RUHR
ECONOMIC PAPERS

Zoryana Olekseyuk
H. Schürenberg-Frosch

Are Armington Elasticities Different across Countries and Sectors?

A European Study

UNIVERSITÄT DUISBURG ESSEN

#513

Imprint

Ruhr Economic Papers

Published by

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Editorial Office

Ruhr Economic Papers #513

Responsible Editor: Volker Clausen

ISSN 1864-4872 (online) – ISBN 978-3-86788-588-1

Ruhr Economic Papers #513

Zoryana Olekseyuk, Hannah Schürenberg-Frosch

Are Armington Elasticities Different across Countries and Sectors?

A European Study

UNIVERSITÄT DUISBURG ESSEN

Bibliografische Informationen der Deutschen Nationalbibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über: *http://dnb.d-nb.de* abrufbar.

http://dx.doi.org/10.4419/86788588
ISSN 1864-4872 (online)
ISBN 978-3-86788-588-1

Zoryana Olekseyuk, Hannah Schürenberg-Frosch[1]

Are Armington Elasticities Different across Countries and Sectors?

A European Study

Abstract

CGE models are widely used for policy evaluation and impact analysis especially with respect to trade reforms, tax reforms, energy sector reform and development policy analysis. However, the results of such models are often argued to be sensitive to the choice of exogenous parameters such as trade elasticities. Several authors show that the choice of the so-called Armington elasticities in the import demand function has a strong influence on the simulation results. Most existing estimates of Armington elasticities are only for the US. The few studies for other countries find substantially differing results. Nevertheless, many CGE modelers simply adopt the elasticities from the literature. This paper aims at providing estimated elasticities based on recent data for a larger group of European countries. Using cointegration and panel fixed effects analyses we estimate the first order condition resulting from cost minimization or utility maximization subject to the CES subutility or cost function in imports and domestic goods. The results show a rather large variation across sectors and countries and the magnitude is only partly comparable to the US elasticities. Moreover, in a small CGE application we are able to show that changing the elasticity set has a quantitative and even qualitative impact on CGE model results, which confirms the concern that one might end up with biased results due to a misspecification of the elasticities.

JEL Classification: F14, C68, F17

Keywords: Armington; trade elasticities; computable general equilibrium; Europe

November 2014

1 -Both UDE. – The authors thank Volker Clausen, Edward J. Balistreri, Miriam Frey and participants at EcoMod2013 (Prague), 15. Göttinger Workshop Internationale Wirtschaftsbeziehungen (Göttingen) for helpful comments and suggestions. The usual disclaimer applies.– *All correspondence to: Zoryana Olekseyuk, University of Duisburg-Essen, Chair of International Economics, Institute for Economics and Business Administration Universitätsstr. 12, 45117 Essen, Germany, e-mail: zoryana.olekseyuk@ibes.uni-due.de*

1 Introduction

CGE models are widely used for policy evaluation and impact analysis. The modeling technique is especially useful in the analysis of trade reforms, tax reforms, energy sector reform and development policy. However, the results of such models are often argued to be sensitive to the choice of exogenous parameters such as elasticities. Apart from the elasticities of substitution between production factors in the production function, the so-called Armington elasticities, which determine the substitutability between domestic goods and imports, are often mentioned as one caveat of CGE models. McDaniel & Balistreri (2003), Schuerenberg-Frosch (2014), Siddig & Grethe (2014) and others show that the choice of the Armington elasticities in the import demand function has a strong influence on the simulation results. Hence, it is very important to choose these elasticities appropriately. Unfortunately, many CGE papers are not very transparent concerning the choice of elasticities and the sensitivity of the results with respect to this choice. As, e.g., Welsch (2008) points out "In practice, the elasticities employed are frequently based on 'guestimation' or on estimates picked from the literature."

There exists a number of estimations for Armington elasticities and the results of these are frequently used in CGE studies. This paper argues that this strategy could lead to severely biased model results as the estimated elasticities might not be applicable to either the specific model or country in question. The reasons are the following:

Most existing studies provide results only for the US (e.g., Reinert & Roland-Holst (1992), Shiells & Reinert (1993), Blonigen & Wilson (1999) and Gallaway *et al.* (2003)). The estimated elasticities for the US display already substantial variation. More importantly, the few studies for other countries (such as Gibson (2003), Welsch (2006), Welsch (2008)) find substantially differing results. Thus, the frequently given argument that time-series studies find rather small elasticities compared to cross-sectional studies might simply be driven by rather small elasticities in the specific US case.

One result that emerges quite clearly from the literature is that elasticities differ depending on the level of aggregation used in the data. Most studies find that elasticities increase with the level of disaggregation in the underlying data. Thus, a CGE modeler ought to use estimated elasticities from a study with the same level of sectoral disaggregation he uses in his model. However, the mentioned studies for the US have a rather high level of disaggregation with 180-200 industries included. Most CGE studies are much more aggregate. Nonetheless, as McDaniel & Balistreri (2003) point out, authors simply calculate the average elasticity across subsectors and use this number for their aggregated sector. This might lead to an aggregation bias and thus to biased CGE results.

Welsch (2006) argues that the Armington elasticities decrease over time due to intra-industry specialization among open economies. He also finds support for this hypothesis in French data. Thus, elasticities from older studies (e.g., from the 1990s or earlier) might not be useful in models based on more recent data as the trade pattern and trade motives might have undergone important changes since then.

2 Literature review

McDaniel & Balistreri (2003) show in a simulation exercise that the choice of the elasticity might be crucial in determining welfare gains or losses from a given policy reform. They find that even a qualitative switch in the overall welfare result is possible by changing the Armington elasticity. Schuerenberg-Frosch (2014) shows by drawing elasticities randomly from a uniform distribution that even though the quantity variables are robust, price results are quite sensitive with respect to the elasticity set. A similar approach is used by Frey & Olekseyuk (2014) and Jensen & Tarr (2012) with comparable results.

Several studies have estimated Armington elasticities since the 1970s, summaries of the literature can be found for instance in McDaniel & Balistreri (2003) and Welsch (2008). We focus here on the most recent findings on the size and determinants of Armington elasticities. The most striking impression from the literature review on estimated Armington elasticities is that the overwhelming majority of time series estimations with disaggregated industries are for the US (e.g., Reinert & Roland-Holst (1992), Shiells & Reinert (1993), Blonigen & Wilson (1999) and Gallaway *et al.* (2003)). Only very few time series analyses exist for other countries as also Welsch (2008) points out.

Most generally, the Armington estimates available can be grouped as follows: There exist single-country time series studies and a limited number of cross-sectional or panel studies. In addition, one needs to distinguish between those studies that estimate a CES function which is basically derived from a corresponding CGE model and those that estimate a multi-equation trade model. While some studies estimate the so-called 'macro'-elasticity, i.e., the elasticity of substitution between domestic and foreign goods others estimate the 'micro'-elasticity which is the elasticity of substitution between different countries of origin. Few studies follow a nested approach and estimate both. Moreover, studies differ in the frequency of the data and degree of sectoral disaggregation used as well as in the econometric procedure applied. To sum up, even though there exists quite a number of studies in the field, results are hardly comparable across these studies - a point also made by McDaniel & Balistreri (2003). Nonetheless, many authors make this exact comparison.

Following McDaniel & Balistreri (2003) some general findings emerge from the literature:

1. Long-term elasticities are larger than short-term elasticities. This point is indeed found by most authors even though using substantially differing approaches to reach this conclusion. The studies by Gallaway *et al.* (2003), Welsch (2006, 2008) and Németh *et al.* (2011) use error correction models and thus explicitly estimate a short-term and a long-term relationship for each sector. Gibson (2003), in contrast, comes to the same conclusion by comparing results obtained with quarterly data and annual data. This finding is very plausible given that the reaction to changes in relative prices might be rather slow due to high adjustment costs.

2. The 'micro'-elasticity which determines the ease of substitution between foreign goods of different origins is much higher than the 'macro'-elasticity between domestic and foreign goods. This point, too, is quite intuitive especially in the context of a large gap in technology between the respective country and its trading partners. McDaniel & Balistreri (2003) argue that some authors confuse these elasticities and compare results for the one with results for the other. This stylized fact can be found by comparing studies that only estimate the macro elasticity (like, e.g., Shiells & Reinert (1993), Reinert & Roland-Holst (1992), with studies that only estimate the micro elasticity. The finding is confirmed by studies that follow a two-stage-procedure and estimate the nested-CES-function like Németh *et al.* (2011) and Feenstra *et al.* (2012).

3. The estimated elasticities increase with the degree of disaggregation in the data. Again, a very plausible finding, as more disaggregate data contains sectors that are more homogeneous in the produced goods and thus also higher in their international substitutability. This phenomenon is generally considered as an "aggregation bias". While this might be true in the econometric context, if the estimated elasticities are to be used for a CGE model, the problem is somewhat more complex. The aggregation in the data used for estimation should, in our view, match the aggregation that will be used in the respective CGE model. Hence, while the estimated elasticities at a 2-digit-level might be too low for the use in a very disaggregate trade model, they might, however, be more convenient for a rather aggregated CGE model - a point also made by Welsch (2006). Given that this aggregation problem has been confirmed by many studies, one should, as McDaniel & Balistreri (2003) point out, be cautious in using elasticities from a very aggregate estimation in a more disaggregate setup or vice versa. However, this is a common practice.

4. Many authors argue that elasticities in time-series studies are smaller than those resulting from "cross-sectional" studies. However, this conclusion can be questioned. First of all, most time-series analyses refer to the US while cross-sectional studies

only partly cover Europe. Hence, the US might as well just be an outlier and the average elasticity in larger cross-sections is simply higher because also the single-country elasticities would be higher if they would have been investigated. An indication for this conjecture can be found in Gibson (2003) who finds at least for South Africa considerably higher elasticities in a time-series study. Note that the definition of "cross-sectional" is not the same across studies. Some have the cross-sectional dimension "trading partner" while others estimate across sectors and a third group uses a cross-section of importing countries. Thus, some in fact estimate the 'micro' elasticity, some estimate the 'macro' elasticity and some estimate a cross-sectoral average elasticity per country which should be highly biased if an aggregation bias exists. Nonetheless, the fact that the US time series estimations lead to considerably lower elasticities compared to alternative approaches should not be ignored and will be part of our focus in this paper.

McDaniel & Balistreri (2003) raise another question which concerns the correspondence between the econometric model and the CGE model. Some authors such as Erkel-Rousse & Mirza (2002) argue that the results of a single equation estimation directly estimating the CES-function are biased as the resulting elasticity also includes the supply elasticity. These authors use a system of equations based on a trade model. Nonetheless, the CES function which is used in most of the studies directly stems from the CGE models in which the Armington elasticity will be employed. Thus, even though the estimates from a direct estimation of the CES function might be biased both due to the left-out supply side and due to a rather high degree of sectoral aggregation they might still be the best possible study design for the Armington elasticity in CGE models.

Most time series studies, especially for the US, use 3-digit-level data (i.e., between 150 and 200 sectors) and employ either a simple OLS, an OLS with lagged endogenous variables or, more recently, error correction approaches as the variables are typically integrated. Examples for time-series approaches are Reinert & Roland-Holst (1992), Shiells & Reinert (1993), Gallaway *et al.* (2003) and Blonigen & Wilson (1999) for the US, Kapuscinski & Warr (1996) for the Philippines, Gibson (2003) for South Africa and Welsch (2006) for France. Saito (2004), Welsch (2008) and Németh *et al.* (2011) provide panel data results. The panel studies typically use a much higher aggregation with only 6-15 sectors. The elasticities in panel studies are slightly smaller than those in time-series studies thus contradicting the argument that cross-sectional studies per se obtain higher elasticities.

This paper tries to shed light on observable patterns in estimated elasticities by comparing the macro elasticity obtained from a 2-digit-level dataset (which is the degree of disaggregation also used in the EU and OECD SAMs and thus used in many CGE studies for these countries) across European countries. We try to fill two gaps in the literature. First, we provide estimated elasticities for a number of countries outside the US. Second, we examine whether it is acceptable to use estimated elasticities for another country when specifying a CGE model - which is very often done in practical CGE work.

3 Theoretical background

Armington (1969) developed the theoretical basis used as modeling approach for import demand in most CGE studies. Armington assumes that product varieties from different places of production are imperfect substitutes. Thus consumers will at the same time consume home and foreign varieties of the same good. Their demand for different varieties will depend on the so-called Armington elasticity. The Armington elasticity will increase with the perceived similarity between the varieties.

The CES subutility function for imports is normally assumed to be:

$$U(M, D) = \alpha \left[\beta \, M^{\frac{\sigma-1}{\sigma}} + (1-\beta) \, D^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where α and β can be calibrated in CGE model applications from base year data and σ denotes the constant elasticity of substitution between imports (M) and domestic supply (D). σ cannot be calibrated and thus needs to be estimated and introduced as an exogenous parameter in CGE models.

Utility maximization of (1) yields the following first-order condition:

$$\frac{M}{D} = \left[\left(\frac{\beta}{1-\beta} \right) \left(\frac{p_D}{p_M} \right) \right]^{\sigma}, \tag{2}$$

where p_D and p_M denote the prices of the domestic and foreign varieties respectively. Taking equation (2) in natural logarithms leads to the regression function:

$$ln \left(\frac{M}{D} \right) = \sigma \, ln \left(\frac{\beta}{1-\beta} \right) + \sigma ln \left(\frac{p_D}{p_M} \right), \tag{3}$$

where the Armington elasticity can be derived directly from the estimated coefficient of the price relation between domestically produced and imported varieties.

4 Data and econometric specification

This paper estimates equation (3) for the manufacturing sectors of eight European countries. The econometric procedure and data sources are described in the following subsections.

4.1 Data sources and limitations

Previous studies differ significantly in both, the frequency of the data and the degree of sectoral disaggregation. Our paper aims at providing guidance on the choice of elasticities in the CGE modeling context. Given that the majority of CGEs is calibrated to yearly data and mainly interpreted to provide insights on medium term developments, we run our regressions based on yearly data, even though this strongly limits data availability. However, as other studies have shown significant differences between long-term and short-term elasticities we stick to our choice of yearly data in order to prevent a downward bias in our results due to the use of quarterly data.

We combine data from two sources: Production data stems from OECD's STAN database which comprises production data both in current and constant prices for 32 OECD countries in ISIC Rev. 3 classification until the year 2009 and for 15 countries in ISIC Rev. 4 up to the year 2011. We need both time series in order to compute the price deflator series. As the STAN database does not comprise data on imports at constant prices, we use data from EUROSTAT's PRODCOM database for the import and export variables. The PRODCOM data is only available from 1995 onwards and only covers the manufacturing sectors. Hence, we had to limit our analysis to these sectors and years as other data sources with sufficient sectoral detail, comparable sector classification and coverage of both values and volumes were not available.

Table 1: Database properties

Indicator	**Source**	**Sector coverage**	**Period coverage**
Production at current prices (PROD)	OECD STAN	ISIC 01-99	1970 - 2009/2011
Production at constant prices (PRODK)	OECD STAN	ISIC 01-99	1970 - 2009/2011
Imports value (IMP_VAL)	PRODCOM	NACE Rev. 1.1 10-40	1995-2011
Imports quantity (IMP_Q)	PRODCOM	NACE Rev. 1.1 10-40	1995-2011
Exports value (EXP_VAL)	PRODCOM	NACE Rev. 1.1 10-40	1995-2011
Exports quantity (EXP_Q)	PRODCOM	NACE Rev. 1.1 10-40	1995-2011

Table 1 describes the two data sources. It shows that the PRODCOM data covers much fewer years and sectors compared to STAN data. In addition, for some countries, esp. new EU member countries, the time series only start in 2001. For other countries the constant price data in STAN was incomplete or not available. Hence, we were only able to calculate the required data for nine countries and a subset of 18-21 sectors. Nevertheless, this is, to our knowledge, the broadest coverage ever included in an analysis of Armington elasticities for European countries.

4.2 Data transformation

Estimation of equation (3) requires data for the relation between imports and domestic supply in quantity terms as well as for the price relation. These data are not readily available in any public data source and the data in constant and current prices from OECD STAN are also not directly comparable to the data in volumes and quantities from PRODCOM. We took the following steps to calculate the required series:

1. Imports and exports from PRODCOM were initially available in quantity and value terms. We first calculated unit prices based on the two series.
2. We then calculated imports and exports in constant terms and choose the base year in accordance to the base year in OECD STAN for the respective country.
3. We then calculate the import and export price deflator, which will be used as price proxy variable in our regression.
4. The production data was readily available in current and constant terms. However, we need data for domestic supply instead of domestic production. Hence, we calculated domestic supply as *Domestic production + Imports - Exports*. This measure was calculated both in current and constant terms as well as the resulting price deflator which serves as a proxy for the domestic price.[1]

As a result we have a dataset which covers 4 countries (Belgium, Czech Republic, Denmark and Greece) in ISIC Rev. 3 sector classification and 5 countries (Austria, Finland, France, Hungary and Italy) in ISIC Rev. 4 sector classification. The data and sector coverage are shown in Table 2.

4.3 Time series properties

We conduct unit root tests to check whether the underlying time series are stationary or integrated. This step is important as a regression with non-stationary time series may lead to a spurious regression with significant parameters and high values for the coefficient of determination even if the variables are not correlated. Hereby, a time series is non-stationary if the mean and autocovariances of the series depend on time. If time series are stationary in the first or second differences (i.e., integrated of order one or two), it is possible to estimate a cointegration relationship. According to Engle & Granger (1987), two variables are cointegrated if they are integrated with the same order and there exists a linear combination of the two series which is integrated with lower order than the series.

[1]This procedure cannot completely account for the demand and imports of intermediates if they belong to the same sector as the respective end product. In some cases this left us with negative domestic supply. The respective sectors were excluded from the dataset.

Table 2: Data coverage

Country	Sectors	Years
ISIC Rev. 3		
Belgium	15, 17-18, 20, 22-25, 27-36	1995-2009
Czech Republic	15-36	2001-2009
Denmark	15-33, 35-36	1995-2007
Greece	13-15, 17-27, 29-33, 36	1995-2009 (incomplete)
ISIC Rev. 4		
Austria	09-13, 16-17,19-20, 22-30	1995-2011
Finland	9-11, 13-17, 20, 22-26, 28, 30	1995-2011
France	9-29	1995-2011 (incomplete)
Hungary	16-17, 20-30	2001-2010
Italy	16-28, 30	1995-2010

Following the Engle-Granger methodology, the residuals from an OLS estimation with time series integrated of order one have to be stationary in case of cointegrated variables.

The results for Augmented Dickey-Fuller (ADF) tests are shown in Tables A.1 and A.2 in the appendix. We test all the time series as well as the residuals for a unit root in the level, first and second difference with different specifications in the test equation: including a constant, including a constant and a linear trend, and excluding both. Most time series are non-stationary, but integrated of order one or two. We hence run regressions for each sector in each country where the requirements of the Engle-Granger-procedure are met (i.e., same order of integration for both series) and for those series which are stationary.

The corresponding residuals from the OLS estimations are stationary only for some sectors in each of the countries. For instance, for Greece we find a cointegrating relationship in such sectors as food products and beverages, paper and paper products, rubber and plastic products and others.

We suspect that the non-stationarity of the OLS residuals is mainly driven by the short time series for single sectors and countries as the number of observations varies between 9 for the Czech Republic and 17 for Finland what implies a poor accuracy of stationarity and integration tests.

4.4 Econometric procedure

For sectors which possess initially stationary or cointegrated time series in a first step we estimate equation (3) using OLS following the above-mentioned Engle-Granger-procedure for integrated time series. The results will be shown in the next section. However, due to the rather small number of observations per sector, we are often not able to clearly identify a cointegrating relationship at the sectoral level. As this leads to the exclusion of many available sectors for every country due to the test result of non-stationary and not cointegrated time series, we try in a second step to increase the number of observations and hence, the accuracy of both the estimation and the test statistics, by pooling the data over comparable (i.e., neighbouring) sectors. A comparable strategy has been chosen by Welsch (2008).

We pool comparable industries to broader groups (see Table A.3 in the appendix) with the aim to increase the degrees of freedom and to obtain further reliable estimates for the Armington elasticities. The approach to combine information from the time series dimension with the cross-sectional one is often used in cases with short time series which are available across a cross-section of units such as countries, regions, firms or industries.[2]

As the pooled sectors include several single industries we implement a panel fixed effects analysis accounting for individual effects. As we expect a contemporaneous correlation between the single industry residuals we use corrected White cross-section standard errors (see White, 1980) to allow for non-zero covariances across cross-sections clustered by period. The procedure of OLS estimation combined with bias correction for autocorrelated disturbances is commonplace in panel analysis according to Arellano (1987), Moulton (1986) and Hansen (2007). Kezdi (2005) demonstrates that finite samples with a low number of observations can be used for panel analysis if standard error correction is used in case of serial correlation in the error process.

5 Results

5.1 Single-sector cointegration analysis

The analysis of the time series properties showed that for most countries both the price and quantity ratio series are non-stationary, but integrated of order one or two. This implies the risk of spurious regression meaning that non-stationary and not cointegrated time series may lead to significant coefficients for the Armington elasticity without any economic meaning. Hence, we perform simple time series OLS estimations only for those

[2]See, for example, Banerjee (1999) and Baltagi & Kao (2000).

sectors of the eight[3] European countries which possess initially stationary or cointegrated time series. Moreover, the restricted data availability[4] reduces the number of estimates further. For instance, for Hungary there is data for only 13 sectors with 10 observations available which is not enough to estimate all industry-level elasticities. We cannot present any estimates for Belgium as the time series for all sectors are non-stationary and obviously not cointegrated being integrated of different orders. Therefore, we present here the estimated coefficients for sectors with available data and stationary or cointegrated time series. These implications allow us to estimate seven elasticities for Finland, Austria, Denmark and Greece, while for France and Italy only three coefficients can be obtained.

Tables 3 and 4 summarize the OLS coefficient estimates for all countries and sectors with stationary or cointegrated time series in the different revisions of the ISIC classification. Only 17% of all estimates are insignificant. Those are the elasticities for wood and rubber products in the Czech Republic, other non-metallic mineral products in Denmark and France, computer, electronic and optical products in Hungary, wearing apparel in Finland as well as for coke and refined petroleum products in Austria. The significant estimates range between 0.30 and 3.67 which is a plausible magnitude when compared to results in the literature. Moreover, only two of the significant elasticities are negative (for food products in Finland and Austria) which lends some support to the validity of the obtained results which are comparable with other studies in this field. For instance, Gibson (2003) finds for South Africa for 32 out of 42 industries positive and significant short-run Armington elasticities in the range between 0.42 and 2.77. For the Philippines, Kapuscinski & Warr (1996) obtain estimates between 0.20 and 4.00. However, only half of their coefficients are positive and significant. Welsch (2008) derives elasticities for four European countries[5] and 17 sectors with values between 0.04 and 3.68. In his study, 64% of all estimates are significant at the 5% level and there are 8 negative estimates out of 53 coefficients.

Our results indicate a rather large variation across sectors and countries. In particular, the country averages over all sectors vary from 0.68 in the Czech Republic to 1.91 in Finland. There are among the European countries also strong differences in the variance of the industry-specific elasticities. While the estimates for Finland and Austria lie in rather broad intervals from 0.60 to 2.95 and 3.67, respectively, the values for Denmark show a much smaller range between 0.88 and 1.42 or for Italy even between 0.93 and 1.31. Such differences also occur for particular sectors. For instance, the estimated values for beverages vary from 1.90 in Finland to 3.67 in Austria. Somewhat smaller differences across

[3]For Belgium, we could not clearly determine the time series properties and have thus excluded it from all regressions shown.

[4]See Table 2.

[5]Germany, France, Italy and United Kingdom.

countries are found for non-metallic mineral products (from 0.94 in Italy to 1.25 in Austria) and for other transport equipment (from 1.13 in Denmark to 1.42 in Czech Republic).

Generally, we find smaller elasticities of substitution between imported and domestic goods for sectors with lower value-added (processing of raw materials and agricultural products and basic manufacturing) while elasticities are higher in sectors with higher value-added (more elaborate manufacturing and technology). In particular, the elasticity for mining support activities in Austria is 0.61 while the value for motor vehicles, trailers and semi-trailers is higher with 1.37. The estimate of 0.30 for coke and petroleum products in Czech Republic is much lower than the elasticity for other transport equipment with the value of 1.42. This implies that substitutability of low-level processed goods, such as primary and consumer products, is lower compared to investment and high value-added goods. A possible explanation for this rather unintuitive result might be a high share of intra-industry trade in high value-added sectors. Saito (2004) shows that there is a difference in magnitude of estimated elasticities if trade consists largely of intermediate inputs.

Table 3: Single-sector results for ISIC Rev. 3 classification

ISIC Rev. 3		Czech Republic		Denmark		Greece	
	Sector	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2
13	Mining of metal ores	NA		NA		-	-
14	Other mining and quarrying	NA		NA	-	-	-
15	Food products and beverages	-	-	-	-	1.300***	0.853
16	Tobacco products	NA		1.318***	0.939	NA	
17	Textiles	-	-	1.416***	0.685	-	-
18	Wearing apparel	-	-	-	-	1.208***	0.681
19	Leather and related products	-	-	NA		-	-
20	Wood and cork products	0.024	0.001	1.149***	0.977	-	-
21	Paper and paper products	-	-	-	-	1.436***	0.789
22	Publishing, printing and reproduction of recorded media	-	-	1.057***	0.978	0.709***	0.737
23	Coke, refined petroleum products and nuclear fuel	0.302*	0.396	NA		NA	-
24	Chemicals and chemical products	-	-	0.880***	0.742	-	-
25	Rubber and plastics products	0.561	0.178	-	-	0.891***	0.884
26	Other non-metallic mineral products	-	-	0.574	0.060	-	-
27	Basic metals	-	-	-	-	1.049***	0.500
28	Fabricated metal products	NA		-	-	NA	
29	Machinery and equipment	-	-	-	-	0.924***	0.992
30	Office, accounting and computing equipment	-	-	-	-	NA	
31	Electrical machinery and apparatus	-	-	-	-	-	-
32	Radio, television and communication equipment	-	-	-	-	-	-
33	Medical, precision and optical instruments	-	-	-	-	-	-
34	Motor vehicles, trailers and semi-trailers	1.096***	0.998	NA		NA	
35	Other transport equipment	1.417***	0.875	1.132***	0.918	NA	
36	Furniture, other manufacturing	-	-	-	-	-	-

***, **, * indicates significance at the 1%, 5% and 10%-level, respectively; NA indicates data unavailability.

Table 4: Single-sector results for ISIC Rev. 4 classification

ISIC Rev. 4		Austria		Finland		France		Hungary		Italy	
	Sector	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2	Coeff.	R^2
9	Mining support service activities	0.611**	0.259	-	-	-	-	NA		NA	
10	Food products	-2.369***	0.721	-2.044***	0.717	-	-	NA		NA	
11	Beverages	3.670***	0.697	1.900***	0.905	-	-	NA		NA	
12	Tobacco products	-	-	-	-	-	-	NA		NA	
13	Textiles	-	-	-	-	1.200***	0.925	NA		NA	
14	Wearing apparel	NA		-2.863	0.081	-	-	NA		NA	
15	Leather and related products	NA		-	-	-	-	NA		NA	
16	Wood and cork products	-	-	2.117***	0.728	-	-	-	-	-	-
17	Paper and paper products	-	-	2.953***	0.954	-	-	-	-	-	-
18	Printing and reproduction of recorded media	NA		NA	-	-	-	NA		1.013***	0.558
19	Coke and refined petroleum products	0.811	0.158	NA		-	-	NA		-	-
20	Chemicals and chemical products	-	-	0.870***	0.606	-	-	-	-	-	-
21	Basic pharmaceutical products and preparations	NA		NA		-	-	-	-	-	-
22	Rubber and plastics products	0.784***	0.623	-	-	-	-	-	-	-	-
23	Other non-metallic mineral products	1.246***	0.873	-	-	0.696	0.101	-	-	0.932***	0.954
24	Basic metals	-	-	-	-	-	-	-	-	-	-
25	Fabricated metal products	-	-	-	-	-	-	1.031***	0.990	-	-
26	Computer, electronic and optical products	-	-	0.595**	0.337	NA		0.202	0.032	1.309***	0.848
27	Electrical equipment	-	-	NA		-	-	-	-	-	-
28	Machinery and equipment	-	-	-	-	NA		-	-	-	-
29	Motor vehicles, trailers and semi-trailers	1.371***	0.967	NA		1.462***	0.997	-	-	NA	
30	Other transport equipment	NA		-	-	NA		-	-	-	-

***, **, * indicates significance at the 1%, 5% and 10%-level, respectively; NA indicates data unavailability

5.2 Panel fixed effects analysis

Given the rather small amount of reliable results from single-sector OLS estimation, we move on to pooled fixed effects estimations across comparable sectors in order to increase the number of observations (i.e., the number of degrees of freedom) and thus the accuracy of the results and the test statistics. Pooling the data over 2-3 sectors implies, of course, a loss in the level of disaggregation. However, we consider the results as more reliable. In addition, panel estimates may also serve as a robustness check for the single-sector cointegration analysis. We use corrected standard errors, clustered by period to control for contemporary correlation among residuals.

The panel estimation results are given in Tables 5 and 6. As with single-sector estimations only 17% of all estimated coefficients are insignificant, this includes the elasticities for food and beverages in France and Austria; rubber, plastics and non-metallic products in France, Hungary and Denmark; textiles, clothing and leather products in the Czech Republic and electronic, computer and optical equipment in Hungary.

The use of panel fixed-effects OLS increases the quality of our estimations as we obtain no negative elasticities among the significant coefficients. Furthermore, according to the redundant fixed effects test all estimations, except for wood products in Finland and rubber products in France, deliver significant cross-section fixed effects. The Jarque-Bera statistic indicates that the estimated residuals are normally distributed.[6]

As pooling of comparable 2-digit commodity groups of ISIC leads to an increased variety of individual goods inside a group, the substitutability between domestic and foreign varieties declines in comparison with the single-sector 2-digit level results. We observe that all significant estimates lie now in the interval between 0.32 and 2.43 compared to the maximum value of 3.67 before. The highest country average across sectors is found for Finland with the value of 1.65 which is lower than the Finnish average found above.

The pooled estimates also indicate a reduced variance in the sector-specific elasticities for each of the European countries. In particular, the coefficients for Finland are only between 1.13 to 2.43, for Czech Republic - between 0.32 and 1.29, while the smallest interval is found for Hungary: from 1.03 to 1.13 only. Anyway, we still find quite large differences between the industry-level estimates across the European countries. The Armington elasticity for wood and paper products varies from 0.62 in the Czech Republic to 2.43 in Finland. For metals and fabricated metal products we obtain the estimates in the

[6] Jarque-Bera test results are not shown here for brevity. For the sake of completeness: The null hypothesis of normally distributed residuals is rejected for coke, petroleum and chemicals in Austria and Italy; electronic, computer and optical products in Austria; textiles, clothing and leather products in Finland and France; wood and paper products in Finland and Italy.

range from 0.84 in Italy to 1.62 in Finland. Somewhat smaller differences can be observed for coke, petroleum and chemicals (from 0.83 in Austria to 1.33 in Italy) as well as for machinery (from 0.92 in Greece to 1.01 in Denmark).

The presented pooled estimates are slightly lower compared to the results of Welsch (2008) who also pooles comparable 2-digit sectors to some extent. However, only a generic comparison is possible as the country samples overlap only for France and Italy. Nevertheless, Welsch (2008) finds an Armington elasticity of 1.495 for textiles, clothing and leather products in France while our coefficient amounts to 1.12. The same can be observed for rubber and plastic products in Italy where our elasticity is lower with 0.80 than the value of 2.22 in the aforementioned study. These differences occur mostly due to the slightly different econometric specification used and another time horizon (1979-1990) of the underlying data.

Our results differ also from the estimated Armington elasticities for the US in the 1980s and 1990s. Reinert & Roland-Holst (1992) estimate the elasticities for 163 sectors in the interval from 0.14 to 3.49 while Gallaway *et al.* (2003) obtain estimates for 306 commodity groups ranging between 0.52 and 4.83 with a long-run average of 1.55. Even though the estimated values by Reinert & Roland-Holst (1992) range in a rather wide interval, the majority of their coefficients lies between 0 and 1, a smaller range than in our estimates. Taking into account the high level of disaggregation (e.g., 4-digit SIC) in the cited study this is surprising as a higher degree of disaggregation is normally associated with higher substitutability. The rather low US elasticities might be a distinct feature of the US economy, however, the higher elasticities for other countries outside the US[7] could partly be explained by the fact that the non-US studies are more recent and thus include the effects of increased international market integration and increasing competition which both lead to higher substitutability between domestic and foreign goods.

[7] See also Gibson (2003) for South Africa.

Table 5: Panel fixed effects results for ISIC Rev. 3 classification

ISIC Rev. 3	Czech Republic			Denmark[a]			Greece[b]		
Pooled series	Coeff.	$\overline{R}^2$	# Obs	Coeff.	$\overline{R}^2$	# Obs	Coeff.	$\overline{R}^2$	# Obs
Textiles, clothing and leather products	1.285*** [12.65]	0.753	27	-0.725 [-1.70]	0.602	26	1.329*** [20.61]	0.739	45
Wood and paper products	0.624** [2.15]	0.881	18	1.147*** [22.70]	0.925	26	1.176*** [34.91]	0.914	30
Coke, petroleum, fuel and chemicals	0.316** [2.84]	0.912	18						
Rubber, plastics and non-metallic products	0.673*** [3.97]	0.779	18	-0.053 [-0.15]	0.653	26	0.954*** [23.67]	0.993	30
Machinery	0.995*** [17.83]	0.933	27	1.011*** [19.52]	0.992	37	0.914*** [31.22]	0.993	27
Transport vehicles and equipment	1.117*** [67.51]	0.979	18						

[a] Textiles and clothing, except leather products
[b] Machinery, except office and computing equipment

***, **, * indicates significance at the 1%, 5% and 10%-level, respectively; t-statistics in parentheses.

Table 6: Panel fixed effects results for ISIC Rev. 4 classification

ISIC Rev. 4	Austria[a]			Finland[b]			France			Hungary[c]			Italy		
Pooled series	Coeff.	$\overline{R}^2$	# Obs	Coeff.	$\overline{R}^2$	# Obs	Coeff.	$\overline{R}^2$	# Obs	Coeff.	$\overline{R}^2$	# Obs	Coeff.	$\overline{R}^2$	# Obs
Food, beverages, tobacco	-0.081 [-0.13]	0.227	51	1.465*** [13.68]	0.559	34	0.161 [0.80]	0.985	36						
Textiles, clothing and leather products				1.620*** [5.15]	0.394	50	1.120*** [10.40]	0.767	40						
Wood and paper products	1.391*** [7.48]	0.746	34	2.433*** [12.21]	0.804	34	0.954*** [8.35]	0.917	24	1.068*** [7.81]	0.964	20	1.103*** [9.39]	0.866	32
Coke, petroleum, chemicals and pharmaceutical products	0.829** [2.48]	0.994	34				1.229*** [16.73]	0.912	51	1.025*** [21.83]	0.925	20	1.331*** [12.88]	0.944	48
Rubber, plastics and non-metallic mineral products	0.867*** [6.75]	0.871	31	1.125*** [12.11]	0.951	32	0.079 [0.23]	0.016	28	0.326 [0.88]	0.542	20	0.796*** [10.88]	0.774	32
Metals and fabricated metal products	1.182*** [9.78]	0.628	34	1.619*** [5.09]	0.723	34	1.096*** [16.77]	0.975	24	1.125*** [14.83]	0.925	20	0.840*** [10.55]	0.987	32
Electronic, computer, optical and electrical equipment	0.819*** [3.96]	0.420	28							0.045 [0.15]	0.392	20	0.924*** [26.68]	0.972	32

[a] Coke, petroleum and chemicals, except pharmaceutical products
[b] Food and beverages, except tobacco
[c] Chemicals and pharmaceutical products, except coke and petroleum

***, **, * indicates significance at the 1%, 5% and 10%-level, respectively; t-statistics in parentheses.

To sum up, our estimates lie within the interval that has emerged from other studies and thus seem to be reliable. However, if investigated in more detail than just comparing the averages and the dispersion of the results, non-negligible differences among sectors within one country as well as within one sector across countries are found. These cross-country and cross-sectoral differences in the Armington elasticities reflect diverging preferences of consumers with respect to domestic and foreign goods in different countries. In addition, differences in the specification of the studies may also explain diverging results. As the elasticities capture the substitutability between imports and domestic goods, which is determined by the degree of product similarity, a higher degree of aggregation leads to lower similarity within one group. Hence, in more aggregated setups, the elasticities should be lower. Keeping this in mind our estimates are surprisingly high compared to other studies given our highly aggregated commodity groups. The composition within one of our sectors at home and abroad can be quite different, thus we would have expected rather low elasticities of substitution. In addition, the estimates also reflect the availability of domestic and foreign goods which may be restricted as a result of protectionist and regulation measures in single countries and sectors. Hence, studies with rather low elasticities might consider sectors in countries with a higher degree of protection. Another difference in the specification simply lies in the time horizon. Most of the mentioned studies for the US use data from the 1970s or even earlier whereas most of the studies investigating countries outside the US use more recent data. It is well possible that with growing international market integration the substitutability between goods from different origins increases. Hence, differences in the results might also stem from differences in the underlying time horizon. Additional explanations for diverging results have been mentioned in the literature review in section 2.

6 Example application

The choice of the Armington elasticity might influence the results of CGE model applications. This fact is shown by McDaniel & Balistreri (2003), Schuerenberg-Frosch (2014), Frey & Olekseyuk (2014). In order to stress the relevance of our results, we show here a small application which compares the effects of a political intervention in a stylized model with two different elasticity sets.

We use a very aggregate version of the GTAP-Model, which is a broadly known and used model.[8] As an example country we use the Czech Republic and the dataset is GTAP8.1. The data is aggregated to just two regions (Czech Republic and Rest of the World) and

[8] A description of the model can be found at `https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=409`

seven sectors (see Table A.4 in the appendix).[9] In this condensed model we alter the elasticity set between the GTAP elasticities (S1) and our estimated elasticities (S2) for the Czech Republic and compare the effects of a policy scenario. As a policy intervention we choose an abolition of the import tax for domestic firms while the import tax rates for the rest of the world remain at the initial level.

The differences between the GTAP elasticities and our elasticities are shown in Table 6. It is quite obvious that the differences are noteworthy.

Table 7: Comparison of Armington elasticities for the Czech Republic

	Sector	GTAP elasticity	Estimated elasticity
TCL	Textiles, clothing and leather products	3.783	1.285
WPP	Wood and paper products	3.103	0.624
CPF	Coke, petroleum, fuel*	2.010	0.302
RPP	Rubber, plastics and non-metallic products	3.211	0.673
MAC	Machinery	4.175	0.995
TVE	Transport vehicles and equipment	3.192	1.170
OTH	Other GTAP sectors	2.501	-

* For coke, petroleum and fuel sector we use the single-sector estimate from Table 3.

Table 8: Aggregate results, change in %

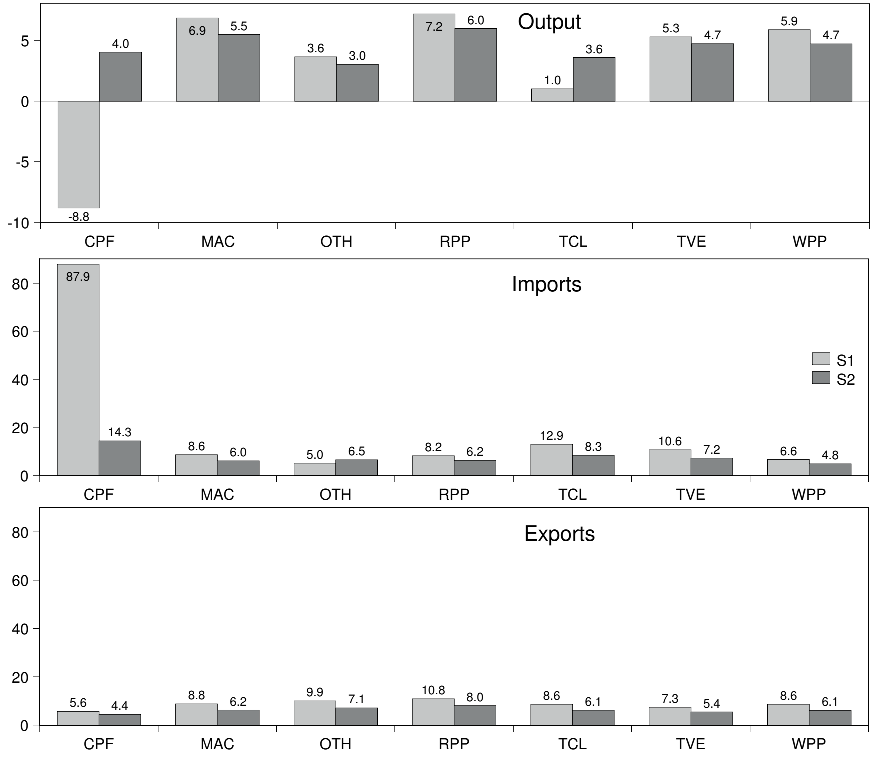
	Czech Republic		Rest of the World	
	S1	S2	S1	S2
Welfare (Hicksian welfare index)	-1.87	-0.49	0.00	0.00
Real GDP	1.28	1.58	0.00	0.00
Aggregate exports	9.03	6.47	3.94	2.36
Aggregate imports	9.21	6.55	3.77	2.29
Capital remuneration	-0.85	-0.47	0.00	0.00
Unskilled labor remuneration	-0.75	-0.37	0.00	0.00
Skilled labor remuneration	-0.98	-0.60	0.00	0.00
Remuneration for provision of natural resources	-1.27	-0.86	0.00	0.00

The changes in economic aggregates as a result of the aforementioned simulations are represented in Table 8. While the rest of the world benefits from the policy intervention only due to the increase of trade flows, the aggregate results for the Czech Republic indicate a welfare loss together with a rise of real GDP. The elimination of firms' import tax lowers the price for imported intermediates and therefore increases firms' intermediate demand for foreign goods which goes together with reduced demand for domestic intermediates. This leads to a decrease of production factors remuneration and thereby to a welfare decrease for Czech consumers. However, comparing the results obtained with dif-

[9] Please note: The sector aggregation of GTAP does not completely match our aggregation for the pooled estimation shown above. In particular, such sectors as wood and paper industry (WPP), rubber, plastics and non-metallic products (RPP) and machinery (MAC) in the GTAP dataset include additional ISIC Rev. 3 2-digit commodity groups.

ferent elasticity sets we observe smaller changes in S2[10] because of lower substitutability between domestic and foreign goods in the case of our estimated elasticities. In particular, the welfare loss is much lower in S2 and amounts to only about one quarter of the effect realized under the GTAP specification. In other words, assuming that our econometric results for the Czech Republic are correct, the GTAP elasticity specification overstates the welfare effect by a factor of four. There are also noticeable differences at the sectoral level (see Figure 1). Disaggregate results demonstrate lower increases of imports and exports for all sectors with the highest difference for the imports of coke, petroleum and fuel (CPF). The small increase by 14.34% in S2 compared to 87.90% in S1 leads even to a switch of output changes for the CPF sector from negative to positive. These even qualitatively different results confirm the concern that one might end up with biased results from CGE simulations due to a misspecification of the elasticities.

Figure 1: Disaggregate results for Czech Republic, change in %



[10]With the exception of real GDP. The increase is higher in S2 due to positive changes in output of the coke, petroleum and fuel sector, which is negative in S1 (see Figure 1 and Table A.5 in the appendix).

7 Conclusion and outlook

In this paper we estimate sector-specific Armington elasticities for a dataset of eight European countries. We obtain results for both, single 2-digit-level sectors as well as pooled sectors. In both single-sector and pooled estimations we find substantial differences across sectors and across countries. Only some of our coefficients are comparable in magnitude to the estimates for the US which are often used as a reference in CGE model specifications. Our results differ as well from the existing evidence for other countries outside the US even though the magnitude and variance of our results is comparable in general. It becomes clear from comparing our results across the included countries that country-specific preferences exist and should not be ignored even for a rather homogenous group of countries like the EU.

Our results support the view that a non-negligible uncertainty about the magnitude of Armington elasticities prevails and that both more investigation of these and a more sensitive modeling practice are needed. The significant cross-country differences emerging from our estimation results as well as quantitatively and even qualitatively different results illustrated in our example application clearly show that it is not acceptable to use estimated elasticities for another country when specifying a CGE model - which is very often done in practical CGE work. One might well end up with biased results from CGE simulations due to a misspecification of the elasticities.

We conclude that much more effort should be placed in both collecting and providing the required data and estimating the elasticities for each country and sector to be included in applied models separately. As the reliable estimation of elasticities of substitution, however, implies rather strong data requirements and, if done soundly, requires quite some effort, it would be ideal if data and results from specific countries would be made available to other modelers in order to improve general empirical validity of CGE model results as well as their policy relevance.

As long as estimated elasticities are not available and cannot be obtained, modelers should handle this problem transparently and try to address this known uncertainty in their model results by providing a detailed sensitivity analysis with respect to the choice of the elasticity set. An increased effort in both aspects, the estimation of elasticities and a transparent sensitivity analysis, would increase the reliability of CGE model results as well as the reputation of the modeling approach as a whole.

References

Arellano, Manuel. 1987. Computing Robust Standard Errors for Within-Groups Estimators. *Oxford Bulletin of Economics and Statistics*, **49**(4), 431–34.

Armington, Paul S. 1969. A Theory of Demand for Products Distinguished by Place of Production. *IMF Staff Papers*, **16**(1), 159–178.

Baltagi, Badi H., & Kao, Chihwa. 2000. *Nonstationary Panels, Cointegration in Panels and Dynamic Panels: A Survey.* Center for Policy Research Working Paper 16. Center for Policy Research, Maxwell School, Syracuse University.

Banerjee, Anindya. 1999. Panel Data Unit Roots and Cointegration: An Overview. *Oxford Bulletin of Economics and Statistics*, **61**(S1), 607–629.

Blonigen, Bruce A., & Wilson, Wesley W. 1999. Explaining Armington: What Determines Substitutability between Home and Foreign Goods? *The Canadian Journal of Economics / Revue canadienne d'Economique*, **32**(1), 1–21.

Engle, Robert F., & Granger, Clive W. J. 1987. Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, **55**(2), 251–76.

Erkel-Rousse, Hélène, & Mirza, Daniel. 2002. Import Price Elasticities: Reconsidering the Evidence. *The Canadian Journal of Economics / Revue canadienne d'Economique*, **35**(2), 282–306.

Feenstra, Robert C., Obstfeld, Maurice, & Russ, Katheryn N. 2012. *In Search of the Armington Elasticity.* http://www.econ.ucdavis.edu/faculty/knruss/FOR_6-1-2012.pdf.

Frey, Miriam, & Olekseyuk, Zoryana. 2014. A general equilibrium evaluation of the fiscal costs of trade liberalization in Ukraine. *Empirica*, **41**(3), 505–540.

Gallaway, Michael P., McDaniel, Christine A., & Rivera, Sandra A. 2003. Short-Run and Long-Run Industry-Level Estimates of U.S. Armington Elasticities. *North American Journal of Economics and Finance*, **14**(1), 49–68.

Gibson, Katherine Lee. 2003. Armington Elasticities for South Africa: Long- and Short-Run Industry Level Estimates. *TIPS Working Paper*, **2003**(12).

Hansen, Christian B. 2007. Generalized least squares inference in panel and multilevel models with serial correlation and fixed effects. *Journal of Econometrics*, **140**(2), 670–694.

Jensen, Jesper, & Tarr, David G. 2012. Deep Trade Policy Options for Armenia: The Importance of Trade Facilitation, Services and Standards Liberalization. *Economics: The Open-Access, Open-Assessment E-Journal*, **6**(2012-1).

Kapuscinski, Cezary A., & Warr, Peter G. 1996. *Estimation of Armington Elasticities: An Application to the Philippines.* Departmental Working Paper 1996-08. The Australian National University, Arndt-Corden Department of Economics.

Kezdi, Gabor. 2005. *Robust Standard Error Estimation in Fixed-Effects Panel Models.* Econometrics 0508018. EconWPA.

McDaniel, Christine A., & Balistreri, Edward J. 2003. A review of Armington trade substitution elasticities. *Economie Internationale*, **2003**(2), 301–313.

Moulton, Brent R. 1986. Random group effects and the precision of regression estimates. *Journal of Econometrics*, **32**(3), 385–397.

Németh, Gabriella, Szabó, László, & Ciscar, Juan-Carlos. 2011. Estimation of Armington elasticities in a CGE economy–energy–environment model for Europe. *Economic Modelling*, **28**(4), 1993–1999.

Reinert, Kenneth A., & Roland-Holst, David W. 1992. Armington elasticities for United States manufacturing sectors. *Journal of Policy Modeling*, **14**(5), 631–639.

Saito, Mika. 2004. Armington Elasticities in Intermediate Inputs Trade: A Problem in Using Multilateral Trade Data. *The Canadian Journal of Economics / Revue canadienne d'Economique*, **37**(4), 1097–1117.

Schuerenberg-Frosch, Hannah. 2014. How to Model a Child in School? A Dynamic Macrosimulation Study for Tanzania. *South African Journal of Economics*, **2014**(forthcoming).

Shiells, Clinton R., & Reinert, Kenneth A. 1993. Armington Models and Terms-of-Trade Effects: Some Econometric Evidence for North America. *The Canadian Journal of Economics / Revue canadienne d'Economique*, **26**(2), 299–316.

Siddig, Khalid, & Grethe, Harald. 2014. International price transmission in CGE models: How to reconcile econometric evidence and endogenous model response? *Economic Modelling*, **38**(C), 12–22.

Welsch, Heinz. 2006. Armington elasticities and induced intra-industry specialization: The case of France, 1970–1997. *Economic Modelling*, **23**(3), 556–567.

Welsch, Heinz. 2008. Armington elasticities for energy policy modeling: Evidence from four European countries. *Energy Economics*, **30**(5), 2252–2264.

White, Halbert. 1980. A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, **48**(4), 817–38.

8 Appendix

Table A.1: Stationarity and integration tests for ISIC Rev. 3

ISIC Rev. 3		Czech Republic			Denmark			Greece		
Sector		$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid
13	Mining of metal ores	-	-	-	-	-	-	I(1)	?	I(1)
14	Other mining and quarrying	-	-	-	-	-	-	I(1)	I(1)	I(1)
15	Food products and beverages	I(2)	I(2)	I(2)	I(2)	I(1)	I(2)	I(1)	I(1)	I(0)
16	Tobacco products	-	-	-	I(1)	I(1)	I(0)	-	-	-
17	Textiles	NI	I(2)	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)	I(1)
18	Wearing apparel	I(2)	I(2)	NI	I(1)	?	I(1)	I(1)	I(2)	I(0)
19	Leather and related products	I(1)	NI	I(1)	-	-	-	(1)	I(0)	I(1)
20	Wood and cork products	I(0)	I(1)	I(0)	I(1)	I(1)	I(0)	I(1)	I(1)	I(1)
21	Paper and paper products	I(2)	I(2)	I(1)	I(1)	I(0)	?	I(1)	I(0)	I(0)
22	Publishing, printing and reproduction of recorded media	I(1)	I(1)	I(1)	I(2)	I(2)	I(0)	I(2)	I(1)	I(0)
23	Coke, refined petroleum products and nuclear fuel	I(2)	NI	I(0)	-	-	-	-	-	-
24	Chemicals and chemical products	I(1)	NI	I(1)	I(1)	I(1)	I(0)	?	I(1)	I(2)
25	Rubber and plastics products	I(1)	I(2)	I(0)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)
26	Other non-metallic mineral products	NI	NI	I(1)	I(1)	I(1)	I(0)?	I(1)	I(0)	?
27	Basic metals	I(2)	I(0)	I(1)	I(1)	I(2)	I(1)	I(0)	I(0)	I(0)
28	Fabricated metal products	-	-	-	I(1)	I(1)	I(1)	-	-	-
29	Machinery and equipment	I(2)	I(2)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)
30	Office, accounting and computing equipment	NI	I(1)	NI	I(1)	I(1)	I(1)	-	-	-
31	Electrical machinery and apparatus	I(0)	I(1)	I(1)	I(2)	I(2)	I(1)	I(0)	I(1)	I(1)
32	Radio, television and communication equipment	NI	I(1)	I(1)	NI	I(0)	?	I(1)	I(1)	I(2)
33	Medical, precision and optical instruments	I(0)	I(1)	I(1)	I(1)	I(2)	?	I(1)	I(1)	I(1)
34	Motor vehicles, trailers and semi-trailers	I(2)	I(2)	I(0)	-	-	-	-	-	-
35	Other transport equipment	NI	I(2)	NI	I(1)	?	I(0)	-	-	-
36	Furniture, other manufacturing	I(2)	I(1)	I(2)	I(1)	I(0)	I(1)	I(0)	I(0)	?

NI = not integrated, ? = ambiguous test results

Table A.2: Stationarity and integration tests for ISIC Rev. 4

ISIC Rev. 4		Austria			Finland			France			Hungary			Italy		
	Sector	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid	$\frac{imp}{ds}$	$\frac{dsdef}{impdef}$	resid
9	Mining support service activities	I(0)/I(1)	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	-	-	-	-	-	-
10	Food products	I(1)	I(2)	I(0)	I(0)/I(1)	I(1)	I(0)	I(1)	I(1)	I(2)	-	-	-	-	-	-
11	Beverages	I(0)/I(1)	I(0)/I(1)	I(0)	I(0)/I(1)	I(2)?	I(0)	I(2)	I(1)	I(2)	-	-	-	-	-	-
12	Tobacco products	I(1)	I(0)	I(2)	-	-	-	I(1)?	I(1)	I(2)	-	-	-	-	-	-
13	Textiles	I(1)	I(1)	I(2)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	-	-	-	-	-	-
14	Wearing apparel	-	-	-	I(1)	I(1)	I(0)?	NI	NI	NI	-	-	-	-	-	-
15	Leather and related products	-	-	-	I(0)	I(1)	I(1)	I(1)	NI	I(1)	-	-	-	-	-	-
16	Wood and cork products	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)	I(0)/I(1)	NI	NI	I(1)	I(1)	I(0)	I(1)
17	Paper and paper products	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)	I(0)/I(1)	I(2)	I(0)	I(1)	I(1)	I(1)	I(1)
18	Printing and reproduction of recorded media	-	-	-	-	-	-	I(1)	I(1)	I(1)	-	-	-	I(1)	I(1)	I(0)
19	Coke and refined petroleum products	I(0)/I(1)	I(0)	I(0)	-	-	-	I(1)	I(1)	I(1)	-	-	-	I(1)	I(0)/I(1)	I(1)
20	Chemicals and chemical products	I(1)	I(0)/I(1)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)	NI	I(1)	I(2)	I(0)	I(1)
21	Basic pharmaceutical products and preparations	-	-	-	-	-	-	I(1)	I(1)	I(1)	I(1)	I(1)	I(2)	I(1)	I(1)	I(1)
22	Rubber and plastic products	I(0)	I(0)	I(0)	I(1)	NI	I(1)	I(1)	I(1)	I(1)	I(1)	I(2)	I(1)	I(1)	I(1)	I(1)
23	Other non-metallic mineral products	I(1)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)/I(1)	I(0)	I(0)	I(2)	NI	I(0)	I(1)	I(1)	I(0)
24	Basic metals	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(0)	I(2)	NI	I(1)	I(1)/I(2)	I(1)	I(0)	I(1)	I(1)
25	Fabricated metal products	I(0)	I(0)	I(1)	I(0)	I(0)	I(1)	NI	NI	I(1)	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)
26	Computer, electronic and optical products	I(1)	I(1)	I(1)	I(2)	I(2)	I(0)	-	-	-	I(0)	I(0)	I(0)	I(1)	I(1)	I(0)
27	Electric equipment	I(1)	I(0)	I(2)	-	-	-	I(1)	I(1)	I(1)	I(2)	I(1)/I(2)	I(0)/I(2)	I(1)	I(1)	I(1)
28	Machinery and equipment	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	-	-	-	I(2)	I(1)	I(2)	I(2)	I(1)	I(2)
29	Motor vehicles, trailers and semi-trailers	I(0)	I(1)	I(0)/I(1)	-	-	-	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)	-	-	-
30	Other transport equipment	-	-	-	I(1)	I(0)	I(1)	-	-	-	I(1)	I(1)	I(1)	I(1)	I(1)	I(2)

NI = not integrated, ? = ambiguous test results

Table A.3: Sector pooling

ISIC Rev.3			ISIC Rev.4		
	single sector	pooled sector		single sector	pooled sector
17	Textiles	Textiles, clothing and leather products	10	Food products	Food, beverages, tobacco
18	Wearing apparel		11	Beverages	
19	Leather and related products		12	Tobacco products	
20	Wood and cork products	Wood and paper products	13	Textiles	Textiles, clothing and leather products
21	Paper and paper products		14	Wearing apparel	
23	Coke, refined petroleum products and nuclear fuel	Coke, petroleum, fuel and chemicals	15	Leather and related products	
24	Chemicals and chemical products		16	Wood and cork products	Wood and paper products
25	Rubber and plastics products	Rubber, plastics and non-metallic products	17	Paper and paper products	
26	Other non-metallic mineral products		19	Coke and refined petroleum products	Coke, petroleum, chemicals and pharmaceutical products
29	Machinery and equipment	Machinery	20	Chemicals and chemical products	
30	Office, accounting and computing equipment		21	Basic pharmaceutical products and preparations	
31	Electrical machinery and apparatus		22	Rubber and plastics products	Rubber, plastics and non-metallic mineral products
34	Motor vehicles, trailers and semi-trailers	Transport vehicles and equipment	23	Other non-metallic mineral products	
35	Other transport equipment		24	Basic metals	Metals and fabricated metal products
			25	Fabricated metal products	
			26	Computer, electronic and optical products	Electronic, computer, optical and electrical equipment
			27	Electrical equipment	

Table A.4: Aggregation of GTAP sectors

Pooled sectors		ISIC Rev. 3	GTAP sectors		ISIC Rev. 3
TCL	Textiles, clothing and leather products	17	TEX	Textiles	17
		18	WAP	Wearing apparel	18
		19	LEA	Leather products	19
WPP	Wood and paper products	20	LUM	Wood products	20
		21	PPP	Paper products, publishing	21, 22
CPF	Coke, petroleum, fuel	23	P_C	Petroleum, coal products	23
RPP	Rubber, plastics and non-metallic products	25	CRP	Chemical, rubber, plastic products	24, 25
		26	NMM	Mineral products nec	26
MAC	Machinery	29, 31	OME	Machinery and equipment nec	29, 31, 33
		30	ELE	Electronic equipment	30, 32
TVE	Transport vehicles and equipment	34	MVH	Motor vehicles and parts	34
		35	OTN	Transport equipment nec	35
OTH	Other GTAP sectors		Other GTAP sectors n.e.c.		

Table A.5: Disaggregate results, change in %

Sector		Czech Republic S1	Czech Republic S2	Rest of the World S1	Rest of the World S2
Output					
Coke, petroleum, fuel	CPF	-8.82	4.03	0.07	0.01
Machinery	MAC	6.86	5.49	-0.01	0.00
Rubber, plastics and non-metallic products	RPP	7.19	5.99	-0.01	-0.01
Textiles, clothing and leather products	TCL	1.00	3.59	0.02	0.01
Transport vehicles and equipment	TVE	5.29	4.73	0.00	0.00
Wood and paper products	WPP	5.89	4.72	-0.01	0.00
All other GTAP sectors	OTH	3.64	3.03	0.00	0.00
Imports					
Coke, petroleum, fuel	CPF	87.90	14.34	0.52	0.31
Machinery	MAC	8.57	6.04	3.51	2.01
Rubber, plastics and non-metallic products	RPP	8.15	6.24	5.46	3.78
Textiles, clothing and leather products	TCL	12.92	8.35	3.37	1.94
Transport vehicles and equipment	TVE	10.57	7.20	2.16	1.26
Wood and paper products	WPP	6.63	4.76	3.33	1.91
All other GTAP sectors	OTH	5.05	6.46	4.64	2.85
Exports					
Coke, petroleum, fuel	CPF	5.62	4.41	78.83	9.85
Machinery	MAC	8.76	6.18	3.33	1.87
Rubber, plastics and non-metallic products	RPP	10.81	8.02	2.94	2.06
Textiles, clothing and leather products	TCL	8.61	6.11	7.47	4.09
Transport vehicles and equipment	TVE	7.34	5.40	5.24	2.99
Wood and paper products	WPP	8.57	6.08	1.48	0.64
All other GTAP sectors	OTH	9.94	7.06	-0.02	2.28