1007-1008**	**0.617* (1.69)**	0.617* (1.90) 0.32456	0.617** (2.08) 0.29753	0.617* (1.70) 0.36253	0.617* (1.74) 0.35389
Oilseeds	**1201-1207**	**0.616*** (4.05)**	0.616*** (3.90) 0.15816	0.616*** (3.90) 0.15809	0.616*** (3.71) 0.16588	0.616*** (3.73) 0.16524
Sugar	**1701-1702**	**2.532*** (7.97)**	2.532*** (6.98) 0.36299	2.532*** (5.74) 0.44109	2.532*** (6.13) 0.41285	2.532*** (6.02) 0.42024
Total agrarian import	**01-24**	**0.112** (2.40)**	0.113** (2.53) 0.04450	0.113*** (2.71) 0.04147	0.113*** (2.48) 0.04236	0.113*** (2.76) 0.04083
Total agrarian import HS01-14	**01-14**	**0.266*** (3.76)**	0.266*** (3.88) 0.06850	0.266*** (3.97) 0.06689	0.266*** (3.76) 0.07076	0.266*** (3.87) 0.06858
Total agrarian import HS15-24	**15-24**	**0.008 (0.15)**	0.008 (0.15) 0.05011	0.008 (0.14) 0.05426	0.008 (0.15) 0.04953	0.008 (0.14) 0.05365

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

*Table 8a: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model **import***

Variable	HS code	m_{it-1}				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.434*** (10.51)**	0.434*** (6.40) 0.06788	0.434*** (6.54) 0.06643	0.434*** (6.59) 0.06586	0.434*** (6.16) 0.07051
Meat of swine	**0203**	**0.620*** (18.86)**	0.620*** (12.40) 0.04998	0.620*** (14.94) 0.04149	0.620*** (15.51) 0.03997	0.620*** (14.21) 0.04361
Meat of poultry	**0207**	**0.513*** (17.14)**	0.513*** (9.48) 0.05412	0.513*** (8.24) 0.06225	0.513*** (9.86) 0.05203	0.513*** (9.27) 0.05537
Meat total	**0201-0210**	**0.534*** (21.10)**	0.534*** (13.08) 0.04083	0.534*** (10.04) 0.05322	0.534*** (10.93) 0.04888	0.534*** (9.93) 0.05379
Milk and cream	**0401-0402**	**0.498*** (13.48)**	0.498*** (7.70) 0.06469	0.498*** (7.68) 0.06482	0.498*** (7.58) 0.06564	0.498*** (7.64) 0.06513
Cheese and curd	**0406**	**0.333*** (10.52)**	0.334*** (3.21) 0.10392	0.334*** (3.62) 0.09207	0.334*** (3.63) 0.09177	0.334*** (3.42) 0.09747
Milk and dairy total	**0401-0406**	**0.469*** (18.03)**	0.469*** (7.79) 0.06026	0.469*** (9.57) 0.04907	0.469*** (8.34) 0.05632	0.469*** (9.30) 0.05047
Cereals without rice	**1001-1005, 1007-1008**	**0.021 (0.39)**	0.021 (0.37) 0.05594	0.021 (0.43) 0.04867	0.021 (0.42) 0.05041	0.021 (0.40) 0.05222
Oilseeds	**1201-1207**	**0.312*** (8.70)**	0.313*** (6.01) 0.05207	0.313*** (5.49) 0.05692	0.313*** (5.25) 0.06135	0.313*** (5.52) 0.05669
Sugar	**1701-1702**	**0.242*** (5.54)**	0.242*** (3.76) 0.06435	0.242*** (3.45) 0.0016	0.242*** (4.01) 0.06040	0.242*** (3.85) 0.06292
Total agrarian import	**01-24**	**0.283*** (16.02)**	0.283*** (5.57) 0.05079	0.283*** (5.88) 0.04810	0.283*** (5.94) 0.04767	0.283*** (5.79) 0.04889
Total agrarian import HS01-14	**01-14**	**0.231*** (12.34)**	0.231*** (7.69) 0.03006	0.231*** (6.32) 0.03660	0.231*** (7.57) 0.03055	0.231*** (8.04) 0.02873
Total agrarian import HS15-24	**15-24**	**0.352*** (18.33)**	0.352*** (8.01) 0.04395	0.352*** (9.61) 0.03662	0.352*** (6.95) 0.05066	0.352*** (7.36) 0.04785

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 8b: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***prices***

Variable	HS code	p_t				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**-0.580*** (-3.78)**	-0.580*** (-3.20) 0.18108	-0.580*** (-3.81) 0.15197	-0.580*** (-3.61) 0.16035	-0.580*** (-3.53) 0.16422
Meat of swine	**0203**	**-0.216* (-1.66)**	-0.216 (-1.35) 0.15997	-0.216 (- 1.23) 0.17574	-0.216 (-1.31) 0.16481	-0.216 (- 1.38) 0.15651
Meat of poultry	**0207**	**-0.124 (-1.36)**	-0.124 (-1.37) 0.09033	-0.124 (- 1.10) 0.09463	-0.124 (-1.36) 0.09114	-0.124 (- 1.32) 0.09436
Meat total	**0201-0210**	**-0.137* (-1.81)**	-0.137 (-1.55) 0.08846	-0.137 (- 1.55) 0.08804	-0.137 (-1.36) 0.10081	-0.137 (- 1.50) 0.09138
Milk and cream	**0401-0402**	**-0.612*** (-5.29)**	-0.612*** (-6.35) 0.09637	-0.612*** (-4.78) 0.12810	-0.612*** (-4.65) 0.13151	-0.612*** (-4.60) 0.13286
Cheese and curd	**0406**	**-0.055 (-0.52)**	-0.055 (-0.40) 0.13692	-0.055 (- 0.42) 0.13236	-0.055 (-0.39) 0.14003	-0.055 (- 0.40) 0.13621
Milk and dairy total	**0401-0406**	**-0.404*** (-6.08)**	-0.404*** (-4.99) 0.08084	-0.404*** (-5.26) 0.07680	-0.404*** (-5.30) 0.07611	-0.404*** (-5.27) 0.07656
Cereals without rice	**1001-1005, 1007-1008**	**-0.686*** (-3.21)**	-0.686** (-2.29) 0.29971	-0.686** (- 2.51) 0.27335	-0.686** (-2.18) 0.31387	-0.686** (- 2.30) 0.29771
Oilseeds	**1201-1207**	**-0.375*** (-3.21)**	-0.375*** (-3.23) 0.11623	-0.375*** (-2.65) 0.14142	-0.375** (-2.53) 0.14806	-0.375** (-2.59) 0.14472
Sugar	**1701-1702**	**-1.518*** (-5.88)**	-1.518*** (-3.94) 0.38503	-1.518*** (-3.71) 0.40906	-1.518*** (-4.44) 0.34224	-1.518*** (-4.21) 0.36046
Total agrarian import	**01-24**	**-0.665*** (-16.42)**	-0.665*** (-11.01) 0.06038	-0.665*** (-11.42) 0.058244	-0.665*** (-12.12) 0.05486	-0.665*** (-12.07) 0.05507
Total agrarian import HS01-14	**01-14**	**-0.710*** (-12.66)**	-0.710*** (-9.91) 0.07169	-0.710*** (-10.65) 0.06669	-0.710*** (-9.86) 0.07203	-0.710*** (-10.77) 0.06593
Total agrarian import HS15-24	**15-24**	**-0.544*** (-12.11)**	-0.544*** (-10.09) 0.05391	-0.544*** (- 11.06) 0.04920	-0.544*** (-8.97) 0.06066	-0.544*** (-8.90) 0.06114

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 8c: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***GDP***

Variable	HS code	y_t				
Number of replications			50		250	
model/Bootstrap		HT	strata	no strata	strata	no strata
Meat of bovine	**0201-0202**	**0.388 (1.12)**	0.388 (1.09) 0.35675	0.388 (1.17) 0.33018	0.388 (1.23) 0.31641	0.388 (1.18) 0.32857
Meat of swine	**0203**	**0.906*** (3.40)**	0.906*** (3.45) 0.26290	0.906*** (3.64) 0.24867	0.906*** (3.47) 0.26103	0.906*** (3.15) 0.28746
Meat of poultry	**0207**	**0.765*** (3.66)**	0.765*** (3.14) 0.24354	0.765*** (3.51) 0.21769	0.765*** (3.63) 0.21100	0.765*** (3.44) 0.22223
Meat total	**0201-0210**	**0.926*** (5.48)**	0.926*** (5.52) 0.16765	0.926*** (5.81) 0.15934	0.926*** (5.37) 0.17242	0.926*** (5.64) 0.16425
Milk and cream	**0401-0402**	**0.065 (0.24)**	0.065 (0.23) 0.28413	0.065 (0.18) 0.35347	0.065 (0.20) 0.32544	0.065 (0.19) 0.34401
Cheese and curd	**0406**	**1.295*** (6.95)**	1.295*** (4.48) 0.28910	1.295*** (4.72) 0.27468	1.295*** (4.69) 0.27647	1.295*** (4.69) 0.27592
Milk and dairy total	**0401-0406**	**0.500*** (3.41)**	0.500** (2.42) 0.20644	0.500*** (2.81) 0.17820	0.500*** (2.81) 0.17795	0.500*** (2.77) 0.18058
Cereals without rice	**1001-1005, 1007-1008**	**0.437 (0.93)**	0.437 (0.81) 0.54292	0.437 (0.80) 0.54455	0.437 (0.85) 0.51299	0.437 (0.86) 0.50785
Oilseeds	**1201-1207**	**0.253 (1.00)**	0.253 (0.84) 0.30053	0.253 (0.84) 0.29977	0.253 (0.93) 0.27240	0.253 (0.91) 0.27777
Sugar	**1701-1702**	**-0.320 (-0.59)**	-0.320 (-0.45) 0.70593	-0.320 (-0.52) 0.61354	-0.320 (-0.45) 0.71677	-0.320 (-0.43) 0.73663
Total agrarian import	**01-24**	**0.218*** (2.81)**	0.218*** (3.11) 0.07024	0.218*** (2.67) 0.08172	0.218*** (2.53) 0.08613	0.218*** (2.76) 0.07920
Total agrarian import HS01-14	**01-14**	**0.213* (1.85)**	0.213* (1.87) 0.11433	0.213* (1.95) 0.10948	0.213* (1.93) 0.11039	0.213* (1.74) 0.12243
Total agrarian import HS15-24	**15-24**	**0.346*** (4.13)**	0.346*** (2.76) 0.12511	0.346** (2.42) 0.14308	0.346** (2.51) 0.13752	0.346*** (2.74) 0.12617

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 8d: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***EU***

Variable	HS code	EU				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.180 (0.82)**	0.180 (0.80) 0.22403	0.180 (0.88) 0.20506	0.180 (0.84) 0.21530	0.180 (0.82) 0.21940
Meat of swine	**0203**	**0.093 (0.59)**	0.093 (0.62) 0.14927	0.093 (0.68) 0.13539	0.093 (0.59) 0.15578	0.093 (0.60) 0.15460
Meat of poultry	**0207**	**0.216* (1.82)**	0.216** (2.30) 0.09383	0.216** (2.07) 0.10436	0.216** (1.99) 0.10824	0.216** (1.97) 0.10966
Meat total	**0201-0210**	**0.043 (0.42)**	0.043 (0.50) 0.08664	0.043 (0.46) 0.09273	0.043 (0.50) 0.08610	0.043 (0.45) 0.09573
Milk and cream	**0401-0402**	**-0.026 (-0.15)**	-0.026 (-0.12) 0.21430	-0.026 (-0.13) 0.20405	-0.026 (-0.14) 0.18617	-0.026 (-0.13) 0.19748
Cheese and curd	**0406**	**0.267** (2.33)**	0.267** (2.29) 0.11657	0.267** (2.15) 0.12408	0.267** (2.11) 0.12628	0.267** (2.36) 0.11308
Milk and dairy total	**0401-0406**	**0.220** (2.38)**	0.220** (1.98) 0.11074	0.220** (2.09) 0.10485	0.220** (2.81) 0.08889	0.220** (2.38) 0.09222
Cereals without rice	**1001-1005, 1007-1008**	**0.306 (0.83)**	0.306 (0.84) 0.36546	0.306 (0.92) 0.33111	0.306 (0.90) 0.33903	0.306 (0.89) 0.34247
Oilseeds	**1201-1207**	**0.588*** (3.31)**	0.588*** (3.13) 0.18772	0.588*** (3.61) 0.16292	0.588*** (2.95) 0.19944	0.588*** (3.02) 0.19452
Sugar	**1701-1702**	**2.518*** (7.03)**	2.518*** (6.24) 0.40323	2.518*** (6.06) 0.41557	2.518*** (5.92) 0.42505	2.518*** (5.64) 0.44615
Total agrarian import	**01-24**	**0.096* (1.94)**	0.096** (2.29) 0.04209	0.096** (2.01) 0.04789	0.096** (2.10) 0.04591	0.096** (2.15) 0.04475
Total agrarian import HS01-14	**01-14**	**0.239*** (3.16)**	0.239*** (3.11) 0.07678	0.239*** (2.87) 0.08316	0.239*** (3.16) 0.07548	0.239*** (2.91) 0.08200
Total agrarian import HS15-24	**15-24**	**-0.015 (-0.29)**	-0.015 (-0.26) 0.05786	-0.015 (-0.25) 0.06059	-0.015 (-0.27) 0.05622	-0.015 (-0.29) 0.05215

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 8e: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***distance***

Variable	HS code	dist				
Number of replications			50		250	
model/Bootstrap		HT	strata	no strata	strata	no strata
Meat of bovine	0201-0202	**0.326** **(0.70)**	0.326 (0.79) 0.41494	0.326 (0.99) 0.32944	0.326 (0.81) 0.40382	0.326 (0.79) 0.41557
Meat of swine	0203	**0.231** **(0.25)**	0.231 (0.33) 0.70685	0.231 (0.28) 0.81924	0.231 (0.25) 0.94256	0.231 (0.25) 0.93215
Meat of poultry	0207	**0.877**** **(2.00)**	0.877*** (2.79) 0.31408	0.877*** (3.45) 0.25424	0.877*** (2.84) 0.30831	0.877*** (2.91) 0.30084
Meat total	0201-0210	**0.313** **(0.55)**	0.313 (0.81) 0.38830	0.313 (0.81) 0.38524	0.313 (0.79) 0.39764	0.313 (0.82) 0.38069
Milk and cream	0401-0402	**0.609** **(0.57)**	0.609 (0.95) 0.64207	0.609 (0.96) 0.63242	0.609 (0.88) 0.69269	0.609 (0.91) 0.66936
Cheese and curd	0406	**0.591** **(2.00)**	0.591 (0.48) 1.22754	0.591 (0.69) 0.85514	0.591 (0.51) 1.16287	0.591 (0.52) 1.13287
Milk and dairy total	0401-0406	**-0.016** **(-0.00)**	-0.016 (-0.01) 2.25266	-0.016 (-0.01) 2.15467	-0.016 (-0.01) 2.44062	-0.016 (-0.01) 2.47031
Cereals without rice	1001-1005, 1007-1008	**0.986** **(1.25)**	0.986* (1.91) 0.51535	0.986** (2.14) 0.46179	0.986* (1.89) 0.52164	0.986* (1.94) 0.50850
Oilseeds	1201-1207	**1.423** **(1.06)**	1.423 (1.00) 1.42572	1.423 (0.83) 1.71054	1.423 (0.80) 1.78757	1.423 (0.68) 2.10064
Sugar	1701-1702	**2.093** **(1.19)**	2.093 (1.63) 1.28351	2.093 (1.42) 1.47124	2.093 (1.31) 1.59641	2.093 (1.53) 1.3657
Total agrarian import	01-24	**1.381** **(0.69)**	1.381 (1.08) 1.28083	1.381 (1.17) 1.18489	1.381 (1.26) 1.09369	1.381 (1.03) 1.33506
Total agrarian import HS01-14	01-14	**1.562** **(0.24)**	1.562*** (3.06) 0.51036	1.562*** (2.61) 0.59745	1.562*** (3.32) 0.47048	1.562*** (3.31) 0.47122
Total agrarian import HS15-24	15-24	**0.384** **(0.48)**	0.384 (0.44) 0.87167	0.384 (0.41) 0.94298	0.384 (0.37) 1.03468	0.384 (0.32) 1.18438

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 8f: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***border***

Variable	HS code	bord				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**1.659 (0.70)**	1.659 (1.34) 1.23935	1.659 (1.60) 1.03389	1.659 (1.30) 1.27831	1.659 (1.29) 1.28488
Meat of swine	**0203**	**0.449 (0.14)**	0.449 (0.14) 3.19553	0.449 (0.14) 3.21278	0.449 (0.10) 4.47800	0.449 (0.09) 4.83031
Meat of poultry	**0207**	**2.958** (2.11)**	2.958*** (2.88) 1.02826	2.958*** (3.68) 0.80492	2.958*** (2.96) 0.99897	2.958*** (3.45) 0.85827
Meat total	**0201-0210**	**1.671 (0.89)**	1.671 (0.82) 2.05053	1.671 (0.89) 1.87808	1.671 (0.96) 1.74248	1.671 (0.95) 1.75958
Milk and cream	**0401-0402**	**1.808 (0.46)**	1.808 (0.72) 2.49458	1.808 (0.88) 2.04811	1.808 (0.69) 2.63193	1.808 (0.71) 2.53453
Cheese and curd	**0406**	**3.620 (1.42)**	3.620 (1.16) 3.11505	3.620* (1.84) 1.97126	3.620 (1.27) 2.85103	3.620 (1.34) 2.70614
Milk and dairy total	**0401-0406**	**1.073 (0.09)**	1.073 (0.15) 7.27820	1.073 (0.13) 8.08503	1.073 (0.14) 7.90824	1.073 (0.12) 8.69296
Cereals without rice	**1001-1005, 1007-1008**	**1.470 (0.40)**	1.470 (0.50) 2.95932	1.470 (0.38) 3.89628	1.470 (0.47) 3.14571	1.470 (0.46) 3.19113
Oilseeds	**1201-1207**	**4.548 (0.67)**	4.548 (0.57) 7.94212	4.548 (0.50) 9.11021	4.548 (0.49) 9.27980	4.548 (0.43) 10.61113
Sugar	**1701-1702**	**13.096 (1.15)**	13.096 (1.00) 13.06179	13.096 (0.98) 13.383	13.096 (0.88) 14.89228	13.096 (1.01) 12.93878
Total agrarian import	**01-24**	**8.768 (0.79)**	8.768 (1.05) 8.33579	8.768 (1.15) 7.59151	8.768 (1.22) 7.21220	8.768 (1.03) 8.50607
Total agrarian import HS01-14	**01-14**	**9.240 (0.27)**	9.240 (1.54) 6.01871	9.240* (1.66) 5.57616	9.240* (1.86) 4.97812	9.240* (1.70) 5.44490
Total agrarian import HS15-24	**15-24**	**3.222 (0.87)**	3.222 (0.66) 4.86572	3.222 (0.70) 4.58797	3.222 (0.62) 5.23757	3.222 (0.57) 5.63001

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 9a: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***export***

Variable	HS code	x_{it-1}				
Number of replications			**50**		**250**	
model/Bootstrap		**FE**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.348*** (7.59)**	0.348*** (4.59) 0.07582	0.348*** (4.79) 0.07260	0.348*** (4.50) 0.07727	0.348*** (5.04) 0.06896
Meat of swine	**0203**	**0.577*** (13.81)**	0.577*** (11.05) 0.05219	0.577*** (10.98) 0.05254	0.577*** (11.21) 0.05146	0.577*** (10.75) 0.05365
Meat of poultry	**0207**	**0.542*** (13.70)**	0.542*** (8.42) 0.06443	0.542*** (7.23) 0.07505	0.542*** (8.46) 0.06408	0.542*** (7.95) 0.06821
Meat total	**0201-0210**	**0.549*** (18.09)**	0.549*** (13.29) 0.04127	0.549*** (9.74) 0.05634	0.549*** (10.95) 0.05013	0.549*** (11.44) 0.04797
Milk and cream	**0401-0402**	**0.393*** (13.33)**	0.393*** (6.78) 0.05789	0.393*** (6.52) 0.06018	0.393*** (6.80) 0.05776	0.393*** (7.48) 0.05250
Cheese and curd	**0406**	**0.470*** (20.07)**	0.470*** (7.60) 0.06190	0.470*** (7.87) 0.05980	0.470*** (7.86) 0.05987	0.470*** (8.25) 0.05702
Milk and dairy total	**0401-0406**	**0.502*** (23.38)**	0.502*** (12.73) 0.03944	0.502*** (10.34) 0.04855	0.502*** (11.40) 0.04405	0.502*** (11.96) 0.04197
Cereals without rice	**1001-1005, 1007-1008**	**0.462*** (5.47)**	0.462*** (3.31) 0.13948	0.462*** (3.49) 0.13224	0.462*** (3.67) 0.12587	0.462*** (3.37) 0.13688
Oilseeds	**1201-1207**	**0.294*** (8.03)**	0.294*** (4.45) 0.06606	0.294*** (3.59) 0.08186	0.294*** (3.79) 0.07744	0.294*** (3.66) 0.08037
Sugar	**1701-1702**	**0.391*** (8.74)**	0.391*** (5.58) 0.07014	0.391*** (5.78) 0.06769	0.391*** (6.05) 0.06461	0.391*** (5.83) 0.06711
Total agrarian export	**01-24**	**0.400*** (21.24)**	0.400*** (10.91) 0.03661	0.400*** (11.52) 0.03470	0.400*** (11.61) 0.03440	0.400*** (11.11) 0.03596
Total agrarian export HS01-14	**01-14**	**0.293*** (14.18)**	0.293*** (10.33) 0.02831	0.293*** (10.01) 0.02924	0.293*** (10.10) 0.02899	0.293*** (10.82) 0.02704
Total agrarian export HS15-24	**15-24**	**0.467*** (26.42)**	0.467*** (13.26) 0.03516	0.467*** (9.56) 0.04879	0.467*** (10.68) 0.04371	0.467*** (10.92) 0.04272

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 9b: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***prices***

Variable	HS code	p_t				
Number of replications			**50**		**250**	
model/Bootstrap		**FE**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**-0.401* (-1.91)**	-0.401* (-1.67) 0.23981	-0.401 (-1.61) 0.24901	-0.401* (-1.83) 0.21847	-0.401 (-1.64) 0.24460
Meat of swine	**0203**	**0.113 (0.68)**	0.113 (0.51) 0.22276	0.113 (0.55) 0.20635	0.113 (0.53) 0.21144	0.113 (0.52) 0.21678
Meat of poultry	**0207**	**-0.512*** (-4.05)**	-0.512*** (-3.27) 0.15650	-0.512*** (-3.35) 0.15267	-0.512*** (-3.75) 0.13626	-0.512*** (-3.35) 0.15255
Meat total	**0201-0210**	**-0.092 (-0.92)**	-0.092 (-0.75) 0.12244	-0.092 (-0.77) 0.11873	-0.092 (-0.77) 0.11883	-0.092 (-0.79) 0.11633
Milk and cream	**0401-0402**	**-0.310** (-2.51)**	-0.310** (-2.34) 0.13268	-0.310** (-2.20) 0.14130	-0.310** (-2.04) 0.15188	-0.310** (-2.41) 0.12878
Cheese and curd	**0406**	**0.335*** (3.17)**	0.335*** (2.95) 0.11383	0.335*** (2.75) 0.12214	0.335*** (2.73) 0.12270	0.335*** (2.67) 0.12575
Milk and dairy total	**0401-0406**	**-0.149** (-2.05)**	-0.149** (-1.98) 0.07523	-0.149** (-2.11) 0.07065	-0.149* (-1.89) 0.07875	-0.149* (-1.92) 0.07772
Cereals without rice	**1001-1005, 1007-1008**	**-0.518 (-1.47)**	-0.518 (-1.56) 0.33090	-0.518 (-1.64) 0.31592	-0.518 (-1.59) 0.32609	-0.518 (-1.46) 0.35352
Oilseeds	**1201-1207**	**-0.733*** (-4.67)**	-0.733*** (-3.86) 0.18976	-0.733*** (-3.34) 0.21943	-0.733*** (-3.85) 0.19049	-0.733*** (-3.89) 0.18841
Sugar	**1701-1702**	**-0.775*** (-3.78)**	-0.775*** (-2.63) 0.29427	-0.775*** (-2.61) 0.29645	-0.775*** (-2.96) 0.26146	-0.775*** (-3.07) 0.25247
Total agrarian export	**01-24**	**-0.533*** (-12.71)**	-0.533*** (-7.97) 0.06686	-0.533*** (-9.19) 0.05799	-0.533*** (-8.46) 0.06297	-0.533*** (-8.48) 0.06287
Total agrarian export HS01-14	**01-14**	**-0.647*** (-11.06)**	-0.647*** (-6.98) 0.09264	-0.647*** (-7.22) 0.08949	-0.647*** (-7.44) 0.08687	-0.647*** (-7.10) 0.09102
Total agrarian export HS15-24	**15-24**	**-0.660*** (-15.12)**	-0.660*** (-9.37) 0.07042	-0.660*** (-7.51) 0.08794	-0.660*** (-7.94) 0.08314	-0.660*** (-8.47) 0.07797

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 9c: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model ***GDP***

Variable	HS code	y_t				
Number of replications			**50**		**250**	
model/Bootstrap		**FE**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**-0.511 (-1.32)**	-0.511 (-1.10) 0.46400	-0.511 (-1.23) 0.41470	-0.511 (-1.11) 0.46004	-0.511 (-1.19) 0.43029
Meat of swine	**0203**	**-0.172 (-0.60)**	-0.172 (-0.54) 0.31861	-0.172 (-0.49) 0.35517	-0.172 (-0.50) 0.34569	-0.172 (-0.46) 0.37587
Meat of poultry	**0207**	**-0.028 (-0.12)**	-0.028 (-0.09) 0.32712	-0.028 (-0.08) 0.36138	-0.028 (-0.07) 0.38828	-0.028 (-0.07) 0.40168
Meat total	**0201-0210**	**-0.071 (-0.39)**	-0.071 (-0.35) 0.20257	-0.071 (-0.27) 0.26045	-0.071 (-0.29) 0.24701	-0.071 (-0.28) 0.25318
Milk and cream	**0401-0402**	**-0.539 (-2.52)**	-0.539** (-2.35) 0.22913	-0.539*** (-2.66) 0.20275	-0.539** (-2.30) 0.23446	-0.539** (-2.31) 0.23346
Cheese and curd	**0406**	**0.767*** (5.43)**	0.767*** (4.66) 0.16456	0.767*** (4.24) 0.18111	0.767*** (3.88) 0.19791	0.767*** (4.00) 0.19187
Milk and dairy total	**0401-0406**	**0.213 (1.64)**	0.213 (1.64) 0.12978	0.213 (1.76) 0.12121	0.213 (1.64) 0.12999	0.213 (1.64) 0.12961
Cereals without rice	**1001-1005, 1007-1008**	**1.632 (1.63)**	1.632 (1.29) 1.26799	1.632 (1.17) 1.39652	1.632 (1.35) 1.20795	1.632 (1.27) 1.28087
Oilseeds	**1201-1207**	**0.334 (1.20)**	0.334 (0.86) 0.38727	0.334 (0.97) 0.34523	0.334 (1.06) 0.31513	0.334 (0.95) 0.35233
Sugar	**1701-1702**	**2.294*** (4.65)**	2.294*** (4.27) 0.53715	2.294*** (3.72) 0.61742	2.294*** (3.77) 0.60916	2.294*** (3.90) 0.58851
Total agrarian export	**01-24**	**0.296*** (3.98)**	0.296*** (3.53) 0.08387	0.296*** (3.46) 0.08541	0.296*** (3.40) 0.08706	0.296*** (3.39) 0.08738
Total agrarian export HS01-14	**01-14**	**0.141 (1.24)**	0.141 (1.00) 0.14141	0.141 (0.97) 0.14544	0.141 (0.96) 0.14755	0.141 (0.98) 0.14370
Total agrarian export HS15-24	**15-24**	**0.281*** (3.75)**	0.281*** (3.36) 0.08364	0.281*** (3.08) 0.09130	0.281*** (3.46) 0.08126	0.281*** (3.39) 0.08284

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

*Table 9d: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for FE model **EU***

Variable	HS code	EU				
Number of replications			50		250	
model/Bootstrap		FE	strata	no strata	strata	no strata
Meat of bovine	0201-0202	0.850*** (3.36)	0.850** (2.45) 0.34718	0.850*** (2.62) 0.32474	0.850*** (2.90) 0.29301	0.850*** (2.72) 0.31283
Meat of swine	0203	0.208 (1.00)	0.208 (1.07) 0.19537	0.208 (0.99) 0.21066	0.208 (1.13) 0.18356	0.208 (1.04) 0.20025
Meat of poultry	0207	0.629*** (3.74)	0.629*** (3.88) 0.16209	0.629*** (2.86) 0.21956	0.629*** (3.26) 0.19301	0.629*** (2.91) 0.21610
Meat total	0201-0210	0.657*** (4.66)	0.657*** (4.97) 0.13207	0.657*** (4.50) 0.14601	0.657*** (4.70) 0.13959	0.657*** (4.64) 0.14158
Milk and cream	0401-0402	0.764*** (4.32)	0.764*** (4.72) 0.16180	0.764*** (5.07) 0.15068	0.764*** (4.99) 0.15294	0.764*** (4.66) 0.16402
Cheese and curd	0406	0.255** (2.16)	0.255** (2.44) 0.10443	0.255** (2.46) 0.10358	0.255** (2.07) 0.12283	0.255** (2.18) 0.11699
Milk and dairy total	0401-0406	0.425*** (4.14)	0.425*** (4.44) 0.09555	0.425*** (4.19) 0.10125	0.425*** (4.56) 0.09319	0.425*** (4.66) 0.09107
Cereals without rice	1001-1005, 1007-1008	-0.003 (-0.01)	-0.003 (-0.00) 0.65378	-0.003 (-0.01) 0.61736	-0.003 (-0.00) 0.66037	-0.003 (-0.00) 0.68722
Oilseeds	1201-1207	0.376 (1.57)	0.376 (1.43) 0.26300	0.376 (1.63) 0.23060	0.376 (1.58) 0.23779	0.376 (1.56) 0.24071
Sugar	1701-1702	1.334*** (3.69)	1.334*** (3.23) 0.41280	1.334*** (3.30) 0.40441	1.334*** (3.04) 0.43837	1.334*** (3.10) 0.43062
Total agrarian export	01-24	0.232*** (4.40)	0.232*** (3.86) 0.06014	0.232*** (4.35) 0.05338	0.232*** (4.42) 0.05255	0.232*** (4.41) 0.05268
Total agrarian export HS01-14	01-14	0.247*** (3.03)	0.247*** (3.62) 0.06811	0.247** (2.56) 0.09636	0.247*** (2.92) 0.088433	0.247*** (2.70) 0.09124
Total agrarian export HS15-24	15-24	0.166*** (3.17)	0.166*** (3.59) 0.04615	0.166*** (3.47) 0.04770	0.166*** (3.43) 0.04831	0.166*** (3.54) 0.04675

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 10a: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***export***

Variable	**HS code**	**x_{it-1}**				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.355*** (7.98)**	0.355*** (4.18) 0.08496	0.355*** (4.86) 0.07299	0.355*** (5.16) 0.06883	0.355*** (4.89) 0.07261
Meat of swine	**0203**	**0.585*** (13.78)**	0.585*** (10.56) 0.05536	0.585*** (11.47) 0.05098	0.585*** (10.84) 0.05392	0.585*** (9.92) 0.05895
Meat of poultry	**0207**	**0.546*** (14.08)**	0.546*** (8.42) 0.06488	0.546*** (8.00) 0.06829	0.546*** (9.34) 0.05847	0.546*** (8.25) 0.06622
Meat total	**0201-0210**	**0.555*** (18.59)**	0.555*** (12.05) 0.04606	0.555*** (10.60) 0.05235	0.555*** (12.11) 0.04584	0.555*** (11.88) 0.04671
Milk and cream	**0401-0402**	**0.393*** (13.70)**	0.393*** (6.50) 0.06045	0.393*** (6.05) 0.06496	0.393*** (6.73) 0.05837	0.393*** (7.44) 0.05282
Cheese and curd	**0406**	**0.470*** (20.51)**	0.470*** (8.77) 0.05367	0.470*** (8.16) 0.05767	0.470*** (8.46) 0.05561	0.470*** (8.23) 0.05714
Milk and dairy total	**0401-0406**	**0.503*** (23.79)**	0.503*** (12.31) 0.04084	0.503*** (9.82) 0.05120	0.503*** (11.88) 0.04234	0.503*** (11.93) 0.04216
Cereals without rice	**1001-1005, 1007-1008**	**0.461*** (5.57)**	0.461*** (3.08) 0.14967	0.461*** (3.55) 0.12990	0.461*** (3.45) 0.13358	0.461*** (3.66) 0.12600
Oilseeds	**1201-1207**	**0.294*** (8.15)**	0.294*** (3.45) 0.08510	0.294*** (4.22) 0.06962	0.294*** (3.78) 0.07771	0.294*** (3.93) 0.07469
Sugar	**1701-1702**	**0.392*** (9.29)**	0.392*** (5.56) 0.07051	0.392*** (6.10) 0.06423	0.392*** (5.93) 0.66092	0.392*** (5.34) 0.07332
Total agrarian export	**01-24**	**0.400*** (21.47)**	0.400*** (11.57) 0.03459	0.400*** (12.32) 0.03249	0.400*** (10.96) 0.03651	0.400*** (11.93) 0.03355
Total agrarian export HS01-14	**01-14**	**0.293*** (14.46)**	0.293*** (10.87) 0.02699	0.293*** (10.48) 0.02799	0.292*** (10.69) 0.02743	0.292*** (10.75) 0.02727
Total agrarian export HS15-24	**15-24**	**0.468*** (26.73)**	0.468*** (10.77) 0.04347	0.468*** (9.87) 0.04743	0.468*** (10.35) 0.04523	0.468*** (10.80) 0.04335

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 10b: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***prices***

Variable	HS code	p_t				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**-0.355* (-1.77)**	-0.355 (-1.40) 0.25354	-0.355 (-1.44) 0.24668	-0.355 (-1.50) 0.23705	-0.355 (-1.62) 0.21916
Meat of swine	**0203**	**0.134 (0.80)**	0.134 (0.66) 0.20267	0.134 (0.85) 0.15774	0.134 (0.67) 0.19910	0.134 (0.66) 0.20277
Meat of poultry	**0207**	**-0.499*** (-4.03)**	-0.499*** (-3.11) 0.16039	-0.499*** (-3.94) 0.12653	-0.499*** (-3.60) 0.13871	-0.499*** (-3.11) 0.16046
Meat total	**0201-0210**	**-0.059 (-0.61)**	-0.059 (-0.52) 0.11394	-0.059 (-0.59) 0.10086	-0.059 (-0.51) 0.11605	-0.059 (-0.55) 0.10864
Milk and cream	**0401-0402**	**-0.309** (-2.57)**	-0.309** (-2.34) 0.13236	-0.309** (-2.40) 0.12869	-0.309** (-2.35) 0.13185	-0.309** (-2.17) 0.14239
Cheese and curd	**0406**	**0.335*** (3.24)**	0.335*** (2.85) 0.11769	0.335** (2.46) 0.13645	0.335*** (2.71) 0.12375	0.335*** (2.75) 0.12205
Milk and dairy total	**0401-0406**	**-0.146** (-2.05)**	-0.146* (-1.75) 0.08376	-0.146* (-1.93) 0.07594	-0.146* (-1.93) 0.07568	-0.146** (-2.04) 0.07169
Cereals without rice	**1001-1005, 1007-1008**	**-0.517 (-1.49)**	-0.517* (-1.77) 0.29142	-0.517 (- 1.62) 0.31872	-0.517 (-1.55) 0.33228	-0.517* (-1.66) 0.31145
Oilseeds	**1201-1207**	**-0.739*** (-4.88)**	-0.739*** (-4.43) 0.16678	-0.739*** (-4.81) 0.15368	-0.739*** (-4.08) 0.18102	-0.739*** (-4.46) 0.16576
Sugar	**1701-1702**	**-0.789*** (-4.09)**	-0.789*** (-3.19) 0.24701	-0.789*** (-3.06) 0.25767	-0.789*** (-3.27) 0.24139	-0.789*** (-2.97) 0.26519
Total agrarian export	**01-24**	**-0.535*** (-12.89)**	-0.535*** (-7.51) 0.07117	-0.535*** (-7.91) 0.06759	-0.535*** (-8.66) 0.06172	-0.535*** (-8.46) 0.06317
Total agrarian export HS01-14	**01-14**	**-0.644*** (-11.22)**	-0.644*** (-6.73) 0.09578	-0.644*** (-7.33) 0.08791	-0.644*** (-7.32) 0.08797	-0.644*** (-7.09) 0.09087
Total agrarian export HS15-24	**15-24**	**-0.666*** (-15.40)**	-0.666*** (-8.37) 0.07957	-0.666*** (-7.22) 0.09229	-0.666*** (-8.25) 0.08075	-0.666*** (-8.32) 0.08001

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 10c: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***GDP***

Variable	HS code	y_t				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**-0.328 (-0.96)**	-0.328 (-0.71) 0.46491	-0.328 (-0.78) 0.41938	-0.328 (-0.81) 0.40235	-0.328 (-0.82) 0.40180
Meat of swine	**0203**	**-0.014 (-0.05)**	-0.014 (-0.04) 0.36273	-0.014 (-0.04) 0.33731	-0.014 (-0.04) 0.34797	-0.014 (-0.04) 0.36390
Meat of poultry	**0207**	**0.024 (0.11)**	0.024 (0.06) 0.42769	0.024 (0.08) 0.29677	0.024 (0.06) 0.39105	0.024 (0.06) 0.39895
Meat total	**0201-0210**	**0.114 (0.72)**	0.114 (0.40) 0.28528	0.114 (0.49) 0.23279	0.114 (0.44) 0.26194	0.114 (0.43) 0.26786
Milk and cream	**0401-0402**	**-0.536*** (-2.58)**	-0.536** (-2.43) 0.22109	-0.536*** (-2.65) 0.20272	-0.536** (-2.14) 0.25099	-0.536** (-2.16) 0.24786
Cheese and curd	**0406**	**0.767*** (5.55)**	0.767*** (4.49) 0.17100	0.767*** (4.44) 0.17280	0.767*** (4.30) 0.17849	0.767*** (4.40) 0.17424
Milk and dairy total	**0401-0406**	**0.225* (1.76)**	0.225 (1.60) 0.14060	0.225 (1.61) 0.13942	0.225 (1.63) 0.13751	0.225* (1.82) 0.12349
Cereals without rice	**1001-1005, 1007-1008**	**1.655* (1.70)**	1.655 (1.42) 1.16421	1.655 (1.52) 1.09130	1.655 (1.41) 1.17042	1.655 (1.32) 1.25757
Oilseeds	**1201-1207**	**0.308 (1.32)**	0.308 (1.04) 0.29637	0.308 (1.07) 0.28703	0.308 (0.97) 0.31675	0.308 (1.10) 0.27949
Sugar	**1701-1702**	**2.201*** (4.84)**	2.201*** (3.97) 0.55481	2.201*** (3.39) 0.64840	2.201*** (3.75) 0.58688	2.201*** (3.79) 0.58115
Total agrarian export	**01-24**	**0.284*** (3.93)**	0.284*** (3.48) 0.08158	0.284*** (3.11) 0.09133	0.284*** (3.47) 0.08177	0.284*** (3.24) 0.08763
Total agrarian export HS01-14	**01-14**	**0.150 (1.35)**	0.150 (0.95) 0.15687	0.150 (1.14) 0.13084	0.150 (0.98) 0.15228	0.150 (0.98) 0.15342
Total agrarian export HS15-24	**15-24**	**0.243*** (3.35)**	0.243*** (2.96) 0.08206	0.243*** (2.78) 0.08740	0.243*** (2.97) 0.08173	0.243*** (2.86) 0.08486

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

*Table 10d: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model **EU***

Variable	HS code	EU				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**0.760*** (3.22)**	0.760** (2.51) 0.30281	0.760** (2.55) 0.29730	0.760** (2.59) 0.29357	0.760** (2.50) 0.30396
Meat of swine	**0203**	**0.148 (0.70)**	0.148 (0.94) 0.15794	0.148 (0.94) 0.15713	0.148 (0.78) 0.19016	0.148 (0.73) 0.20103
Meat of poultry	**0207**	**0.605*** (3.68)**	0.605** (2.46) 0.24625	0.605*** (3.00) 0.20167	0.605*** (3.19) 0.18930	0.605*** (3.10) 0.19526
Meat total	**0201-0210**	**0.590*** (4.35)**	0.590*** (4.59) 0.12857	0.590*** (4.61) 0.12783	0.590*** (4.23) 0.13935	0.590*** (3.98) 0.14834
Milk and cream	**0401-0402**	**0.763*** (4.44)**	0.763*** (4.51) 0.16900	0.763*** (4.45) 0.17129	0.763*** (4.66) 0.16380	0.763*** (5.14) 0.14822
Cheese and curd	**0406**	**0.255** (2.21)**	0.255** (2.09) 0.12212	0.255** (2.44) 0.10441	0.255** (2.06) 0.12406	0.255** (2.45) 0.10412
Milk and dairy total	**0401-0406**	**0.421*** (4.17)**	0.421*** (4.97) 0.08464	0.421*** (4.16) 0.10106	0.421*** (4.74) 0.08876	0.421*** (4.43) 0.09488
Cereals without rice	**1001-1005, 1007-1008**	**-0.007 (-0.01)**	-0.007 (-0.01) 0.73319	-0.007 (-0.01) 0.55402	-0.007 (-0.01) 0.64054	-0.007 (-0.01) 0.64450
Oilseeds	**1201-1207**	**0.383* (1.65)**	0.383* (1.71) 0.22420	0.383* (1.92) 0.19904	0.383* (1.68) 0.22708	0.383* (1.77) 0.21620
Sugar	**1701-1702**	**1.356*** (3.99)**	1.356*** (3.23) 0.42017	1.356*** (2.77) 0.48951	1.356*** (3.52) 0.38545	1.356*** (3.22) 0.42150
Total agrarian export	**01-24**	**0.236*** (4.51)**	0.236*** (4.62) 0.05100	0.236*** (4.91) 0.04799	0.236*** (4.86) 0.04845	0.236*** (4.61) 0.05109
Total agrarian export HS01-14	**01-14**	**0.243*** (3.04)**	0.243*** (2.97) 0.08179	0.243*** (2.78) 0.08749	0.243*** (2.83) 0.08595	0.243*** (2.68) 0.09061
Total agrarian export HS15-24	**15-24**	**0.177*** (3.43)**	0.177*** (2.76) 0.06423	0.177*** (3.38) 0.05242	0.177*** (3.42) 0.05178	0.177*** (3.67) 0.04824

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 10e: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***distance***

Variable	HS code	dist				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**1.133 (0.77)**	1.133 (0.52) 2.1715	1.133 (0.63) 1.81267	1.133 (0.66) 1.71826	1.133 (0.68) 1.65477
Meat of swine	**0203**	**0.964 (0.065)**	0.964 (0.63) 1.52745	0.964 (0.71) 1.35731	0.964 (0.71) 1.35321	0.964 (0.63) 1.52571
Meat of poultry	**0207**	**1.159 (0.83)**	1.159 (0.76) 1.52095	1.159 (0.94) 1.23763	1.159 (0.86) 1.34275	1.159 (0.84) 1.37908
Meat total	**0201-0210**	**-0.281 (-0.46)**	-0.281 (-0.34) 0.83197	-0.281 (-0.39) 0.72449	-0.281 (-0.29) 0.95208	-0.281 (-0.31) 0.90703
Milk and cream	**0401-0402**	**2.908 (0.63)**	2.908** (2.14) 1.36164	2.908** (2.28) 1.27399	2.908** (2.29) 1.26864	2.908** (2.23) 1.30387
Cheese and curd	**0406**	**-0.023 (-0.03)**	-0.023 (-0.09) 0.26451	-0.023 (-0.09) 0.29973	-0.023 (-0.08) 02.9561	-0.023 (-0.07) 0.32878
Milk and dairy total	**0401-0406**	**0.708 (1.28)**	0.708** (2.10) 0.33776	0.708* (1.90) 0.37195	0.708** (2.00) 0.35399	0.708** (2.20) 0.32162
Cereals without rice	**1001-1005, 1007-1008**	**0.292 (0.14)**	0.292 (0.16) 1.81308	0.292 (0.20) 1.48035	0.292 (0.18) 1.58899	0.292 (0.20) 1.44052
Oilseeds	**1201-1207**	**0.556 (0.48)**	0.556 (0.78) 0.71681	0.556 (0.71) 0.78751	0.556 (0.64) 0.86550	0.556 (0.81) 0.68941
Sugar	**1701-1702**	**-0.196 (-0.10)**	-0.196 (-0.18) 1.06593	-0.196 (-0.16) 1.20594	-0.196 (-0.19) 1.01843	-0.196 (-0.14) 1.37701
Total agrarian export	**01-24**	**0.414 (1.20)**	0.414 (0.88) 0.46851	0.414 (1.00) 0.41382	0.414 (0.95) 0.43711	0.414 (0.72) 0.57792
Total agrarian export HS01-14	**01-14**	**0.692 (1.16)**	0.692 (1.22) 0.56640	0.692 (1.63) 0.42461	0.692 (1.37) 0.50365	0.692 (0.97) 0.71386
Total agrarian export HS15-24	**15-24**	**-0.033 (-0.10)**	-0.033 (-0.06) 0.56843	-0.033 (-0.06) 0.57062	-0.033 (-0.04) 0.87075	-0.033 (-0.4) 0.89057

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 10f: The bootstrap sample mean and standard error for 50 and 250 replications with N subsample dimension for HT model ***border***

Variable	HS code	bord				
Number of replications			**50**		**250**	
model/Bootstrap		**HT**	**strata**	**no strata**	**strata**	**no strata**
Meat of bovine	**0201-0202**	**2.577** **(1.11)**	2.577 (0.84) 3.07819	2.577 (1.05) 2.45171	2.577 (1.16) 2.21423	2.577 (1.19) 2.15770
Meat of swine	**0203**	**3.965** **(1.15)**	3.965 (1.23) 3.22954	3.965 (1.28) 3.09749	3.965 (1.28) 3.0905	3.965 (1.22) 3.2504
Meat of poultry	**0207**	**4.810** **(1.58)**	4.810 (1.57) 3.06448	4.810* (1.76) 2.72802	4.810* (1.80) 2.67775	4.810* (1.91) 2.52184
Meat total	**0201-0210**	**1.501** **(1.06)**	1.501 (0.73) 2.04618	1.501 (0.90) 1.66562	1.501 (0.77) 1.94254	1.287 (0.79) 1.89860
Milk and cream	**0401-0402**	**13.570** **(0.83)**	13.570*** (2.69) 5.03854	13.570*** (2.75) 4.94070	13.570*** (2.68) 5.0609	13.570** (2.47) 5.49472
Cheese and curd	**0406**	**1.239** **(0.51)**	1.239 (0.99) 1.25556	1.239 (0.76) 1.63460	1.239 (0.95) 1.30861	1.239 (0.78) 1.58425
Milk and dairy total	**0401-0406**	**3.409*** **(1.79)**	3.409** (2.12) 1.60546	3.409** (2.09) 1.63414	3.409** (2.06) 1.65117	3.409** (2.32) 1.46968
Cereals without rice	**1001-1005, 1007-1008**	**-2.235** **(-0.27)**	-2.235 (-0.31) 7.2933	-2.235 (-0.32) 7.02447	-2.235 (-0.43) 5.14993	-2.235 (-0.35) 6.32701
Oilseeds	**1201-1207**	**2.032** **(0.64)**	2.032 (0.90) 2.26348	2.032 (0.80) 2.54292	2.032 (0.71) 2.87452	2.032 (0.88) 2.32124
Sugar	**1701-1702**	**3.513** **(0.38)**	3.513 (0.42) 8.33248	3.513 (0.38) 9.18745	3.513 (0.40) 8.71986	3.513 (0.33) 10.71835
Total agrarian export	**01-24**	**2.923*** **(1.76)**	2.923 (1.26) 2.33077	2.923 (1.36) 2.15116	2.923 (1.37) 2.1363	2.923 (1.06) 2.76162
Total agrarian export HS01-14	**01-14**	**5.259*** **(1.77)**	5.259 (1.55) 3.38652	5.259* (1.91) 2.74727	5.259* (1.86) 2.82739	5.259 (1.35) 3.90848
Total agrarian export HS15-24	**15-24**	**0.594** **(0.38)**	0.594 (0.19) 3.11655	0.594 (0.20) 2.91362	0.594 (0.13) 4.68090	0.594 (0.13) 4.62626

Notes: *t*-statistics are in parentheses and the third value determines the bootstrap standard error

*, **, *** denote significance at the 10, 5 and 1 per cent level

All variables were tested in their natural logarithm form.

Table 11a: The panel unit root tests

		Levin, Lin and Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
EXPORT	**cereals**	-10.2153***	-8.16650***	-11.2255***	326.432***	550.410***
	cheese	-4.81061***	-0.90651	-5.41279***	201.279***	299.568***
	meatb	-13.2049***	-2.51213***	-9.25265***	219.105***	250.756***
	meatp	-5.14999***	-0.97448	-5.18217***	181.796***	262.491***
	meats	0.16382	-2.20102**	-1.93010**	107.753***	217.339***
	meatt	-26.0267***	-3.80375***	-9.45829***	262.024***	379.577***
	milkcr	0.05454	-4.09274***	-4.84769***	200.546***	293.620***
	milkt	-0.81656	-4.42925***	-6.07087***	303.104***	387.552***
	oilseeds	-9.10031***	-8.90233***	-12.0694***	398.734***	574.090***
	sugar	-0.57834	-3.48218***	-15.5819***	350.929***	494.994***
	totale	-10.5664***	-8.13426***	-10.1263***	521.328***	689.191***
	p_cereals	-10.6816***	-6.83400***	-11.5228***	308.528***	523.461***
	p_cheese	-8.39319***	-1.63322*	-5.13930***	166.156***	246.125***
	p_meatb	-2.54416***	-2.19033**	-6.67657***	243.360***	315.537***
	p_meatp	-6.05503***	-5.20240***	-10.2234***	302.773***	326.971***
	p_meats	4.89635	-2.80625***	-6.24168***	159.757***	245.869***
	p_meatt	-14.7624***	-4.08237***	-17.1069***	396.328***	465.046***
	p_milkcr	97.7290	-5.62586***	10.3129	206.274***	260.993***
	p_milkt	90.8970	-6.49318***	3.71053	346.592***	402.870***
	p_oilseeds	-0.97077	-6.38743***	-9.89016***	368.610***	597.684***
	p_sugar	-4.09423***	-4.93487***	-9.13149***	300.358***	483.431***
	p_totale	-14.1572***	-11.4265***	-16.3176***	701.192***	904.304***
	cpi	-5.21436***	-0.79293	-4.74087***	109.827***	239.936***

Notes: *t*-statistics are in parentheses
*, **, *** denote significance at the 10, 5 and 1 per cent level
All variables were tested in their natural logarithm form.

Table 11b: The panel unit root tests

		Levin, Lin and Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
IMPORT	**cereals**	-10.2153***	-8.16650***	-11.2255***	326.432***	550.410***
	cheese	-4.81061***	-0.90651	-5.41279***	201.279***	299.568***
	meatb	-13.2049***	-2.51213***	-9.25265***	219.105***	250.756***
	meatp	-5.14999***	-0.97448	-5.18217***	181.796***	262.491***
	meats	0.16382	-2.20102**	-1.93010**	107.753***	217.339***
	meatt	-26.0267***	-3.80375***	-9.45829***	262.024***	379.577***
	milkcr	0.05454	-4.09274***	-4.84769***	200.546***	293.620***
	milkt	-0.81656	-4.42925***	-6.07087***	303.104***	387.552***
	oilseeds	-9.10031***	-8.90233***	-12.0694***	398.734***	574.090***
	sugar	-0.57834	-3.48218***	-15.5819***	350.929***	494.994***
	totali	-11.1765***	-8.78788***	-12.5252***	656.223***	849.357***
	p_cereals	-10.6816***	-6.83400***	-11.5228***	308.528***	523.461***
	p_cheese	-8.39319***	-1.63322*	-5.13930***	166.156***	246.125***
	p_meatb	-2.54416*	-2.19033**	-6.67657***	243.360***	315.537***
	p_meatp	-6.05503***	-5.20240***	-10.2234	302.773***	326.971***
	p_meats	4.89635	-2.80625***	-6.24168***	159.757***	245.869***
	p_meatt	-14.7624***	-4.08237***	-17.1069***	396.328***	465.046***
	p_milkcr	97.7290	-5.62586***	10.3129	206.274***	260.993***
	p_milkt	90.8970	-6.49318***	3.71053	346.592***	402.870***
	p_oilseeds	-0.97077	-6.38743***	-9.89016***	368.610***	597.684***
	p_sugar	-4.09423***	-4.93487***	-9.13149***	300.358***	483.431***
	p_totali	-13.3710***	-8.04065***	-17.0398***	727.762***	851.010***
	gdp	0.29288	-2.74597***	4.37574	8.79567	12.7546
	I(1) gdp	-12.2027***	-15.1189***	-14.7193***	248.445***	347.418***

Notes: *t*-statistics are in parentheses
*, **, *** denote significance at the 10, 5 and 1 per cent level
All variables were tested in their natural logarithm form.

Bibliography

[1] Ahn, S.G., Lee, Y.H., Schmidt, P. (2001): GMM Estimation of Linear Panel Data Models with Time-varying Individual Effects, Journal of Econometrics, 101, 219-255.

[2] Ahn, S.C., Schmidt, P. (1995): Efficient estimation of models for dynamic panel data, Journal of Econometrics, 68, 5-28.

[3] Arellano, M. (1989): A Note on the Anderson-Hsiao Estimator for Panel Data, Economic Letters, 31, 337-341.

[4] Arellano, M., Bond, S.R. (1991): Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, Review of Economic Studies, 58, 277–297.

[5] Arellano, M., Bover, O. (1995): Another Look at the Instrumental Variables Estimation of Error Components Models, Journal of Econometrics, 68, 29–51.

[6] Anderson, J.E. (1979): A Theoretical Foundation for the Gravity Equation, The American Economic Review, Vol. 69, No. 1, pp. 106-116.

[7] Anderson, J.E., van Wincoop, E. (2001): Gravity with Gravitas: A Solution to the Border Puzzle, NBER Working Papers 8079, National Bureau of Economic Research, Inc.

[8] Anderson, T.W., Hsiao, Ch. (1981): Estimation of dynamic models with error components, Journal of the American Statistical Association.

[9] Anderson, T.W., Hsiao, Ch. (1982): Formulation and Estimation of Dynamic Models Using Panel Data, Journal of Econometrics, 18, 47-82.

[10] Bai, J., Ng, S. (2002): Determine the Number of Factors in Approximate Factor Models, Econometrica, 70, 191-221.

[11] Baldwin, R.E. (1994): Towards an Integrated Europe. CEPR, London.

[12] Baldwin, R.E., Francois, J.F., Portes R. (1997): The Costs and Benefits of Eastern Enlargement: The Impact on the EU and Central Europe. Economic Policy, April. 127-176.

[13] Baldwin, R.E., Taglioni, D. (2006): Gravity for dummies and dummies for gravity equations, Working Paper 12516, National Bureau of Economic research, Cambridge.

[14] Balestra, P., Nerlove, M. (1966): Pooling cross section and time series data in the estimation of a dynamic model: The demand for natural gas, Econometrica 34, 585-612.

[15] Baltagi, B.H. (2001): Econometric Analysis of Panel Data. Wiley, New York.

[16] Bartošová, D., Bartová, Ľ., Fidrmuc J. (2007): Agropotravinársky obchod po vstupe do Európskej únie, Ekonomický časopis – Journals of Economics, 55, April: 327-344.

[17] Bartošová, D., Bartová, Ľ., Fidrmuc J. (2008): EU Enlargement Implications on the New Member States Agri-food Trade, International Congress, Ghent, Belgium, no. 44122, August 26-29, European Association of Agricultural Economists.

[18] Bartošová, D., Bartová, Ľ., Fidrmuc J. (2007): Implications of EU Enlargement for the New Member States' Agri-food Trade," Working Papers 7320, TRADEAG - Agricultural Trade Agreements.

[19] Beran, R., Ducharme, G.R. (1991): Asymptotic Theory for Bootstrap Methods in Statistics, Les Publications CRM, Centre de recherches mathematiques, Universite de Montreal, Montreal, Canada.

[20] Bergstrand, J.H. (1989): The generalized gravity equation, monopolistic competition, and factor proportions theory of international trade. Review of Economics and Statistics 71: 143-153.

[21] Brenton, P., Di Mauro, F. (1998): Is there Any Potential in Trade in Sensitive Industrial Products Between the CEECs and the EU? World Economy, 21: 285-304.

[22] Bun, M. J.G., Klaassen, F.J.G.M. (2002): The Importance of Dynamics in Panel Gravity Models of Trade, Mimeo. University of Amsterdam.

[23] Burstaller, J., Landesmann, M. (1997): Vertical Product Differentiation in EU Markets: Position of East European Producers. Research Report No. 234a and 234b, Vienna Institute of Comparative Economic Studies, Vienna.

[24] Bussière, M., Fidrmuc, J., Schnatz, B. (2005): Trade Integration of Central and Eastern European Countries: Lessons from a Gravity Model, Working Paper No. 545, European Central Bank, Frankfurt.

[25] Cheng, I., Wall, H.J. (2002): Controlling Heterogenity in Gravity Models of Trade, Working Paper 1999-010C, Federal Reserve Bank of St. Luis.

[26] Choi, I., Chue, T.K. (2007): Subsampling Hypothesis Tests for Nonstationary Panels with Applications to Exchange Rates and Stock Prices, Journal of Applied Econometrics, Vol. 22, No. 2, pp. 233-264.

[27] Davison, A.C., Hinkley, D.V. (1997): Bootstrap Methods and Their Application, Cambridge, U.K.: Cambridge University Press.

[28] Deardorff, A.V. (1998): Determinants of bilateral trade: Does gravity work in a neoclassical world? NBER, Working Paper No.5377.

[29] Efron, B. (1979): Bootstrap methods: another look at the jackknife, Annals of Statistics, 7, 1-26.

[30] Efron, B., Tibshirani, R.J. (1993): An Introduction to the Bootstrap. New York: Chapman & Hall.

[31] Egger, P., Pfaffermayr, M. (2002): The Proper Econometric Specification of the Gravity Equation: A Three-way Model with Bilateral Interaction, Working Paper, Austrian Institute of Economic Research.

[32] Engel, R.F., Granger, C.W.J. (1987): Co-integration and error-correction: Representation, estimation and testing, Econometrica 55, 251—276.

[33] Evenett, S.J., Keller, W. (2002): On the theories explaining the success of the gravity equation. Journal of Political Economy 110: 281-316.

[34] Eves, H. (1980): Elementary Matrix Theory, Dover publications.

[35] Fidrmuc, J., Huber, P., Michalek, J.J. (2001): Poland's Accession to the European Union, Demand for Protection of Selected Sensitive Products, MOCT/MOST 11, (1), 47-70.

[36] Frohberg, K., Hartmann, M. (1997): Promoting CEA Agricultural Exports through Association Agreements with the EU - Why it is not Working. Disscussion paper No. 1. IAMO, Halle. 28 pp.

[37] Glink, R., Rose, A.K. (2002): Does a currency union affect trade? The time series evidence. European Economic Review 46: 1125-51.

[38] Graybill, F.A. (1961): An Introduction to Linear Statistical Models. McGraw-Hill, New York.

[39] Hamilton, C.B., Winters, A.L. (1992): Opening up International Trade with Eastern Europe. Econo-mic Policy, April, 78-115.

[40] Hansen, L. P. (1982): Large sample properties of generalized method of moments estimators, Econometrica, 50, 1029-1054.

[41] Helpman, E. (1987): Imperfect competition and international trade: Evidence from fourteen industrialized countries. Journal of the Japanese and International Economies 1: 62-81.

[42] Horowitz, J.L. (1997): Bootstrap methods in econometrics: theory and numerical performance, in D.M. Kreps and K.F. Wallis, eds. Advances in Economics and Econometrics: Theory and Applications, Seventh World Congress, vol. 3, Ch. 7. Cambridge, U.K.: Cambridge University Press.

[43] Hsiao, C. (1986): Analysis of Panel Data, Cambridge, University Press.

[44] Im, K.S., Pesaran, M.H., Shin, Y. (2003): Testing for unit roots in heterogeneous panels, Journal of Econometrics, n.º 115, pp. 53-74.

[45] Kailath, T., Sayed, A.H., Hassibi, B. (2000): Linear estimation, Prentice Hall.

[46] Kiviet, J.F. (1995): On bias, inconsistency, and efficiency of various estimators in dynamic panel data models, Journal of Econometrics, Elsevier, vol. 68(1), pages 53-78, July.

[47] Krugman, P.R. (1979): Increasing returns, monopolistic competition and international trade. Journal of International Economics 9: 469-79.

[48] Levin, A., Lin, C.F., Chu, C. (2002): Unit roots tests in panel data: Asymptotic and finite-sample properties, Journal of Econometrics, n.º 108, pp. 1-24.

[49] Linnemann, H. (1966): An econometric study of international trade flows, North Holand, Amsterdam.

[50] Lukas, Z., Mládek, J. (2006): Further Expanding Agro-Food Trade of the NMS-4 in Europe, Monthly Report No. 5, The Vienna Institute for International Economic Studies, Vienna.

[51] Madala, G.S. (1971): The use of variance components models in pooling cross section and time series data, Econometrica 39, 341-358.

[52] Maddala, G.S., Jeong, J. (1993): A perspective on application of bootstrap methods in econometrics, in G.S. Maddala, C.R. Rao, and H.D. Vinod (eds.), Handbook of Statistics, vol. 11. Amsterdam: North-Holland, pp. 573-610.

[53] Mammen, E. (1992): When Does Bootstrap Work? Asymptotic Results and Simulations. New York: Springer-Verlag.

[54] Matyas, L. (1997): Proper Econometric Specification of the Gravity model, The World Economy, 20, 363-368.

[55] Matyas, L., Sevestre, P. (eds.) (1996): The Econometrics of Panel Data: A Handbook of the Theory with Applications, 2nd ed., Dordrecht, Kluwer Academic Publishers.

[56] Mundlak, Y. (1978): On the pooling of the time series and cross section data, Econometrica 46, 69-85.

[57] Neck, R., Haber, G., MacKibbin, W.J. (2000): Macroeconomic Impacts of European Union Membership of Central and Eastern European Economies. Atlantic Economic Journal 28(1), 71-82.

[58] Nerlove, M. (1971): Further evidence on the estimation of dynamic economic relations from a time series of cross-sections, Econometrica 39, 359-387.

[59] Olper, A., Raimondi, V. (2005): Access to OECD Agricultural Market: A Gravity Border Approach. Presented at 99th Seminar of the European Association of Agricultural Economists, August 24-27, Denmark.

[60] Pesaran, M.H. (2002): Estimation and Inference in Large Heterogeneous Panels with Cross Section Dependence, University of Cambridge DAE Working Paper No.0305.

[61] Phillips, P.C.B., Sul, D. (2002): Dynamic Panel Estimation and Homogeneity Testing Under Cross Section Dependence, Cowles Foundation Discussion Paper No.1362, Yale University.

[62] Pohyonen, P. (1963): A tentative model for the volume of trade between countries, Weltwirtschaftliches Archiv, 90, pp 93-99.

[63] Rose, A.K. (2000): One money, one market: the effect of currency unions on trade, Economic Policy 30, 7-46.

[64] Rose, A.K., van Wincoop, E. (2001): National Money as a Barrier to International Trade: The Real Case for Currency Union, American Economic Review, American Economic Association, vol. 91(2), pages 386-390, May.

[65] Serlenga, L., Shin, Y. (2004): Gravity Models of the Intra-EU Trade: Application of the Hausman-Taylor Estimation in Heterogeneous Panels with Common Time-specific Factors. School of Economics, University of Edinburgh.

[66] Tinbergen, J. (1962): Shaping the world economy: suggestions for an international economic policy, Twentieth Century Fund, New York.

[67] Vinod, H.D. (1993): Bootstrap methods: applications in econometrics, in G.S. Maddala, C.R. Rao, and H.D. Vinod (eds.), Handbook of Statistics, vol. 11. Amsterdam: North-Holland, pp. 629-661.

[68] Wallace, T.D., Hussain, A. (1969): The Use of Error Components Models in Combining Cross Section with Time Series Dada, Econometrica, 37.

[69] Agriculture and the environment in the EU accession countries, European Environment Agency, Environmental issue report, No 37.

Index

Resumé

V dizertačnej práci sme analyzovali vplyv determinantov obchodu s agropotravinárskymi komoditami počas integrácie krajín CEEC (Central and Eastern European countries) do Európskej únie (EÚ). Cieľom bolo odhadnúť dynamické gravitačné panelové modely exportu a importu agropotravinárskych komodít krajín CEEC s vybranými obchodnými zoskupeniami. Základom odhadov bola dynamická verzia gravitačného modelu rozšírená o substitučné efekty. Tieto modely sú použité na diskusiu vplyvu vstupu krajín CEEC do EÚ na trh s agropotravinárskymi komoditami a na analýzu dynamiky obchodu krajín CEEC s EÚ15, s jednotlivými novými členskými krajinami EÚ vrátane Rumunska a Bulharska, CIS (Spoločenstvo nezávislých štátov), USA a zvyškom sveta.

Prvá kapitola je úvodom do problematiky, ktorej sa v práci venujeme – či a ako ovplyvnil vstup krajín do EÚ ich trh s agropotravinárskymi komoditami. Stručne v nej charakterizujeme agropotravinársky sektor v krajinách, ktoré v práci analyzujeme a uvádzame základné metódy, ktoré sa používajú, a ktoré sme použili my, na modelovanie bilaterálneho obchodu. Druhá kapitola je nielen zhrnutím základnej teórie o panelových modeloch, popisujeme tu aj konkrétne modely, ktoré sú používané na modelovanie medzinárodného obchodu. Uvádzame tu základný *Within-estimator* s fixnými efektmi, Hasman-Taylorovu metódu s *time-specific* faktormi a metódu GMM (Generalized method of movements) v podaní Arellano-Bond. Taktiež sme v tejto kapitole načrtli problematiku jednotkového koreňa, ktorý je pre mnohé makroekonomické časové rady charakteristický, preto uvádzame teóriu *Panel unit root* testov. V krátkosti uvádzame techniku *bootstraping*, ktorá sa používa na vyjadrenie asymptotického rozdelenia odhadnutých koeficientov. Základné poznatky o gravitačných modeloch sú zhrnuté v tretej kapitole. Štvrtá kapitola je krátkym zhrnutím ekonomického vývoja analyzovaných krajín v oblasti

agropotravinárskych výrobkov. Na základe teoretických poznatkov analyzujeme dostupné dáta v piatej kapitole, v ktorej sme vytvorili vlastný model pomocou viacerých metód.

Najčastejšie sa obchodné toky analyzujú dvomi prístupmi. Prvý predstavuje agregované, alebo rozčlenené obchodné toky jednotlivých krajín závisiace od vývoja príjmu a cien na vývoznom trhu pomocou numerického modelu všeobecnej rovnováhy (computable general equilibrium model, CGEM). Výhodou modelovania CGEM v prípadne makroekonomických prognostických modelov pre jednotlivé krajiny je, že obsahujú relatívne detailné informácie pre viaceré sektory ekonomiky.

Okrem komplexných modelov svetovej ekonomiky, ktoré sa zvyčajne koncentrujú na vybrané svetové regióny, zahraničný obchod vstupuje do modelu na úrovni externých predpokladov. Tie sú často založené na parciálnych gravitačných modeloch, ktoré odhadujú obchodné toky viacerých krajín za daný časový úsek ako funkciu dopytu a ponuky v partnerských krajinách, transportných a transakčných nákladov a integračných efektov (napríklad členstvo v EÚ). Tieto modely predstavujú druhý najčastejšie používaný prístup. Nevýhodou gravitačných modelov je, že rozsiahla detailná geografická štruktúra neumožňuje komplexnú analýzu pre jednotlivé sektory ekonomiky. Napriek tomu sa tieto modely používajú na analýzu integračných efektov vo vybraných oblastiach, zvyčajne pre užší rozsah krajín. Tieto modely poskytujú v porovnaní s modelmi CGEM aj odhady o geografickej štruktúre obchodu po úplnom zahrnutí integračných efektov. Nakoľko ide o parciálne modely, gravitačné modely neukazujú možné závislosti medzi jednotlivými komoditami.

Odrážajúc vlastnosti našich dát, skombinovali sme oba prístupy. V našich odhadoch sme uvažovali premenné, ktoré boli špecifikované súčasne pre krajinu a komoditu a celkové makroekonomické dáta. Vychádzajúc zo štandardnej dopytovej rovnice obchodu, uvažovali sme celkový príjem a ceny výrobkov v porovnaní s celkovým cenovým vývojom v ekonomike ako hlavné determinanty obchodu s vybranými komoditami vo vybraných krajinách. Vzhľadom na malý počet pozorovaní sme použili menší prierezový rozmer ako pri typických gravitačných modeloch. Vytvorili sme tak jedinečný model, ktorý vznikol skĺbením dvoch alternatívnych prístupov – dynamickú verziu gravitačného panelového modelu. Na záver piatej kapitoly uvádzame výsledky jednotlivých regresií.

Šiesta kapitola je zhrnutím základných výsledkov a záverov z nich plynúcich, podľa ktorých vstup krajín do EÚ priaznivo ovplyvnil najmä export vstupujúcich krajín.