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MAKRO

Estimating trade elasticities for Denmark

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Abstract

We estimate the elasticity of substitution between domestically produced goods and imported goods. In particular, we estimate the home-foreign elasticity of substitution - also known as the macroelasticity. We use a methodological approach based on Feenstra et al. (2018), in which we distinguish the elasticity of substitution of imported goods from different countries of origin (microelasticity) and the macroelasticity. The median microelasticity is 2.97, while we estimate the macroelasticity to be 1.81.

1 Introduction

The elasticity of substitution between domestic and foreign-produced goods (the macroelasticity) is a central parameter in open economy models. It determines the substitution and income effects generated by changes in the terms of trade and ultimately the international comovement of business cycles (Backus et al., 1994; Kose and Yi, 2006; Drozd et al., 2021). This parameter is likewise central to the effect of shocks in MAKRO and should therefore be empirically well-founded. To this end, this paper aims to provide new estimates of the Danish macroelasticity.

The actual value of the macroelasticity is still under debate and varies widely across studies (Bajzik, 2019). Whereas macroeconomists typically apply low values (around unity) to match short-run fluctuations of business cycles (Backus et al., 1994; Justiniano and Preston, 2010), trade economists argue for a value around 5 (Fontagné et al., 2022). This discrepancy is likely a consequence of differences in estimation methodologies and data considerations.

Traditionally, the elasticity is estimated using Error-correction models, which typically find values around unity (Hilberry and Hummels, 2013). However, the correlation between price and demand may be generated by either movement along the demand or the supply curve. Consequently, a standard OLS estimation tends to underestimate the elasticity as the identified elasticity is a mix of a demand (negative slope) and supply elasticity (positive slope). Therefore, recent literature applies instrumentation strategies to identify the demand elasticity (Boehm et al., 2020; Fontagné et al., 2022; Yilmakuday, 2019; Feenstra et al., 2018). With proper instrumentation, the elasticity is estimated to be close to 5.

Another potential reason why trade economists typically find higher estimates is the applied data. The estimation methodologies using instrumentation strategies often rely on detailed product-level trade data with export from many countries. Thus, the identified elasticity is a foreign-foreign elasticity (microelasticity) and is often estimated larger than the macroelasticity (Feenstra et al., 2018). This data choice results from a need for more detailed product-level data on domestic production in the home market.

To circumvent these issues, currently, MAKRO is using the estimated macroelasticities from Kronborg et al. (2021), which is obtained by calculating a weighted average of the estimated elasticity of the microelasticity.[1] However, the issue with this method is that the micro- and macroelasticities are assumed identical. Previous studies (see for example Feenstra et al. (2018)) show that this is not the case.[2]

[1] The authors are following a method suggested by Imbs and Mejean (2015).

[2] Consequently, some studies have employed an ad hoc assumption known as the rule of two, which states that the macroelasticity should be half the microelasticity, see Hilberry and Hummels (2013) for discussion.

To avoid the drawback mentioned above in Kronborg et al. (2021), we use an approach that simultaneously estimates both micro- and macroelasticities. In particular, we apply an estimation strategy developed by Feenstra et al. (2018) which utilizes the dimension of trade data combined with detailed product-level data on domestic production for the home market. At the same time, the framework estimates both a demand and a supply curve to separate demand and supply shocks properly.

The estimation procedure is a three-step procedure. The first step estimates the microelasticity, i.e., the elasticity between imports from different countries. The second step estimates the macroelasticity, i.e., the elasticity between import from *all* countries and Danish production for the home market. However, as the estimation of the macroelasticity is sensitive (Feenstra et al., 2018), and therefore as a third step, the estimates from the two steps are combined to re-estimate the macroelasticity. In all three steps, a demand and a supply elasticity are estimated simultaneously to identify a demand elasticity.

We apply data on Danish imports from many countries obtained from the Baci database (Gaulier and Zignago, 2010). The import data is combined with input-output data on Danish production to the domestic market. We estimate the median micro elasticity to 2.97, which is similar to estimates obtained in the literature using the same methodology (Feenstra et al., 2018; Soderbery, 2015; Broda and Weinstein, 2006; Temere, 2017; Kronborg et al., 2021). The macroelasticity is estimated to be 1.82 and close to the estimates obtained on US data from Feenstra et al. (2018).

The considerably lower value of the macroelasticity, compared to the microelasticity, suggests that open economy models using the microelasticity as the home-foreign elasticity highly overstates the substitution and income effects from shocks to the terms of trade. The new estimate of the macroelasticity suggests that the actual value of the macroelasticity is in the middle ground between the business cycle and trade literature.

2 Method

Our estimation of trade elasticities follows Feenstra et al. (2018). Their approach is based on the identification through heteroskedasticity, which can solve the issue raised by Leamer (1981) of separating import demand and supply elasticities. By assuming that demand and supply elasticities are identical across all countries and that demand and supply shocks are uncorrelated on average over time, the authors use heteroskedasticity in the error term to pin down the demand and supply elasticity.

The estimation approach by Feenstra et al. (2018) is built on a general equilibrium trade model, which allows two different elasticities of substitution - one which measures the macroelasticity and the other the microelasticity. The model assumes that J countries and G different goods exist and that households have CES preferences for buying domestically or foreign-produced goods.

The resulting expression for import demand in the model is:

$$\Delta log(\frac{V_{gt}^{ij}}{V_{gt}^{jj}}) = \underbrace{(1-\sigma_g)\Delta log(\frac{UV_{gt}^{ij}}{UV_{gt}^{Fj}})}_{\text{Step 1}} + \underbrace{(1-\omega)\Delta log(\frac{UV_{gt}^{Fj}}{UV_{gt}^{jj}})}_{\text{Step 2}} + \epsilon_{gt}^{ij} \quad (1)$$

where the left-hand side of equation (1) is the log difference of the fraction between the product value of the country j's import from country i and the value of domestically produced good g. UV_{gt}^{ij} is the unit value of country j's import from country i, UV_{gt}^{Fj} denotes the unit value of all country j's imports while UV_{gt}^{jj} is the unit value of products produced and sold in country j. The error term ϵ_{gt}^{ij} is a demand shock reflecting exogenous preference shocks and shocks to changes in product variety.[3]

Our interest lies in the parameters for the microelasticity, σ_g, and in particular, the macroelasticity, ω. In order to estimate σ_g and ω, Feenstra et al. (2018) proposes a three-step procedure.

First step

The first step is estimating the microelasticity (Step 1 in equation 1). This step is based on Feenstra (1994) and assumes that the import demand and supply shocks are uncorrelated on average over time. The equation we estimate in step 1 is obtained by deriving and then combining a relative demand for imports equation with a reduced supply function in order to arrive to the following expression:

$$Y_{gt}^{iF} = \theta_{1,g} X_{1,g,t}^{iF} + \theta_{2,g} X_{2,g,t}^{iF} + u_{g,t}^{iF} \tag{2}$$

for $i = 1, ..., J, i \neq j, t = 2, ..., T_g^i$ where

$$Y_{gt}^{iF} = [\Delta ln[\frac{UV_{gt}^{ij}}{UV_{gt}^{Fj}}]]^2 \qquad X_{1,g,t}^{iF} = [\Delta ln[\frac{V_{gt}^{ij}}{V_{gt}^{Fj}}]]^2$$

[3] For derivation and a more detailed explanation of the model, see Feenstra et al. (2018)

$$X^{iF}_{2,g,t} = [\Delta ln[\frac{UV^{ij}_{gt}}{UV^{Fj}_{gt}}]\Delta ln[\frac{V^{ij}_{gt}}{V^{Fj}_{gt}}]]$$

$$\theta_{1,g} = \frac{\rho_{1,g}}{(\sigma_g - 1)^2(1-\rho_{1,g})} \qquad \theta_{2,g} = \frac{2\rho_{1,g} - 1}{(\sigma_g - 1)(1-\rho_{1,g})}$$

where on the left-hand side we have the (log) change in relative prices of country j's import of good g produced in country i to the overall import price. The change in the relative import price is determined by the (log) change in the value of imports from country i to total imports and an interaction term of the relative import price to relative import value.

The estimation of $\hat{\sigma}_g$ proceeds in a two steps GMM procedure.[4] First, we transform equation (2) so that it expresses the average value of each country over time and estimate it by weighting each country observation by T^i_g.[5] Consequently, after the time average of equation (2) is estimated, the fitted residuals, $\hat{u}^{iF}_{g,t}$, are calculated based on equation (2). The inverse variances of the countries' observations over time are then used as weights in the second GMM estimation of equation (2). This, in turn, gives a set of moment conditions that are used to obtain estimates of the microelasticity, σ_g.[6]

[4]The authors argue that because heterogeneity is present in the error term of equation (2), the estimation should be done with a two-step GMM procedure where we weight with the inverse variance in the second step.

[5]Feenstra et al. (2018) argue that the error term in equation (2) is correlated with the explanatory variables. In order to solve this, the authors suggest using country dummies as instruments, which is equivalent to taking the time average of equation (2).

[6]Step one has also been done by Kronborg et al. (2021) since they base their approach to estimate the microelasticities on Feenstra et al. (2018)

Second step

The second step is similar to the first in regards to the procedure of the two-step GMM. However, instead of working with product-level trade data, the estimation of the macroelasticity is obtained by aggregating the data across countries.[7] We make two assumptions: 1) The aggregation implies that the country dimension is removed. Therefore, we assume that the supply and demand elasticities are constant across products within a sector. 2) We assume that demand and supply shocks are uncorrelated on average over time for all countries. With these assumptions, we estimate the macroelasticity, ω.

The estimated expression derived from the macro demand and macro supply equations is:

$$Y_{gt}^{Fj} = \phi_1 X_{1,g,t}^{Fj} + \phi_2 X_{2,g,t}^{Fj} + u_{g,t}^{Fj} \tag{3}$$

for $g = 1, ..., G, t = 2, ..., T_g$ where

$$Y_{gt}^{iF} = [\Delta ln[\frac{UV_{gt}^{Fj}}{UV_{gt}^{jj}}]]^2 \qquad X_{1,g,t}^{Fj} = [\Delta ln[\frac{V_{gt}^{Fj}}{V_{gt}^{jj}}]]^2$$

$$X_{2,g,t}^{Fj} = [\Delta ln[\frac{UV_{gt}^{Fj}}{UV_{gt}^{jj}}]\Delta ln[\frac{V_{gt}^{Fj}}{V_{gt}^{jj}}]]$$

$$\phi_1 = \frac{\rho^F}{(\omega - 1)^2(1 - \rho^F)} \qquad \phi_2 = \frac{2\rho^F - 1}{(\omega_g - 1)(1 - rho^F)}$$

where Y_{gt}^{Fj} is the relative (log) change in the overall import prices of product g to the price of the equivalent domestically produced good. The left hand side of equation (3) is determined by the (log) change

[7] In step 1, we use a three-dimensional data set where we have time, sector, and source country while it is two dimensional in step 2 (time and source country).

in the relative import value and an interaction term. Like step 1, equation (3) is averaged over time to obtain an estimating equation that estimates the macroelasticity, ω, and the supply parameter ρ^F.

So far, the moments in step 1 and step 2 have been estimated with the help of a two-step GMM.[8] However, Feenstra et al. (2018) find that GMM estimates in step 2 could perform better because the estimates of ω in simulated data converge to the true value very slowly. For this reason, the authors suggest a third step that combines the estimates from the previous steps.

Third step

In step 3, the authors add another moment condition, obtained from their nested-CES demand equation, that involves both micro- and macroelasticities. The estimating equation is:

$$Y_{gt}^{iF} = \sum_{n=1}^{2} \theta_{n,g} X_{n,g,t}^{ij} + \sum_{n=3}^{4} (\omega - 1)\theta_{n,g} X_{n,g,t}^{ij} + (\omega - 1)^2 \theta_{5,g} X_{5,g,t}^{j} + u_{g,t}^{ij} \quad (4)$$

for $i = 1, ..., J, i \neq j, t = 2, ..., T_g^i$ where

$$Y_{gt}^{iF} = [\Delta ln[\frac{UV_{gt}^{ij}}{UV_{gt}^{Fj}}]]^2 \qquad X_{1,g,t}^{iF} = [\Delta ln[\frac{V_{gt}^{ij}}{V_{gt}^{jj}}]]^2$$

$$X_{2,g,t}^{iF} = [\Delta ln[\frac{UV_{gt}^{ij}}{UV_{gt}^{Fj}}]\Delta ln[\frac{V_{gt}^{ij}}{V_{gt}^{jj}}]]$$

[8] Feenstra et al. (2018) suggests that GMM results in the most efficient estimates for σ_g and ω.

$$X^{iF}_{3,g,t} = [\Delta ln[\frac{UV^{Fj}_{gt}}{UV^{jj}_{gt}}]\Delta ln[\frac{UV^{ij}_{gt}}{UV^{Fj}_{gt}}]]$$

$$X^{iF}_{4,g,t} = [\Delta ln[\frac{UV^{Fj}_{gt}}{UV^{jj}_{gt}}]\Delta ln[\frac{V^{ij}_{gt}}{V^{jj}_{gt}}]]$$

$$X^{iF}_{5,g,t} = [\Delta ln[\frac{UV^{Fj}_{gt}}{UV^{jj}_{gt}}]^2$$

with the coefficients θ_1 and θ_2 already defined in step 1, while the rest of the coefficients are defined in the following way:

$$\theta_{3,g} = \frac{-(1+\rho_{2,g}-2\rho_{1,g})}{(\sigma_g-1)(1-\rho_{1,g})} \qquad \theta_{4,g} = \frac{-(\rho_{2,g}-2\rho_{1,g})}{(\sigma_g-1)^2(1-\rho_{1,g})}$$

$$\theta_{5,g} = \frac{-(\rho_{2,g}-\rho_{1,g})}{(\sigma_g-1)^2(1-\rho_{1,g})}$$

with $\rho_{2,g} = \frac{\rho_{1,g}}{\rho^F}$. The dependent variable in (4) is the same as in step 1, but the explanatory variables are different.

In practice, the third and last step proceeds by first obtaining the microelasticity estimates $(\hat{\sigma_g})$, the coefficients $\hat{\theta}_1$ and $\hat{\theta}_2$ and the supply elasticity, $\hat{\rho}_{1,g}$, from step 1, and substituting these into the estimations in step 3. Moreover, the estimated value of the macro supply parameter, $\hat{\rho}^F$, from step 2 is also used in the last step. Similar to the previous steps, step 3 is estimated with the help of a two-step GMM.[9]

[9] For a detailed explanation of the different steps involved in the estimation procedure, please refer to Feenstra et al. (2018).

3 Data

To estimate the trade elasticities, input-output (IO) data from Denmark and trade data from foreign trade partners are needed. The data is gathered as IO-tables from Statistics Denmark (denoted DST) and import data from the BACI database. Both datasets cover the time period 1995-2019 and are on yearly frequency. The DST data contains IO-tables for danish production in current and previous year's prices (measured in 1,000 DKK). The data is distributed on the sector level given by the DB07-classification from Statistics Denmark.

The BACI data, on the other hand, contains trades from more than 200 countries. Each entry in the BACI data represents the value (in 1,000 USD) and quantity (in tons) of the trades for a given year by exporter, importer, and HS6 product. Our interest is in the entries for Danish imports. The products follow the HS92-classification.

A conversion of the sector classifications is needed to match the datasets from both DST and BACI. We convert all the sector codes to NACE rev. 2. The conversion of the DST data from DB07 to NACE rev. 2 comes down to extracting the first two digits of the DB07-codes and then aggregating the sectors with the same first and second digits by summing their values.[10]

The HS92-classification used in the BACI data (six-digit level) is con-

[10] The DB07-classification is based on NACE rev. 2 such that for a given sector, the first four digits in DB07 and NACE rev. 2 are equal. However, it turns out that the sector codes presented in the DST data only differ on the first, second, fifth, and sixth digits. The fifth and sixth digits must be ignored, as they are not translatable to NACE rev. 2. The four digits left is a NACE rev. 2 code, but as already noted, all sectors with identical first and second digits in DB07 have identical third and fourth digits too. This means the fourth and third digits do not provide any additional information to the first two.

verted to ISIC rev. 4 (four-digit level).[11] The conversion from ISIC rev.4 to NACE rev. 2 afterward is reasonably straightforward, as they, in almost all cases, are equal on the four-digit level. The third and fourth digits are dropped to match the sectors in the converted DST data. When the sector codes in all entries of the BACI data are converted to NACE rev. 2, all the entries with identical years, exporters, and sectors are aggregated by summation. Some data is lost during conversion and aggregation, as not all the HS codes seem to be convertible to ISIC rev. 4. However, after these steps, 98.0% of the total trade values in the BACI data is left.

With all the data converted to the same sector classification, the unit values for every entry in the BACI data can be calculated simply as value divided by quantity, resulting in a unit value measured in 1,000 USD / ton. Before proceeding further, all values and unit values in the BACI data are converted from USD to DKK.[12] A price index is also calculated for each sector in the DST data based on the total trade value in the current year and the previous year's prices.[13]

When estimating trade elasticities, we are only interested in the import utilized in Danish production or consumed by Danish consumers. This means imported goods that are exported again without added value are not of interest in the estimation. In the DST IO

[11] We do this using the R package `https://rdrr.io/github/insongkim/concordance/`

[12] We use the average DKK/USD exchange rate for 2010. Using current prices does not change our results.

[13] The price index for a given sector can be calculated as $p_t = \frac{V_t^{current}}{V_t^{previous}} \cdot p_{t-1}$ where p_t is the price in year t, and $V_t^{current}$ and $V_t^{previous}$ are value in year t measured in current and previous year's prices respectively. The price in 1994 is set to 100 in all sectors.

tables, the amount of imports to export is shown for each sector. However, it is not distributed on which countries Denmark imports it from. Hence, subtracting it directly from the relevant export countries in BACI data is impossible. Instead, weights based on the amount of import to export in each sector are calculated using the DST IO-tables and then applied to the BACI trade data, V_{gt}^{ij}. In this way, the sectors with a large amount of import-to-export are given less weight in estimating the elasticities. The weights are calculated as

$$1 - \frac{\text{Import to export}}{\text{Total import}}$$

for each sector in each year and then multiplied on all the corresponding V_{gt}^{ij}.

Note that some sectors exist in the BACI data but not in the DST data, and vice versa. All these sectors are discarded in the estimations as import, and domestic data are needed.[14] This leaves data covering 30 sectors. Moreover, our trade dataset contains few extreme outliers due to measurement errors. Hence the data is filtered using the method presented in Hidiroglou and Berthelot (1986). The methodology detects outliers based on the deviation between the given data point and the first or third quartile in terms of the interquartile range. Data points are removed if this deviation is above a specified suspicion level. This method is applied to growth rates of both trade values and unit values for a given sector across time and export countries. We apply a threshold (suspicion) level of 2 in our baseline estimation. See Appendix B for a more detailed

[14]Furthermore, sector 09 (Mining support service activities) is removed manually as it is a small sector (resp. for $< 0.02\%$ of import) with very volatile data, causing meaningless results in the estimation of microelasticity in the Extraction sector.

Restriction on data	Coverage		Number of	
	BACI	**Nat. acc.**	**Sectors**	**Countries**
No filter of outliers used	94.5%	82.9%	29	83
Filter, suspicion level 4	93.4%	81.9%	29	76
Filter, suspicion level 3	93.1%	81.6%	29	72
Filter, suspicion level 2	84.0%	73.6%	27	69

Table 3.0.1: Data coverage when imposing different outlier filters. The coverage percentages represent the share of total trade value (summed for all years) that is left after imposing different restrictions, when compared to the total import value in the untreated BACI data and national account, respectively. The four cases represent different outlier filters. However, they are all restricted, so sectors that cannot be matched between DST and BACI, countries with less than ten observations in the time series, and sectors with fewer than 15 countries are removed. The two right-most columns show the number of remaining sectors and the average amount of countries in these sectors. Note that even with no outlier filter, only 29 sectors are represented due to the criterium of having a minimum of 15 countries in a sector.

explanation.

After removing outliers, we construct the variables presented in the above section. A detailed description of this procedure is found in Appendix A. Last, before the estimation, we ensured that each export country has at least ten observations in the time series and that each sector trades with at least 15 countries. Export countries with less than ten observations in the time series and sectors with less than 15 countries are removed from the estimation. This is done to ensure that sectors with sporadic trade partners do not drive the results from the estimation. The coverage of data is shown in Table 3.0.1. The final dataset cover 84% of trade flows from the Baci dataset, corresponding to 73.6% of Danish goods trade.

4 Results

This section presents the results from the estimation procedure outlined above. We start by showing the estimated microelasticities obtained from step 1, followed by documenting the results for the macroelasticity (steps 2 and 3).

The microelasticities for different sectors are estimated in step 1 and are presented in Table 4.0.1 and Figure 4.0.1. The resulting distribution of the estimates for the sectors is left-skewed, indicating that most of the sectors in our sample have a low or moderate microelasticity. However, there are also a few sectors with relatively high elasticity of substitution; see Figure 4.0.1. Moreover, the median estimate for all Danish sectors is 2.97. This is somewhat lower than 4.05 found by Feenstra et al. (2018) or 3.1 from Broda and Weinstein (2006), both studies estimating on US data. Moreover, in contrast to previous studies using US data (e.g., Imbs and Mejean (2015), Feenstra (1994), Broda and Weinstein (2006)), we do not find considerable heterogeneity in our sector-level estimates of microelasticities. For instance, Feenstra (1994), and Imbs and Mejean (2015) report a range between 2.2 and 29 while our results suggest that the Danish microelasticities are between approximately 2 and 6 (see Figure 4.0.1). This may result from the aggregation level as the elasticity is typically estimated higher in disaggregated data.

The estimation of the elasticity between domestically produced goods

	Number of	Estimated σ_g		Estimated ω
Sectoral Groups	**Sectors**	**Median**	**Average**	
All sectors	27	2.97	3.18	1.81 (1.77, 1.85)
Extraction	1	2.66	2.66	5.95 (5.61, 6.29)
Manufacturing	20	2.87	3.16	2.24 (2.21, 2.28)

Table 4.0.1: The table reports the median estimate for the 27 different sectors in our data set, organized in a few sectoral groups. The sectoral groups Energy, Services and Agriculture are not shown separately as they are either very small or yield corner solutions in the estimation. A more detailed description of which sectors belong to the sectoral groups is found in Appendix D. Note that the estimation of the macroelasticities on the sectoral level is based on relatively few observations and thus increasing the uncertainty around the estimate. The 90% confidence intervals shown in parentheses are computed by bootstrapping the data set 1000 times. Confidence bands for the estimated microelasticity are shown in Figure 4.0.1.

and imports obtained from step 3 is also presented in Table 4.0.1. The point estimate of the macroelasticity for all sectors in our trade data sample is 1.82. This is slightly smaller than 2.21, which is what Feenstra et al. (2018) finds for US data. Our results thus show that, on average, the responsiveness of Danish demand to international prices is somewhat lower than the equivalent response of the US demand. Consequently, we find indications that the Danish price level is relatively insulated from foreign shocks.

Table 4.0.1 presents the two-step GMM estimates of the macroelasticities on sectoral group levels. Even if the results for this particular

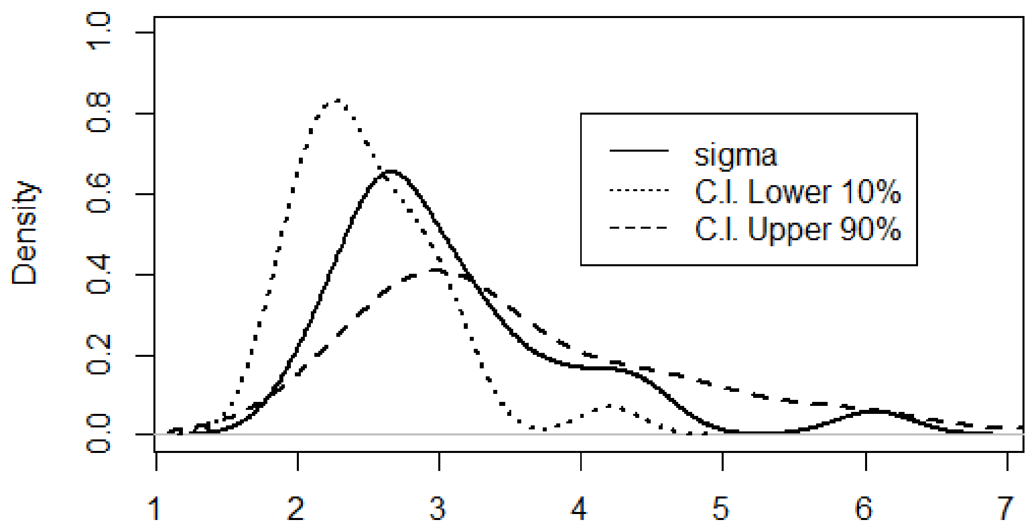

Figure 4.0.1: Kernel Density for estimates of microelasticity. The estimated microelasticities for the median, upper, and lower confidence bands are calculated from 1000 bootstrapped samples. The x-axes show the value of the bootstrapped sigma while on the y-axis we have the probability for the sigma to take the value on the x-axis.

exercise are somewhat uncertain due to the significantly reduced number of sectors used in the estimate, our point estimates on the macroelasticities are 2.24 for the manufacturing sector while we find a vaulue of 5.96 for the extraction sector. We find that the home-foreign elasticity is highest in sectors operating within extraction (e.g., extraction of oil, gas, gravel, and stone), indicating a relatively significant shift in demand towards domestically produced goods within the extraction sector when international prices for similar goods rise. Furthermore, our results for sectors in manufacturing show a macroelasticity of 2.24. This is close to 2.30 that Feenstra et al. (2018) finds for the US.[15]

Last, according to Imbs and Mejean (2015), a potential drawback of the Feenstra et al. (2018) method is that the identification of the elasticities needs to be made in the cross-section of sectors, and consequently, heterogeneity is difficult to establish. For this reason, the confidence intervals in Feenstra et al. (2018) is too wide. However, our estimates do not show such wide confidence intervals (see Table 4.0.1 and Figure 4.0.1).

5 Conclusion

This paper aims to provide new estimates of the Danish macroelasticity. Despite the expanding body of empirical studies, there has yet to be a clear consensus on estimating macroelasticities. We estimate the elasticity of substitution between goods from different countries based on the methodology of Feenstra et al. (2018). This method is built on a general equilibrium trade model, which allows disaggregated import demand and supply equations to be derived. With the help of these two equations, both micro- and macroelasticities can be estimated. We also match trade data between countries from the BACI database with input-output data from Denmark to estimate both microelasticities and macroelasticity based on the same level of disaggregated data.

Based on an unbalanced panel data set with 27 sectors divided between 69 countries, we find a median microelasticity of 2.97 and a macroelasticity o 1.81. Our results are somewhat lower than previous literature for US data indicating that the Danish economy is relatively

[15] Please see Appendix C for robustness checks.

more insulated from foreign price shocks.

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Appendix A

Detailed procedure of data processing

The following variables are generated based on the BACI-data. The notation corresponds to the notation used in Feenstra et al. (2018):

- UV_{gt}^{ij}
- V_{gt}^{ij}
- V_{gt}^{Fj}
- $\frac{UV_{gt}^{Fj}}{UV_{gt-1}^{Fj}}$

where i is export country, j is import country ($j =$ Denmark), g is sector and t is year. F denotes "total for all i".

UV_{gt}^{ij} and V_{gt}^{ij} can be extracted directly from the BACI-data as the values are given and the unit values are calculated as described in the Data section above. V_{gt}^{Fj} is calculated as a sum across all export countries in the given year and sector. The last of the listed variables above is calculated as:

$$\frac{UV_{gt}^{Fj}}{UV_{gt-1}^{Fj}} = \prod_{i=1, i\neq j} \left(\frac{UV_{gt}^{ij}}{UV_{gt-1}^{ij}} \right)^{w_{gt}^{ij}}$$

where the weights w are the so-called Sato-Wartia weights:

$$w_{gt}^{ij} = \frac{\frac{s_{gt}^{ij} - s_{gt-1}^{ij}}{\ln s_{gt}^{ij} - \ln s_{gt-1}^{ij}}}{\sum_{i=1, i\neq j} \left(\frac{s_{gt}^{ij} - s_{gt-1}^{ij}}{\ln s_{gt}^{ij} - \ln s_{gt-1}^{ij}} \right)}$$

where s^{ij}_{gt} denotes the share of total import value that comes from country i in sector g for the year t.

The following variables are generated based on the DST-data. The notation corresponds to the notation used in Feenstra et al. (2018):

- UV^{jj}_{gt}
- V^{jj}_{gt}

where jj denotes sales to domestic market (j=Denmark), g is sector and t is year. UV^{jj}_{gt} is the price calculated as described in the Data section above and V^{jj}_{gt} is generated by summing all production in the IO-table for given sector and year, except production to export.

With these variables calculated, the estimators presented in equation (15) in Feenstra et al. (2018) can be generated:

$$\begin{aligned}\Delta \ln\left(\frac{V^{ij}_{gt}}{V^{jj}_{gt}}\right) &= \ln\left(\frac{V^{ij}_{gt}}{V^{jj}_{gt}}\right) - \ln\left(\frac{V^{ij}_{gt-1}}{V^{jj}_{gt-1}}\right)\\ &= \ln\left(\frac{UV^{ij}_{gt}}{UV^{Fj}_{gt}}\right) - \ln\left(\frac{UV^{ij}_{gt-1}}{UV^{Fj}_{gt-1}}\right)\end{aligned}$$

$$\begin{aligned}\Delta \ln\left(\frac{UV^{ij}_{gt}}{UV^{Fj}_{gt}}\right) &= \ln\left(\frac{UV^{ij}_{gt}/UV^{Fj}_{gt}}{UV^{ij}_{gt-1}/UV^{Fj}_{gt-1}}\right)\\ &= \ln\left(\frac{UV^{ij}_{gt}/UV^{ij}_{gt-1}}{UV^{Fj}_{gt}/UV^{Fj}_{gt-1}}\right)\\ &= \ln\left(\frac{UV^{ij}_{gt}}{UV^{ij}_{gt-1}}\right) - \ln\left(\frac{UV^{Fj}_{gt}}{UV^{Fj}_{gt-1}}\right)\end{aligned}$$

$$
\begin{aligned}
\Delta \ln\left(\frac{UV_{gt}^{Fj}}{UV_{gt}^{jj}}\right) &= \ln\left(\frac{UV_{gt}^{Fj}}{UV_{gt}^{jj}}\right) - \ln\left(\frac{UV_{gt-1}^{Fj}}{UV_{gt-1}^{jj}}\right) \\
&= \ln\left(\frac{UV_{gt}^{Fj}/UV_{gt}^{jj}}{UV_{gt-1}^{Fj}/UV_{gt-1}^{jj}}\right) = \ln\left(\frac{UV_{gt}^{Fj}/UV_{gt-1}^{Fj}}{UV_{gt}^{jj}/UV_{gt-1}^{jj}}\right) \\
&= \ln\left(\frac{UV_{gt}^{Fj}}{UV_{gt-1}^{Fj}}\right) - \ln\left(\frac{UV_{gt}^{jj}}{UV_{gt-1}^{jj}}\right)
\end{aligned}
$$

These estimators can again be used to calculate the estimating equations for micro elasticity,

$$
Y_{gt}^{iF} = \left[\Delta \ln\left(UV_{gt}^{ij}/UV_{gt}^{Fj}\right)\right]^2, X_{1gt}^{iF} = \left[\Delta \ln\left(V_{gt}^{ij}/V_{gt}^{Fj}\right)\right]^2,
$$
$$
X_{2gt}^{iF} = \left[\Delta \ln\left(UV_{gt}^{ij}/UV_{gt}^{Fj}\right)\right]\left[\Delta \ln\left(V_{gt}^{ij}/V_{gt}^{Fj}\right)\right]
$$

and the corresponding equations for macro elasticity,

$$
Y_{gt}^{Fj} = \left[\Delta \ln\left(UV_{gt}^{Fj}/UV_{gt}^{jj}\right)\right]^2, X_{1gt}^{Fj} = \left[\Delta \ln\left(V_{gt}^{Fj}/V_{gt}^{jj}\right)\right]^2,
$$
$$
X_{2gt}^{Fj} = \left[\Delta \ln\left(UV_{gt}^{Fj}/UV_{gt}^{jj}\right)\right]\left[\Delta \ln\left(V_{gt}^{Fj}/V_{gt}^{jj}\right)\right]
$$

Furthermore the variables X_{1gt}^{ij}, X_{2gt}^{ij}, X_{3gt}^{ij}, X_{4gt}^{ij} and X_{5gt}^{j} defined in Feenstra et al. (2018) are calculated likewise.

Appendix B

Filtering outliers

The outlier filtration presented in Hidiroglou and Berthelot (1986) works as follows: the first (q_1) and third quartile (q_3) of a growth rate data set $\Delta \ln(Z)$ is calculated. Whether or not a given datapoint $\Delta \ln(Z^i_{gt})$ is removed depends on the deviation ϵ^i_{gt}:

$$\epsilon^i_{gt} = \begin{cases} \frac{q_1 - \Delta \ln(Z^i_{gt})}{q_3 - q_1} & \text{if } \Delta \ln(Z^i_{gt}) < q_1 \\ \frac{\Delta \ln(Z^i_{gt}) - q_3}{q_3 - q_1} & \text{if } \Delta \ln(Z^i_{gt}) > q_3 \\ 0 & \text{else} \end{cases}$$

The data point $\Delta \ln(Z^i_{gt})$ is then removed if ϵ^i_{gt} is above the chosen suspicion level (e.g. 2, 3 or 4).

This filter is applied for a given sector g across time t and export countries i on the data sets $\Delta \ln(UV^{ij}_{gt})$ and $\Delta \ln(V^{ij}_{gt})$. It is also applied across sector and time on the data sets $\Delta \ln(V^{jj}_{gt})$, $\Delta \ln(UV^{jj}_{gt})$, and $\Delta \ln(V^{Fj}_{gt})$. All these data sets are used to calculate the estimating equations as described in Appendix A.

Appendix C

Robustness check

In this section, we conduct several robustness checks for our estimated σ_g and ω. First, we focus on changing the distance of a given growth rate from the nearest quartile relative to the interquartile distance to detect outliers in our data set. In particular, we investigate if increasing the permitted threshold level for the growth rate, the so-called suspicion level, to detect outliers change our overall results presented in Table 4.0.1.

Table 5.0.1 and 5.0.2 show that when increasing the suspicion level, the estimates for microelasticities remain robust, but the estimates for home-foreign elasticity change remarkably. A rise in suspicion level from 2 to 3 or 4 increases the number of sectors in our sample to 29. Furthermore, increasing the suspicion level also increases our data coverage to approximately 93 percent (from 84 percent) of the original raw dataset. When we set a higher threshold for detecting outliers, we notice that our results for the estimates of macroelasticities for each sectoral group presented in the previous section seem to depend on the definition of outliers in the data. This instability could still result from the fact that the estimations are based on relatively few observations, thus increasing the uncertainty. Moreover, the macroelasticity for all sectors also increases considerably to approximately 4. This is most likely because the sample now includes the "Oil refinery" sector, which includes many outliers. Removing this sector, we get similar estimators as in Table 4.0.1.

	Number of	Estimated σ_g		Estimated ω
Sectoral Groups	**Sectors**	**Median**	**Average**	
All	29	2.86	3.27	4.50
				(4.46, 4.54)
Extraction	1	2.70	2.70	$1^{\dagger}$
				(0.92, 1.08)
Manufacturing	21	2.86	3.03	6.34
				(6.30, 6.37)

Table 5.0.1: The table reports the median estimate for the 29 different sectors in our data set, organized in a few sectoral groups, with a higher threshold for removing outliers (suspicion level = 3). † represents a corner solution. The sectoral groups Energy, Services and Agriculture are not shown separately as they are either very small or yield corner solutions in the estimation. A more detailed description of which sectors belong to the sectoral groups is found in Appendix D. Note that the estimation of the macroelasticities on the sectoral level is based on relatively few observations and thus increasing the uncertainty around the estimate. The 90% confidence intervals shown in parentheses are computed by bootstrapping the data set 1000 times.

	Number of	Estimated σ_g		Estimated ω
Sectoral Groups	**Sectors**	**Median**	**Average**	
All	29	2.84	3.16	4.14
				(4.10, 4.18)
Agriculture	2	2.86	2.86	1.20
				(1.15, 1.24)
Extraction	1	2.59	2.59	$1^{\dagger}$
				(0.89, 1.11)
Manufacturing	21	2.77	2.99	6.04
				(5.99, 6.09)

Table 5.0.2: The table reports the median estimate for the 29 different sectors in our data set, organized in a few sectoral groups, with a higher threshold for removing outliers (suspicion level = 4). † represents a corner solution. The sectoral groups Energy and Services are not shown separately as they are either very small or yield corner solutions in the estimation. A more detailed description of which sectors belong to the sectoral groups is found in Appendix D. Note that the estimation of the macroelasticities on the sectoral level is based on relatively few observations and thus increasing the uncertainty around the estimate. The 90% confidence intervals shown in parentheses are computed by bootstrapping the data set 1000 times.

Appendix D

Overview of data

Sectoral group	**NACE**	**Share in BACI**	**Description**
Agriculture	01	3.03%	Agriculture and horticulture
	03	0.86%	Fishing
Energy	19	6.36%	Oil refinery etc.
Extraction	08	0.225%	Extraction of gravel and stone
Manufacturing	10	10.37%	Production of meat and meat products, processing and preserving of fish, manufacture of dairy products, grain mill and bakery products, among others
	11	1.26%	Manufacture of beverages
	12	0.12%	Manufacture of tobacco products
	13	8.36%	Manufacture of textiles
	14	0.05%	Manufacture of wearing apparel
	15	1.51%	Manufacture of leather and footwear
	16	1.58%	Manufacture of wood and wood products
	17	2.42%	Manufacture of paper and paper products

	18	0.02%	Printing etc.
	20	3.70%	Manufacture of basic chemicals, paints and soap
	21	4.02%	Pharmaceuticals
	22	5.21%	Manufacture of rubber and plastic products
	23	1.29%	Manufacture of glass, ceramic products, concrete and bricks
	24	4.97%	Manufacture of basic metals
	25	5.55%	Manufacture of fabricated metal products
	26	15.88%	Manufacture of computers, communication equipment, and other electrocnic products
	27	2.48%	Manufacture of electric motors, wires and cables, household appliances, lamps, etc.
	28	7.94%	Manufacture of engines, windmills and pumps, and other machinery
	29	5.01%	Manufacture of motor vehicles and related parts
	30	2.74%	Manufacture of ships and other transport equipment
	32	0.98%	Manufacture of medical instruments, toys and other manufacturing
Services	58	0.19%	Publishing and publishing of computer games and other software

	59	0.50%	Motion picture and television programme production, and sound recording activities
Others	74	0.001%	Other technical business services
	79	0.05%	Travel agent activities

Table 5.0.3: Only sectors found in both the DST and BACI data sets are included. The sectors' share of the BACI data is calculated before outlier detection and for the year 2010.