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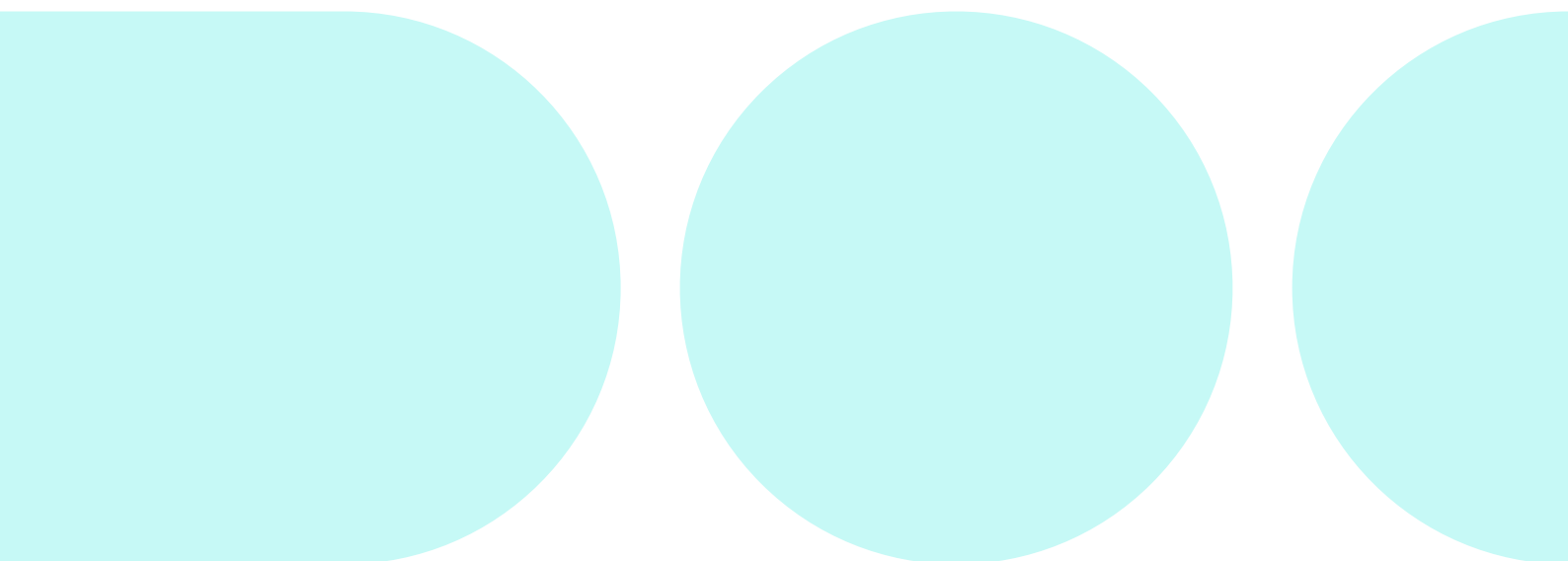
Estimating trade elasticities in MAKRO

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Resumé

In this working paper, we estimate the elasticities of substitution of imports and exports used in MAKRO for the industries manufacturing and energy. The data used is from the international trade database BACI and is available on annual frequency for the period 1995-2016. By using detailed trade data for many countries at the product level, the trade elasticities can be estimated while taking into account typical endogeneity problems and it allows potential problems with aggregation bias to be investigated and addressed. Our methodical starting point is Feenstra (1994), where the supply and demand curves are separately identified by utilizing the heteroskedasticity of shocks in the country dimension. The resulting import elasticity between domestic and foreign-produced manufacturing goods is estimated at 2.76. We then estimate the export elasticity as a weighted average of the import elasticity of Denmark's 50 largest trading partners and obtain an estimate of 5.42 for the manufacturing sector. This estimated export elasticity is robust to an alternative assumption, that the elasticity is the same across the countries to which Denmark exports. For energy, we find elasticities of 3.50 and 5.03 for imports and exports, respectively. There are indications of aggregation bias, as the elasticity estimates are generally higher when more disaggregated data is used in the estimation.

1 Introduction

In macroeconomic models of small open economies, the trade elasticities for imports and exports are important for the overall dynamics of the model, including the general adjustment to shocks via the effect of competitiveness on exports. For both MAKRO's structural and cyclical properties, it is therefore important that these parameters are empirically based with accurate estimates. Both in Denmark and in other countries, trade elasticities have traditionally either been estimated on the basis of aggregated time series models, for example as a parameter in the long run relationship in an error correction model, or the parameters have been calibrated to external literature. However, in recent years, international trade models have shifted towards an approach where the estimation of trade elasticities is instead done by exploiting the cross-sectional element in panel datasets (e.g. GTAP, see Hilberry and Hummels, 2013). There are likely two main reasons behind this: First, unlike previously, researchers now have access to high-quality data and at a significantly more disaggregated level. As a result, we can estimate the elasticities by panel data estimation at a detailed product group level. Second, estimates of trade elasticities based on aggregate time series may suffer from significant aggregation bias, giving a downward bias in the estimates. This occurs if firms facing a relatively low elasticity tend to make the largest adjustment of the prices (e.g., Imbs and Mejean, 2015). As a result, changes in the overall import price index will result in limited quantity changes at the aggregate level.¹

By estimating foreign trade elasticities at the product level, we can avoid this aggregation bias. Subsequently, it raises a key question in relation to macroeconomic models such as MAKRO: Can foreign trade elasticities be appropriately used at the aggregate level (e.g. by sector) based on elasticities estimated on microdata (e.g. at product level)? Imbs and Mejean (2015) show that a single-sector model does best at replicating the so-called »J-curve dynamics« from a multi-sector model when the elasticity used is based on a weighting of more disaggregated estimates rather than an estimate of aggregated data. They argue that the composite (disaggregated) dynamics is best expressed - also at the aggregate level - by applying an elasticity found via disaggregated estimates.

The method used in this analysis requires that the estimated import elasticities are corrected before they can be included in a model such as MAKRO. This is because a model shock to the import price in a given sector will correspond to a shock that affects the import price identically for all product groups in this sector. Imports constitute a significant share of Danish consumption, implying that such a shock will not only affect import prices, but also the domestic CES price index. Estimations on product data instead reflect the elasticity of a shock that only affects the individual product group as well as the individual importing country, for example a shock to the

¹This general problem with aggregate series is well known (e.g. Orcutt et al., 1968) and is confirmed by recent empirical literature in international trade (see e.g. Broda and Weinstein (2006) and Imbs and Mejean (2017)).

import price of leather from Italy. With sufficiently disaggregated data, this shock will only have a very limited impact on total import prices, and will therefore have no effect on the domestic price level like an aggregated shock will. To obtain an estimate of the import elasticities that reflects an aggregate shock to import prices, we weight the estimates at product level so that they take into account the impact on domestic prices in the case where a hypothetical shock affects all prices simultaneously and identically. We hereinafter refer to this elasticity as the »macro elasticity« and will elaborate on how it is calculated.

In this working paper, we estimate the macro elasticity of both imports and exports of goods. Estimation of the macro elasticity first involves estimating import elasticities at product level (micro elasticities) and subsequently calculate a weighted average of these. In this step, we take into account the import content in the CES price index based on Danish IO data. A well-known challenge when estimating demand elasticities however, is that the observed price and quantity changes in a given market may be driven by shifts along the demand curve as well as the supply curve. We therefore estimate the trade elasticities based on the method described in Feenstra (1994). The approach solves this identification problem by exploiting the heteroskedasticity of the country dimension, whereby we can simultaneously identify a demand curve and effects that arise because of movements along a supply curve. The method is frequently used in similar and recent empirical studies (Soderbery, 2010, 2015; Imbs and Mejean, 2015, 2017; Feenstra et al., 2018). We use highly detailed data from the BACI database covering the period 1995-2016 for the panel data estimation.

When comparing to previous analyzes on Danish data, the method in this note is related to Temere (2017), which estimates the Danish micro elasticities for all SITC groups (Standard International Trade Classification) at the most disaggregated level. Our analysis differs from Temere (2017) in three ways: First, we estimate the elasticities at different levels of aggregation (corresponding to a one- to three-digit level of detail in the SITC Convention). This gives an indication of whether aggregation bias is present when using Danish trade data. Second, we calculate a macro elasticity by weighting the micro elasticities so that the estimate is consistent with the application in MAKRO. The product groups from the SITC codes are grouped and weighed together so that they correspond to the industries for goods in MAKRO, i.e. manufacturing and energy in the current version. Third, we also use the method to estimate the export elasticity. Consistent with the approach for the estimation of Denmark’s import elasticity, we can estimate the export elasticity in the following way: We define the export elasticity as a weighted average of import elasticities for different product groups for Denmark’s 50 most important export markets. In the aggregation, we impose a small-open-economy assumption, implying that Denmark’s export price is assumed not to affect foreign prices, consistent with the modeling in MAKRO.

For the manufacturing sector, we find macro elasticities of 2.76 and 5.42 for imports and exports,

respectively, when using the most detailed data. In general, we find that the estimates for foreign trade elasticities are higher when using more disaggregated data. This applies to both the weighted and unweighted averages as well as the median. The systematically higher elasticities due to increasing disaggregation indicate that aggregation bias can be a significant problem in data. For energy, we have less data available, because Denmark imports from fewer countries. As a result, we estimate the elasticities at a one-digit product group level as our preferred specification. We estimate the macro elasticity in the energy sector of 3.50 and 5.03 for imports and exports, respectively. Overall, the results are relatively robust to the assumptions made regarding the estimations.

The structure of the rest of the note is as follows: In section 2, we present the method used to estimate the elasticities. Section 3 describes the data, including how it compares to MAKRO’s sector structure. The estimated elasticities for imports and exports are presented in section 4, while section 5 discusses the robustness of the results. Section 6 summarizes.

2 Description of method

The estimation method is based on Feenstra (1994) and is often used in the empirical literature (e.g. Imbs and Mejean (2017) and Feenstra et al. (2018)).² The approach is based on the intuition of Leamer (1981), which shows that although the supply and demand curves cannot be identified separately, the data provide some limits for the estimates of the slope of the curves. Leamer (1981) then shows that the *maximum likelihood* estimate under this condition gives rise to a hyperbole of possible supply and demand elasticities.³ For a given market however, the elasticity (supply or demand) which is primarily identified in the data is that of which the shocks are the smallest (since changes in quantities reflect primarily movements along the other curve). Feenstra (1994) solves this identification problem in the context of trade data, as several hyperbolas can be formed when a given country imports from a number of different countries or markets. Assuming that the elasticities are identical, given the product group and across trading partners, one can thus exploit the heteroskedasticity for shocks in the country dimension in the identification of both elasticities (see simplified illustration of the identification method in Appendix A.1). We use averages across

²Another alternative is to use tariffs instead of import prices, where we assume that the variation in prices across countries stems from differences in tariffs. Harmonized data on tariffs are, however, to a lesser extent available at a disaggregated level. Tariffs can also be endogenous, e.g. because tariffs are often politically motivated by developments in trade between countries (a current example is the trade conflict between the United States and China).

³While prices and quantities by definition indicate a market equilibrium, changes in them can reflect movements along both the supply and the demand curve. The correlation between import prices and quantities therefore includes the effects of both the demand and the supply elasticity. A simple OLS regression of import quantities on prices therefore depends on the relationship between the curves, which will have a dampening effect on the estimate of demand elasticity. We can therefore not use the estimate from this regression to derive the exact elasticity of supply and demand, but the estimate can be used to form a hyperbola that restricts their interrelationship.

time as instruments, which implicitly assumes that supply and demand shocks are uncorrelated and have a zero mean over time. Soderbery (2010) shows that this instrument is typically strong enough to identify the elasticity of demand, as long as the time period used is not too short.⁴

Specifically, we take first differences of import prices and quantities to eliminate constant product-specific unobservable factors. Thus, we have the following demand curve:

$$\Delta \log(S_{kit}) = (1 - \sigma_k) \Delta \log(P_{kit}) + \phi_{kt} + \xi_{kit}, \quad (1)$$

where S_{kit} and P_{kit} are respectively the import value and the price of product k exported from country i to a given import country at time t . σ_k is the elasticity of substitution of product k . ϕ_{kt} is a demand shock that affects all exporting countries identically (for example, a general increase in consumption in a given importing country) and ξ_{kit} is an idiosyncratic demand shock (e.g. increasing preferences for Swedish goods) that is independent across exporting countries. We have the following supply curve:

$$\Delta \log(P_{kit}) = \omega_k \Delta \log(S_{kit}) + \delta_{kit}, \quad (2)$$

where δ_{kit} is a supply shock for the exporting country i and ω_k is a mapping to the inverse supply elasticity. We subsequently write the equations in terms of changes relative to a reference country to remove time-specific unobservable factors. In order to reduce the noise in the estimation, we follow Mohler (2009) and select the country with the highest import value for a given product group as reference country.

By combining the demand and supply curves in (1) and (2), respectively, we obtain the following equation, which we can then estimate⁵:

$$Y_{kit} = \psi_{1k} X_{1kit} + \psi_{2k} X_{2kit} + u_{kit}. \quad (3)$$

The variables are defined as $Y_{kit} = (\Delta \log(P_{kit}) - \Delta \log(P_{krt}))^2$, $X_{1kit} = (\Delta \log(S_{kit}) - \Delta \log(S_{krt}))^2$ and $X_{2kit} = (\Delta \log(S_{kit}) - \Delta \log(S_{krt}))(\Delta \log(P_{kit}) - \Delta \log(P_{krt}))$ where the subscript r is the reference country. The error term can be expressed as $u_{kit} = \frac{1}{\sigma_k - 1} (\xi_{kit} - \xi_{krt})(\delta_{kit} - \delta_{krt})$. By estimating equation (3), both the supply and demand elasticity are obtained, as $\psi_{1k} = \frac{\omega_k}{\sigma_k - 1}$ and $\psi_{2k} = \omega_k - \frac{1}{\sigma_k - 1}$. A crucial condition is that the error terms are heteroskedastic, implying an asymmetric relationship between supply and demand shocks across countries. If this was not the case, there would be perfect multicollinearity between X_{1kit} and X_{2kit} , as all countries would »have

⁴A number of the empirical and methodological considerations in this working paper are based on a MAKRO master's thesis project by Kastrup (2020).

⁵We refer to Feenstra (1994) for a closer look at the demand and supply curves and detailed derivation of the estimation equation .

the same hyperbola« (in Leamer terms). The method is therefore an example of identification through the heteroskedasticity in the supply and demand shocks in the country dimension.

It appears from (1) that demand shocks ξ_{kit} are correlated with import values, and from the supply curve (2) it appears that supply shocks δ_{kit} are correlated with prices. Thus, the error term in (3) is correlated with X_{1kit} and X_{2kit} . By making the assumption $E(u_{kit}) = 0$, it also holds that $E(u_{kit}, \bar{X}_{1kit}) = E(u_{kit}, \bar{X}_{2kit}) = 0$, where \bar{X}_{1kit} og \bar{X}_{2kit} are time averages. Therefore, we can solve the endogeneity problem by using country dummies as instruments. This is equivalent to estimating the following:

$$\bar{Y}_{ki} = \psi_{1k}\bar{X}_{1ki} + \psi_{2k}\bar{X}_{2ki} + \bar{u}_{ki}. \quad (4)$$

We follow most of the recent empirical literature in the field and estimate the equation above with a 2-step GMM procedure (Imbs and Mejean, 2015, 2017 and Feenstra et al., 2018). As a consequence, we first estimate equation (4) after which the fitted residuals \hat{u}_{kit} are calculated based on equation ((3)). The inverse variances of the countries' observations over time are then used as weights in the estimation of equation (4). We obtain the associated standard errors via bootstrapping.

We estimate the parameters under the restrictions that $\omega_k \in (0.01; 0.99)$ and $\sigma_k \in (1; 30)$, which corresponds to an assumption of a positive slope for the supply curve and a negative slope for the demand curve.⁶

It is standard to set an upper limit on the demand elasticity. This is partly because it is difficult to distinguish between two different but very high elasticities (the CES production function has almost the same numerical properties above a certain limit), and partly because an average estimate has no meaningful interpretation if it is polluted by some extreme estimates. The limit of 30 chosen for the demand elasticity is the same as e.g. Imbs and Mejean (2017). The fact that we have not chosen a higher limit value can be seen as a precautionary principle: This avoids that the weighted trade elasticities are excessively affected by extreme estimates for individual product groups. We examine the robustness of this restriction in section 5, just as the results are reported including the median as well as with and without the elasticities at the limit.

2.1 From micro to macro elasticities

This section elaborates on how the estimates obtained at product level - i.e. the micro elasticities - can be used to calculate the macro elasticity relevant for an aggregate model such as MAKRO.

⁶The alternative would be to estimate the parameters freely and perform a *grid-search* if the estimates are theoretically inconsistent (e.g. a positively sloping demand curve), which, however, is computationally heavy and therefore not used. As shown in Soderbery (2015), estimation under parameter restrictions works at least as well. This is the same as we found during initial experiments with the method.

The macro elasticity is defined as the import elasticity that applies to an aggregate shock to the import price in an entire sector, e.g. manufacturing. Thus, we assume that this shock affects the prices identically for all product groups from all import countries in the given sector. On the contrary, when we estimate the micro elasticities based on product level data they are identified as a change in the price of a single product in a single country. Given that the product group and the exporting country constitute only a small share of Danish imports, this shock will not affect the Danish aggregate CES price index, in contrast to an aggregate shock to import prices. In order to make the two shocks comparable, we first weigh the elasticities together at the product level, where we use the shares of the individual product groups in Danish imports as weights. We then correct this weighted average by the import content of the CES price index to take into account the fact that the aggregated shock does also affect the aggregate domestic price level.

The macro elasticity of a given country in a given sector, σ^M , can be found by assuming that domestic consumers make decisions based on a nested structure. In the upper nest, it is assumed that the consumers' utility of various goods, k , is represented by a Cobb-Douglas function. This has the advantage that changes in import prices do not affect the budget shares for the various consumer goods. This property greatly simplifies the subsequent calculations, but has been shown to have limited importance for the results.⁷ In the lower nest, the consumer chooses which country a given product is demanded from according to a CES utility function. This nest also includes Denmark, implicitly assuming that the percentage response to Danish price changes is identical to foreign price changes, as they face the same elasticity. It should be noted that the resulting CES demand does allow the share parameters to be different across countries. We thus allow consumers to have so-called *home-bias* or preference for e.g. Swedish products that are different from, for example, German products. The resulting macro elasticity is given by (see also appendix for detailed derivations):⁸

$$(1 - \sigma^M) = \sum_k m_k (1 - \sigma_k) (1 - \lambda_k), \quad (5)$$

where m_k is product k 's share in total Danish imports and λ_k is the share in total Danish consumption of the imported product k . We scale the weights such that $\sum_k m_{kj} = 1$, which is equivalent to taking into account only the products and countries included in the estimation. The interpretation of the macro elasticity is that a higher import content leads to a lower macro elasticity, as a higher import content leads to a greater effect on the CES price index.

We calculate λ_k as $\lambda_k = \frac{M_k}{Y_k - X_k + M_k}$, where Y_k is the country's own production of product k ,

⁷Imbs and Mejean (2010) instead use a CES consumption function between different goods and tests several different calibrated elasticities. They find that it does not make much difference whether elasticities are used differently from or equal to 1. Imbs and Mejean (2015) also use a Cobb-Douglas function.

⁸Further intuition behind this is further described in Imbs and Mejean (2010, 2015).

X_k is export excluding re-export and M_k is import. Since only trade data is divided into SITC groups, we do not have data on the own production for the desired disaggregation levels. Thus, we calculate λ_k for the total manufacturing sector and assume that the share of domestic production of domestic consumption is the same for all underlying SITC groups at higher disaggregation levels. A similar assumption is made for the energy sector. Thus, an important assumption is that there is no systematic relationship between elasticities and the share of own produced domestic consumption. With data for 2016, we use the values $\lambda_k = 0.30$ for the energy sector and $\lambda_k = 0.60$ for the manufacturing sector.

3 Data

To estimate both import and export elasticities we need bilateral trade data for both Denmark and Denmark's trading partners. Therefore, we use data from the BACI database (see Gaulier and Zignago (2010) for a detailed description of the dataset). Data are on an annual frequency for the period 1995-2016 and include more than 200 countries and 5,000 product groups, covering about 95 pct. of world trade. For a given product and a given importing country, the data contain the import value as well as the corresponding quantities of the given product for each exporting country. Values are in USD 1,000 and quantities are measured in tons, so that the prices used are unit values. Data have a high disaggregation level and products are divided into more than 5,000 HS product codes (Harmonized Commodity Description and Coding System). To achieve the correct mapping sectoral mapping for use in MAKRO, we convert the HS product codes to their respective SITC product codes Rev. 3.⁹. We aggregate the classification of data into SITC products to different levels. The product groups are divided according to the first digit into one-digit groups, such that e.g. "01213" (goat meat, fresh, chilled or frozen) belongs to SITC 0, etc. Likewise, two-digit SITC groups are formed after the first two digits of the SITC product code, and the three-digit SITC groups are formed after the first three digits.

We use an unbalanced panel in the estimation, which is standard in the literature (e.g. Imbs and Mejean (2015), Soderbery (2015) and Temere (2017)). To reduce noise, we remove countries if their share of the import value for the whole product group is less than 0.1 percent or if less than 10 years of data are available. The countries are weighted by the number of available time periods for each exporting country, so the highest emphasis is placed on the countries where the most data are available. For the sake of convergence of the estimator, we remove whole SITC groups if there are fewer than 15 exporting countries in the given group. Finally, it is well known in the literature that measurement errors in unit values can occur, e.g. due to incorrect calculation of quantities. For this reason, we use the outlier criterion of Hidioglou and Berthelot (1986) as

⁹Tables used to convert HS to SITC product codes are from UN Trade Statistics

in Temere (2017). This method removes observations where the distance in growth rates to the nearest quartile exceeds twice the interquartile distance.¹⁰

Given these restrictions, we omit relatively few product groups for the manufacturing sector, and the data coverage is 68-75 pct. and includes on average 26-40 countries, depending on the level of aggregation (see Table 5 in Appendix). However, for the energy sector, the data coverage at the highest disaggregation level is 40 percent. In addition, when the restrictions are applied to the raw dataset, there are only 2 remaining product groups that meet the criteria (see Table 6 in appendix). The main reason is that the number of countries from which Denmark imports is too small for the other groups. In order to use as much data as possible, we look at the highest level of aggregation for the energy sector. The data coverage here is approx. 58 pct. and includes 25 countries. Due to data availability, it is therefore not possible to investigate aggregation bias for this sector.

To calculate the weights included in the macro elasticities for the import elasticities, we use Danish imports and exports excluding re-exports divided into SITC groups. We make this correction based on IO data from ADAM's database at sector level, which is subsequently matched to SITC groups. We use IO data at sector level, because there is no data for domestic production at the disaggregated SITC groups level. We assume that the share of own production is the same for all SITC groups in the same sector. As alternative, CGE models of international trade have previously used a »rule of two«, i.e. where the macro elasticity is half of the weighted average of the micro elasticities (Hilberry and Hummels, 2013). This rule of thumb will yield approximately the same results.

4 Results

This section displays the results using the method from section 2. Section 4.1 looks at import elasticities for Danish imports, i.e. micro elasticities (substitution between exporting countries) by product group. In addition, the macro elasticity (substitution between domestically produced goods and imports) is reported, consistent with sector level IO data. Section 4.2 looks at the Danish elasticity of substitution exports.

4.1 Import elasticities

First, we look at imports for MAKRO's manufacturing sector. Figure 1 shows the distribution of the estimated micro elasticities for imports of different product groups at a disaggregation level corresponding to three-digit SITC classification (see Appendix 5.1 for corresponding figures at

¹⁰See e.g. Kastrup (2020) for a more detailed description of the method and for application to Danish data.

one- and two-digit disaggregation levels). The upper graph shows the unweighted distribution, while the lower is a weighted histogram, based on the product groups' share of the total import value for the manufacturing sector. The distribution of estimates for the product groups is right skewed, where most product groups have a low or moderate import elasticity, but there is also a significant number with a relatively high elasticity of substitution. One could therefore consider whether data indicate a need for heterogeneous export firms, based on whether they trade in a market within product groups with a high or low degree of competition, respectively. In this case, one elasticity (correct on expectation) could conversely be an inaccurate description of these two types of markets.

Table 1 shows the average estimates at different aggregation levels. At the most disaggregated level, the unweighted average for the estimated elasticities is 5.93, but 5.44 when the import content is taken into account. This is partly because the product groups at the upper limit of 30 are typically smaller. If we remove the product groups at the limit, the weighted average drops slightly below 4. The aggregate estimate is thus relatively robust and not driven by corner solutions. The median for import elasticities in the manufacturing sector is 3.37.

After estimating the import elasticities, we calculate the relevant macro elasticity to be included in MAKRO, i.e. the elasticity of substitution between domestically produced goods and imports in the manufacturing sector. We find that the resulting macro elasticity of imports in manufacturing is 2.76 - just slightly higher than half the weighted micro elasticity (Table 1). Finally, Table 1 shows how the estimated import elasticities are affected by the level of disaggregation in data used in the estimation. The weighted and the unweighted averages tend to increase as more disaggregated data is used in estimation: From 2-3, 3-4 and 5-6 for one-, two- and three-digit SITC classification, respectively. The same holds for the median.

The energy sector in MAKRO consists of the product groups in SITC 3 (primarily fuel and various oil products). At the more disaggregated level, data availability for this sector is low in the country dimension specifically. As mentioned in section 2, this is problematic, as the estimation depends on the fact that one can exploit the heteroskedasticity of the country dimension. As a result, one elasticity is reported rather than a distribution: We find a micro elasticity of 4.56 that is scaled to a macro elasticity of 3.50 when import content is taken into account (see Appendix 4.1 for more details).

4.2 Export elasticities

For exports, we assume that Denmark is a small open economy, implying that Denmark's export price does not affect the foreign CES price index. Thus, the macro elasticity is equal to the estimated weighted average of the micro elasticities. This approximation is reasonable for the vast majority of countries and product groups, but there are a few product groups where Denmark's market

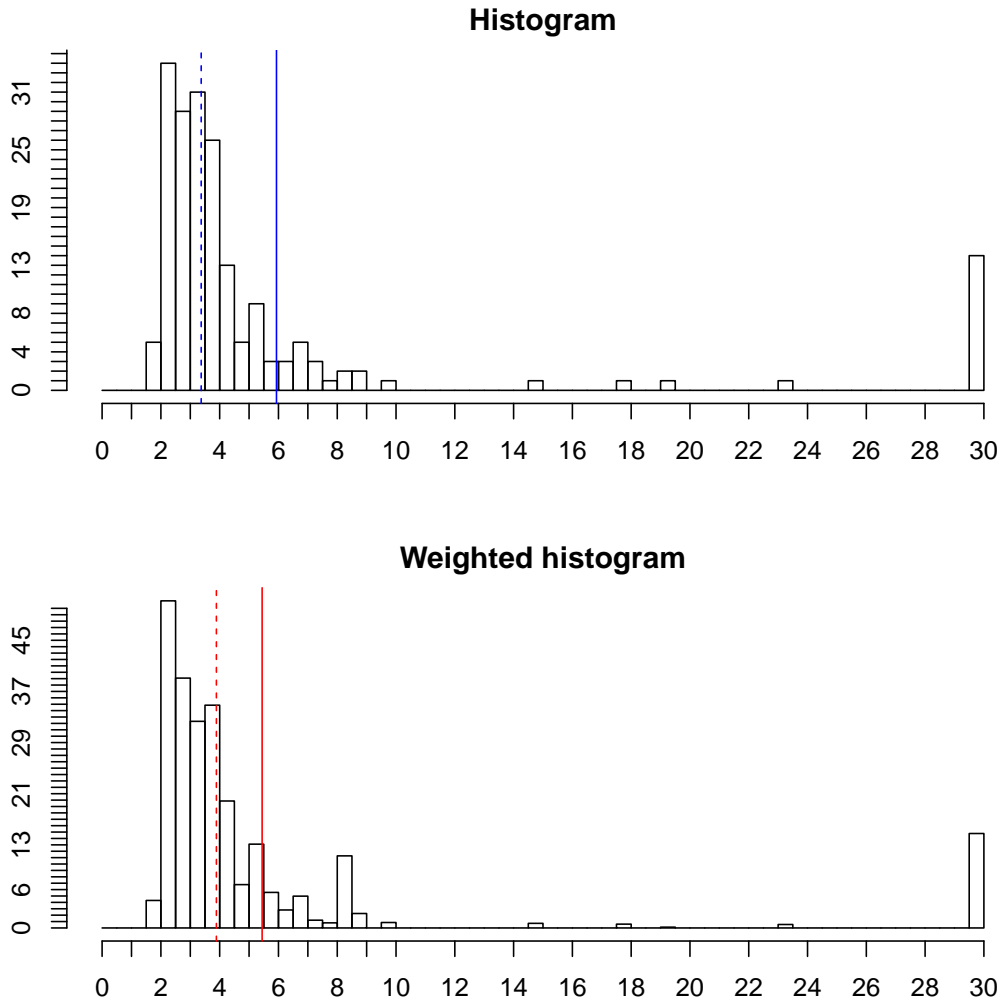


Figure 1: Import elasticities for MAKRO's manufacturing sector for three-digit SITC groups.
Note: The blue solid line is a simple average of the elasticities of each SITC group, and the blue dashed line is the median. The red solid line is a weighted average, using the SITC group's share of total imports as a weight. The red dashed line is the weighted average where elasticities of 30 are removed and the weights are rescaled.

Tabel 1: Import elasticities for MAKRO’s manufacturing sector

	Micro elasticities			Macro elasticities
	Weighted average	Simple average	Median	
SITC one-digit	2.97	2.67	2.53	1.78 (0.23)
SITC two-digit	3.57	3.97	3.42	2.02 (0.32)
SITC three-digit	5.44	5.93	3.37	2.76 (0.23)

Note: The micro elasticity is the elasticity for the SITC product group. The weighted elasticities are weighted by the share of their product group in total imports. We only include the countries and SITC groups included in the estimations, so that their weights sum to 1. The macro elasticities are a weighted sum of the micro elasticities where the import content of the SITC groups is taken into account.

share in the country’s imports is of substantial size. As the import elasticities for the product groups in these countries should ideally be scaled down to the extent that Danish prices affected domestic prices in our trading countries, this will all other things being equal contribute to a certain degree of upward bias in the estimate for export elasticity. However, as we include many countries and product groups, each import elasticity is included with a low weight. As the elasticities for product groups with a large Danish market share are relatively low, we expect the contribution of the correction to the total export elasticity to be modest. We define the export elasticity based on the import elasticities for Denmark’s 50 largest export markets. We weigh these elasticities by their importance for Danish exports in the given sector. These weighted import elasticities for Denmark’s trading partners can then be regarded the effective export elasticity for Denmark. Table 2 shows the estimated export elasticity for Denmark when it is calculated as a weighted average of the import elasticities for Denmark’s 50 largest trading partners. These countries cover more than 90 pct. of Danish exports (Figure 4 in Appendix 2 shows the importance of the number of countries that we find to be of a limited extent). Again, we find that estimates are increasing as more disaggregated data is used. At the most detailed product group level, we find an elasticity for exports in the manufacturing sector 5.42 (and at the least disaggregated it is 3.48). For the energy sector, we estimate the elasticity for exports of approximately 5 (again, we look at the one-digit SITC group 3).

5 Robustness

In this section, we examine the robustness of the results from the previous section. As mentioned, we set an upper limit value for the demand elasticity of 30. This is the same value as used in e.g.

Tabel 2: Export elasticities for MAKRO’s sectors

	Manufacturing	Energy
SITC one-digit	3.48 (0.09)	5.03 (0.18)
SITC two-digit	5.01 (0.05)	14.88 (0.10)
SITC three-digit	5.42 (0.03)	13.82 (0.08)

Note: The export elasticities are based on a weighting of the import elasticities of the 50 most important trading partners, where the imports of these 50 countries account for 91 pct. of Danish exports.

Imbs and Mejean (2017), but other studies set the limit higher. When we have not set it higher in the first place, this is among other things because high elasticities are difficult to distinguish. In this case, a lower limit value serves as a precautionary principle, i.e. so that the estimates used in MAKRO are not overestimated. In the estimations, however, it turns out that only a relatively small fraction of the elasticities for the product groups are restricted by this upper limit. As mentioned, while the majority of the estimates are below the average, this means that the overall average estimate (weighted and unweighted) is increased somewhat (this is in fact a weakness of the methodology, but applies generally to the literature). Therefore, it is relevant to investigate how the estimated average of the import elasticities (section 4.1) is affected by raising the upper limit to 131.5 which is in the high end of the values used in the literature (e.g. Broda and Weinstein, 2006). In MAKRO’s energy sector, there are no estimates that hit the limit of $\sigma_k = 30$, and hence this does obviously conclusions. For the manufacturing sector’s one-digit and two-digit SITC groups, there are no estimates that hit the limit either. In the manufacturing sector with three-digit SITC groups, there are 14 product groups on the limit of $\sigma_k = 30$, where this number drops to 11, if the limit is raised to $\sigma_k = 131,5$. The macro elasticity here increases from 2.76 to 4.80 (Table 3).

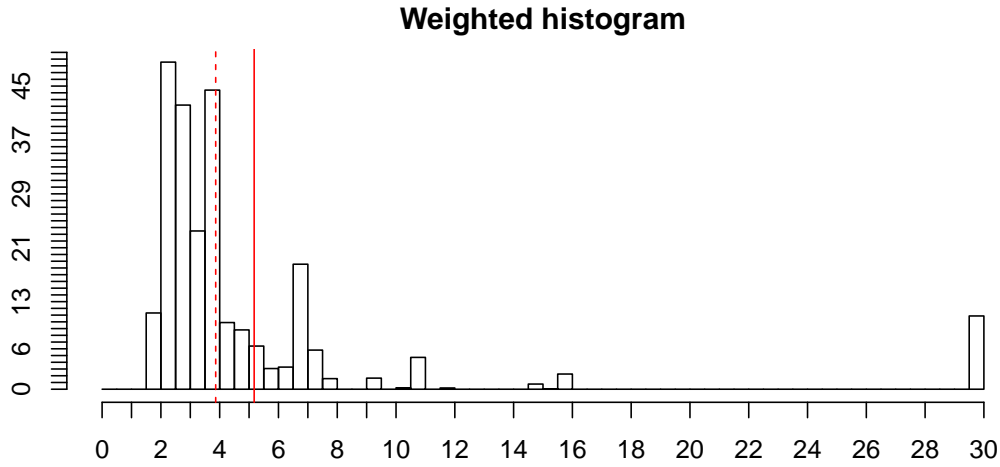
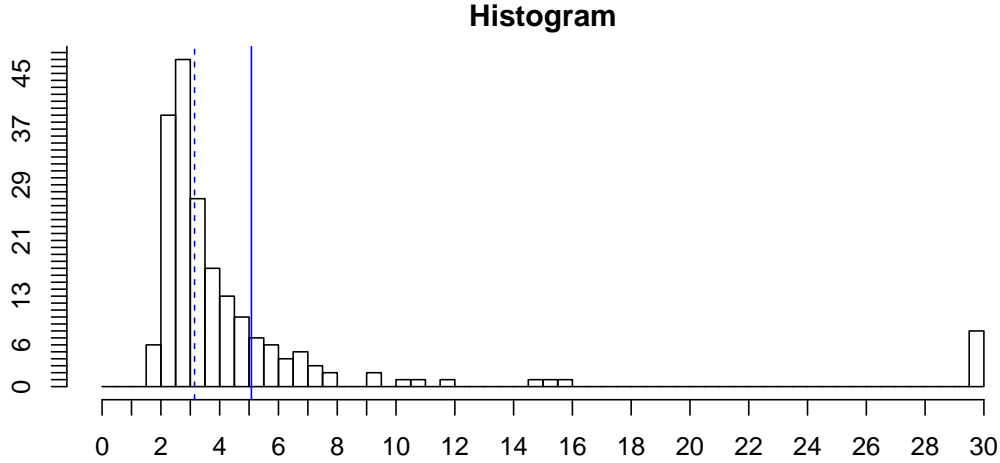
The export elasticity in section 4.2 is calculated on the basis of Denmark’s 50 most important trading partners. Overall, it does not change the estimates considerably if the number of countries varies, which probably reflects that - even with a smaller number of countries - a majority of Danish exports is included. By increasing the number of countries in the estimation, less important countries for Danish exports are gradually included in the estimation. Specifically, Figure 4 in the appendix shows that the elasticity is around 5.2 when the 5-15 most important countries are included, but increases to around 5.4 when more than 20 countries are included. When a higher number of countries is included, the estimate of the export elasticity is relatively stable, and the data coverage does not improve substantially compared to our preferred specification. We therefore consider the 50 countries used in our dataset of exporting countries to be representative of Denmark’s total exports.

Tabel 3: Import elasticities for MAKRO’s manufacturing sector with an upper limit of $\sigma_k = 131, 5$.

	Micro elasticity			Macro elasticity
	Weighted average	Simple average	Median	
SITC one-digit	2.97	2.67	2.53	1.78 (0.23)
SITC two-digit	3.57	3.97	3.42	2.02 (0.32)
SITC three-digit	10.60	12.01	3.37	4.80 (0.23)

Note: The micro elasticity is the elasticity for the SITC product group. The elasticities are weighted by the share of their product group in total imports. We only include the countries and SITC groups included in the estimations, so that their weights sum to 1. The macro elasticities are a weighted sum of the micro elasticities where the import content of the SITC groups is taken into account.

An alternative method of estimating export elasticities is by »reversing the estimation«: We estimate Denmark’s export elasticity rather than import elasticity, which implicitly corresponds to an assumption of identical import elasticities abroad. Figure 2 shows the distribution of the estimated micro elasticities for exports of different product groups in MAKRO’s manufacturing sector at a disaggregation level corresponding to the three-digit SITC classification. Table 4 shows the estimates at different disaggregation levels. The total export elasticity for the manufacturing sector (after weighting of product groups at a three-digit level) is 5.17 and thus remarkably close to the result of the weighting of the import elasticities of the export markets. For exports, the average is also positively affected by a few product groups that have a high elasticity of substitution, including some elasticities at the upper limit (the weighted average without these product groups is 3.86). However, the result is not driven by the composition of the estimates divided by the size of the product groups, as we find that the unweighted average (5.08) is close to the weighted one. As was the case for imports, the distribution of elasticities for exports is also right skewed with a median of 3.15 and thus somewhat below the average. As for imports, the elasticity is estimated higher, the more disaggregated data used in the estimation. This also applies to both the weighted and unweighted averages and the median. As was the case with imports, data is relatively thin in the country dimension for MAKRO’s energy sector and we therefore only estimate one export elasticity for this sector and find an estimate of 4.04. Overall, the differences in the estimated export elasticities depending on the choice of method are small, and therefore the results are considered to be robust.



Figur 2: Export elasticities for MAKRO's manufacturing sector for three-digit SITC groups
Note: The blue solid line is a simple average of the elasticities of each SITC group, and the blue dashed line is the median. The red solid line is a weighted average, using the SITC group's share of total exports as a weight. The red dashed line is the weighted average where elasticities of 30 are removed and the weights are rescaled.

Tabel 4: Eksport elasticities for MAKROs manufacturing sector

	Weighted average	Simple average	Median	Weighed average without $\sigma = 30$
SITC one-digit	2.11	2.67	2.13	2.11
SITC two-digit	3.90	4.24	2.99	3.75
SITC three-digit	5.17	5.08	3.15	3.86

Note: The weighted average is weighted by the product group's share in total exports measured in export value.

6 Summary

We estimate the foreign trade elasticities in MAKRO's two private goods industries (manufacturing and energy) using the method in Feenstra (1994) and highly detailed data from the BACI database. Data covers the period 1995-2016 as well as more than 200 countries and 5,000 product groups. For imports of manufacturing goods, we find a macro elasticity relevant for MAKRO of around 2.8. We form this elasticity first as a weighted average of the elasticities estimated on product data. We then correct this weighted so that the shock we identify is a shock that affects all product groups and exporting countries identically, which corresponds to the type of shock performed in aggregate models such as MAKRO. The export elasticity is defined as a weighted average of Denmark's 50 largest trading partners' import elasticities. The estimate for manufacturing is found to be approximately 5.4 and to be relatively robust to alternative specifications as well as changes in the number of countries. For the energy sector, we find macro elasticities of approximately 3.5 and 5, for imports and exports respectively. For both imports and exports, we find that the estimates are systematically higher when the data used in estimation are more disaggregated (more digits in the SITC classification). This indicates that there may be issues with aggregation bias, so that estimates based on aggregate data would tend to be too low.

A1. Identification method

Figure 3 is a simple illustration of a given market for two different countries. Repeated observations of prices and quantities form clouds in the (Q, P) -diagram. For country A (the left part of the figure), the demand shocks are more volatile than the supply shocks, and this helps to identify a supply curve. For country B (the right part of the figure), the supply shocks help to identify the demand curves. If we assume the same supply and demand curves for both countries, we can identify both curves for both countries. This emphasizes the importance of heterogeneity in shocks in the country dimension.

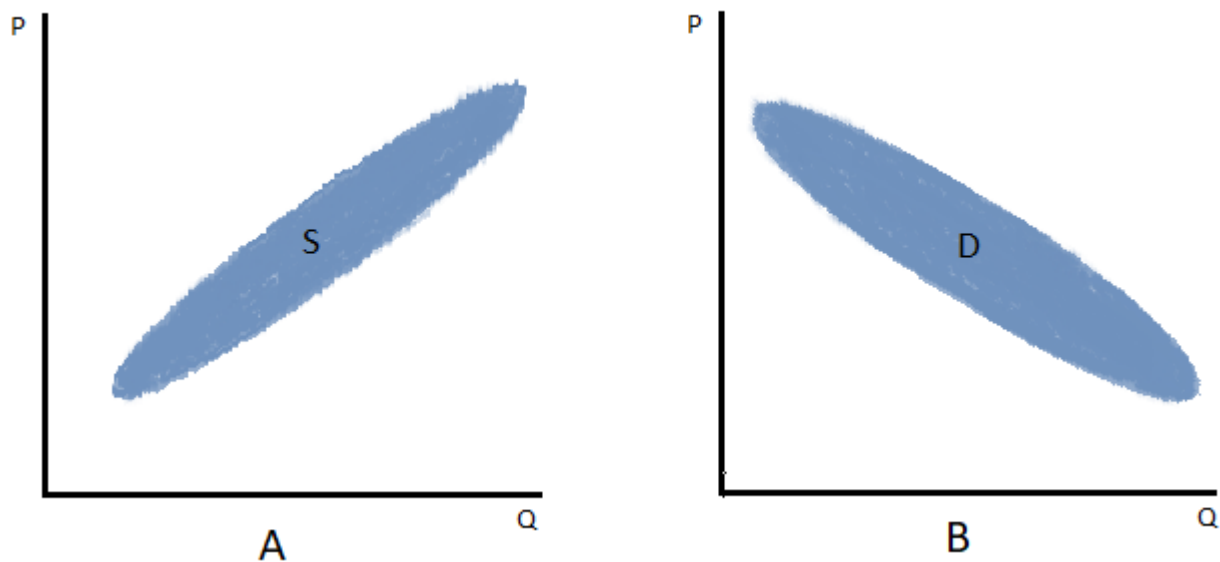


Figure 3: Simple illustration of market equilibria in country A and country B.

A2. Data

A2.1 Summary of data with Denmark as import country

Table 5: Manufacturing sector: Summary of data for unbalanced panel

	Data coverage	SITC groups	Remaining SITC groups	avg. number of countries
SITC one-digit	75	9	8	40
SITC two-digit	72	61	58	31
SITC three-digit	68	248	197	26

Note: Data coverage is the total import value in all the years for countries and SITC groups included in the estimates relative to the available import value in the raw data set. The criteria for including data in the estimation are described in section 3.3.

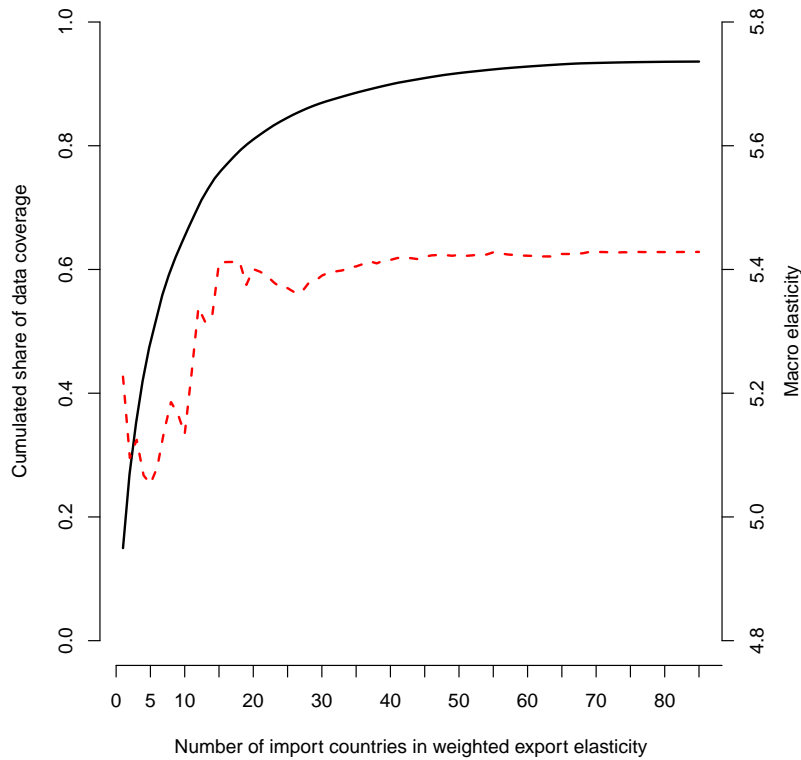
Tabel 6: Energy sector: Summary of data for unbalanced panel

	Data coverage	SITC groups	Remaining SITC groups	Avg. number of countries
SITC one-digit	58	1	1	25
SITC two-digit	50	4	1	22
SITC three-digit	40	11	2	21

Note: Data coverage is the total import value in all the years for countries and SITC groups included in the estimates relative to the available import value in the raw data set. The criteria for including data in the estimation are described in section 3.3.

A2.2 Import data for Danish exporting countries

Figur 4: Cumulative data coverage and elasticity of substitution for exports



Note: The black solid line shows the cumulative share of data coverage for the countries when they are ranked according to importance in Danish exports. The red dotted line is export substitution elasticities for MAKRO's manufacturing sector at the highest disaggregation level estimated as in section 4.2. This elasticity is estimated for different numbers of importing countries as an approximation for all of Denmark's exports.

A3. Macro elasticity

In this section, the macroeconomic import elasticity for e.g. Denmark. Derivation are based on a Cobb-Douglas consumption function in the upper nest, where the consumer substitutes between different products, noted by k . In the lower nest, substitution is made between countries where the product is imported from, which includes Danish goods. Thus, we assume that the foreign-foreign elasticity is identical to the home-foreign elasticity. The demand for product k originating from country i is given by:

$$C_{ki}P_{ki} = \beta_{ki} \left(\frac{P_{ki}}{P_k} \right)^{1-\sigma_k} C_k P_k. \quad (6)$$

C_{ki} is the quantity demand and P_{ki} is the price of product k from country i . Note here that i also contains Denmark. A home bias is expressed through differences in β_{ki} , which express »love of variety« after products from different countries. Thus, only the response to price changes $(1 - \sigma_k)$ is assumed to be constant across countries. C_k and P_k are respectively. the demand and price of product k in the importing country. As the upper nest is Cobb-Douglas, $C_k P_k$ is kept constant when a shock to the import price of product k from e.g. Sweden occurs. This is an important advantage when calculating the macroeconomic elasticity.

Based on equation (6) we can define two different types of shocks. We define a microeconomic shock as a shock that affects P_{ki} but keeps P_k constant, which holds given that country i is sufficiently small. The elasticity of this shock is therefore $1 - \sigma_k$. A macroeconomic shock to the import price as in MAKRO, on the other hand, is a shock that affects the import price for all k and $i \neq DK$. Let us denote this shock as $\partial \log(P^M) \equiv \partial \log\left(\sum_k \sum_{i \neq DK} P_{ki}\right)$. This shock is thus a percentage change in the import price of all products in the given sector as well as all importing countries, not including Denmark. To derive this elasticity, we start by deriving the macro elasticity at product level (aggregated across countries in one product group) and then at aggregated level (aggregated across importing countries and products). The derivative of (6) in logs and aggregated across importing countries (the macroeconomic elasticity of product k) is as follows:

$$\frac{\partial \log\left(\sum_{i \neq DK} C_{ki} P_{ki}\right)}{\partial \log(P^M)} = \sum_{i \neq DK} m_{ki} (1 - \sigma_k) \left(1 - \frac{\partial \log(P_k)}{\partial \log(P^M)}\right).$$

Where $m_{ki} = \frac{C_{ki} P_{ki}}{\sum_{i \neq DK} C_{ki} P_{ki}}$ is the individual importing country's share in total imports. Since the function is CES, it applies that $\frac{\partial \log(P_k)}{\partial \log(P^M)} = \sum_{i \neq DK} w_{ki} \frac{\partial \log(P_{ki})}{\partial \log(P^M)}$, where $w_{ki} = \frac{C_{ki} P_{ki}}{\sum_i C_{ki} P_{ki}}$, i.e. country i 's share of total consumption (import + own production) in Denmark of product k . Since $\frac{\partial \log(P_{ki})}{\partial \log(P^M)} = 1$ for all $i \neq DK$ in CES functions, then $\frac{\partial \log(P_k)}{\partial \log(P^M)} = \sum_{i \neq DK} w_{ki} = \lambda_k$, i.e. the import content of product k in Denmark. Since $\sum_{i \neq DK} m_{ki} = 1$, the macroeconomic elasticity at product

level (σ_k^M) can be reduced to:

$$(1 - \sigma_k^M) \equiv \frac{\partial \log \left(\sum_{i \neq DK} C_{ki} P_{ki} \right)}{\partial \log (P^M)} = (1 - \sigma_k) (1 - \lambda_k). \quad (7)$$

The effect of the shock on total imports, aggregated across products and countries, is given by:

$$(1 - \sigma^M) \equiv \frac{\partial \log \left(\sum_k \sum_{i \neq DK} C_{ki} P_{ki} \right)}{\partial \log (P^M)} = \sum_k m_k (1 - \sigma_k^M) = \sum_k m_k (1 - \sigma_k) (1 - \lambda_k). \quad (8)$$

Where σ^M is the macroeconomic elasticity of data aggregated across products and importing countries. This elasticity is a weighted average of the macro elasticities at the product level, $(1 - \sigma_k^M)$, where $m_k = \frac{\sum_{i \neq DK} C_{ki} P_{ki}}{\sum_k \sum_{i \neq DK} C_{ki} P_{ki}}$ is the share of product k in total imports. It is this elasticity that is of primary interest and relevant to MAKRO.

A4. Estimation results for Energy

A4.1 Import

Tabel 7: Import elasticities for the energy sector at one-digit disaggregation level

SITC group	Elasticity	Number of countries in estimation	Weight of group in import value
energy 3	4.56	23	1.00

Tabel 8: Import elasticities for the energy sector at two-digit disaggregation level

SITC group	Elasticity	Number of countries in estimation	Weight of group in import value
energy 33	4.86	20	1.00

Tabel 9: Import elasticities for the energy sector at three-digit disaggregation level

SITC group	Elasticity	Number of countries in estimation	Weight of group in import value
energy 334	3.39	23	0.95
energy 335	3.69	16	0.05

Tabel 10: Import elasticities for MAKRO's energy sector

	Macro elasticity
SITC one-digit	3.50 (3.92)
SITC two-digit	3.71 (1.72)
SITC three-digit	2.69 (3.68)

Note: The macro elasticities are a weighted sum of the micro elasticities, taking into account the import content of the SITC groups.

A4.2 Export elasticities, conditional on the assumption that all countries have identical import elasticities

Tabel 11: Export elasticities for the energy sector at one-digit disaggregation level

SITC group	Elasticity	Number of countries in estimation	Weight of group in import value
energy 3	4.04	22	1.00

Tabel 12: Export elasticities for the energy sector at two-digit disaggregation level

SITC group	Elasticity	Number of countries in estimation	Weight of group in import value
energy 32	30.00	19	0.00
energy 33	2.67	21	1.00

Tabel 13: Export elasticities for the energy sector at three-digit disaggregation level

SITC group	Elasticity	Number of countries in estimation	Weight of group in import value
energy 322	5.35	28	0.00
energy 334	3.12	28	0.94
energy 335	5.88	17	0.05

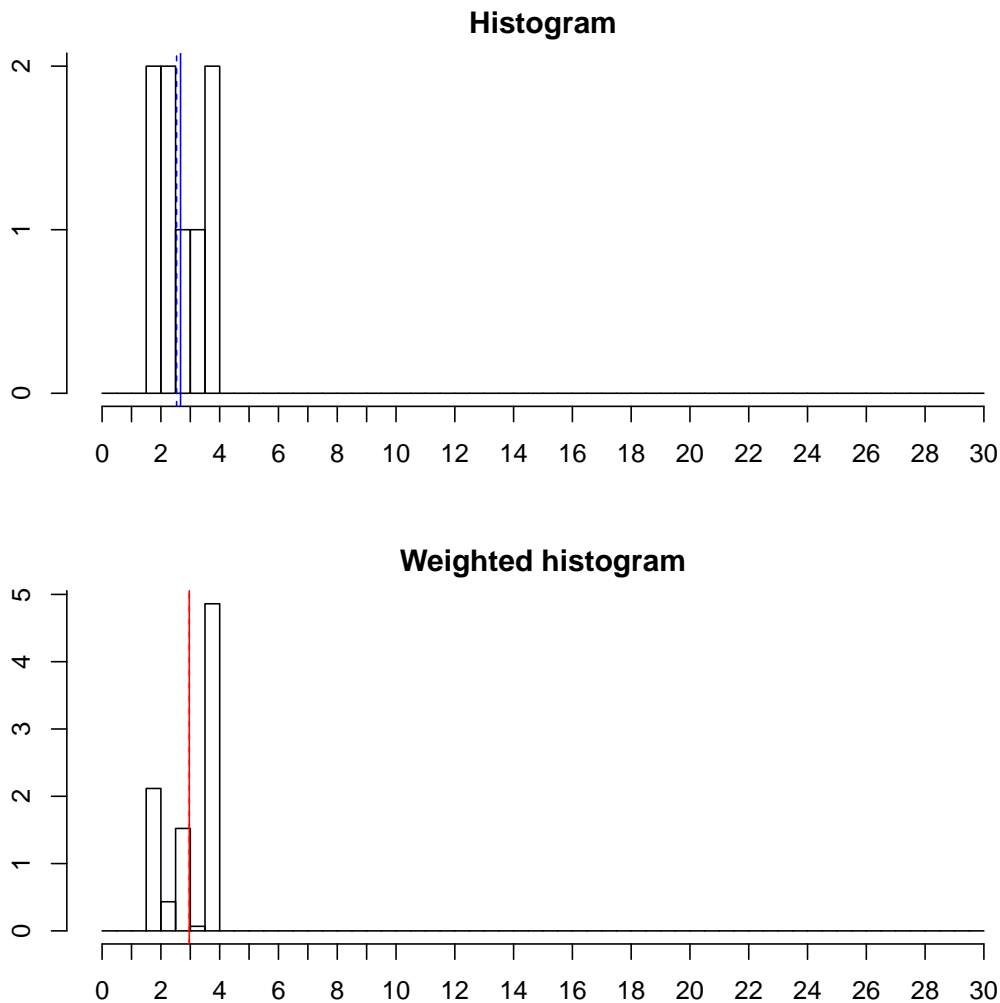
Tabel 14: Export elasticities for MAKRO's energy sector

	Macro elasticity
SITC one-digit	4.04
SITC two-digit	2.78
SITC three-digit	3.27

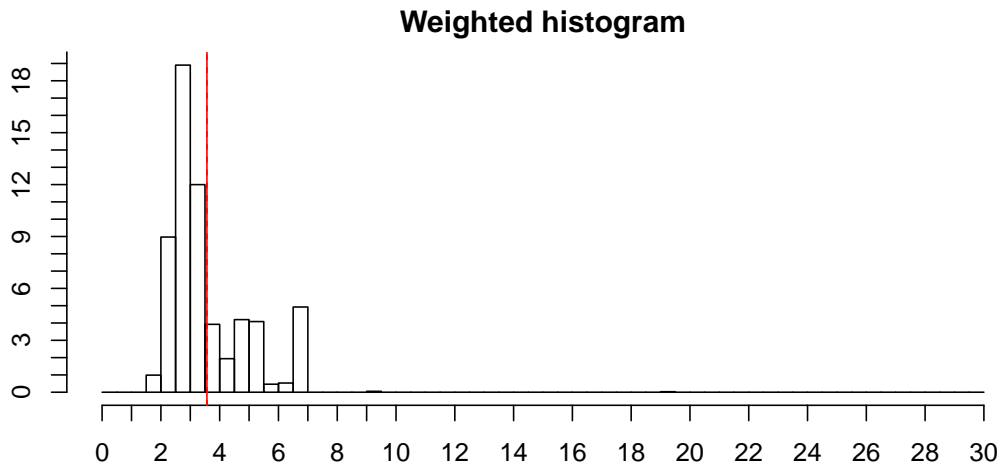
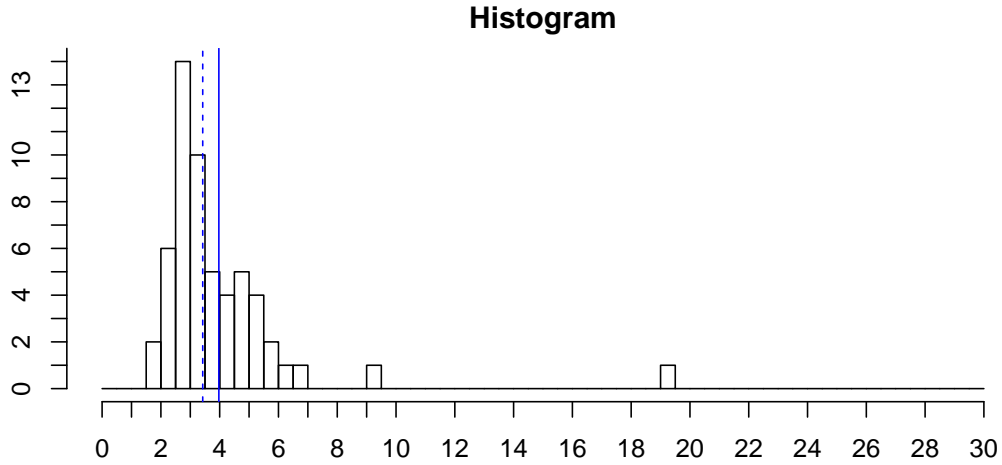
Anm.: The macro elasticities are a weighted sum of the micro elasticities, corrected for the export content in the different SITC groups.

A5. Figures

A5.1 Import

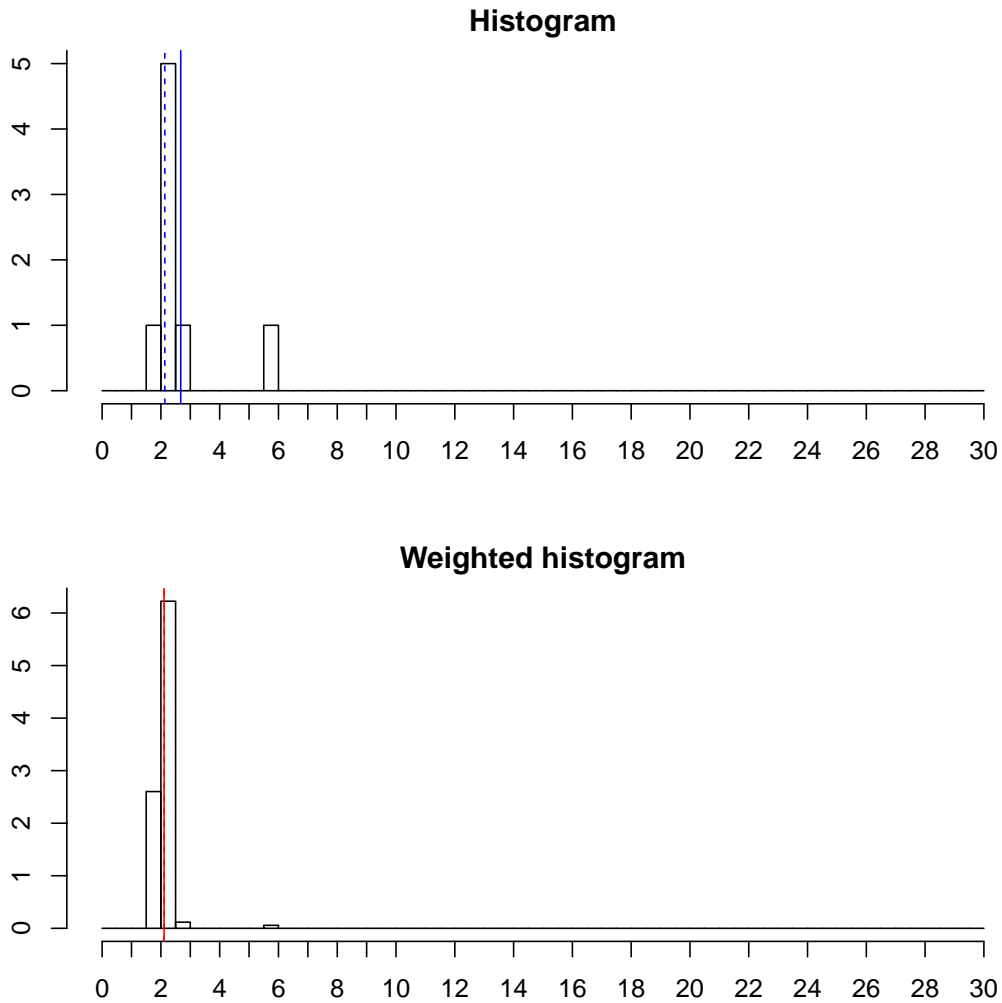


Figur 5: Import elasticities for MAKRO's manufacturing sector for one-digit SITC groups
Note: The blue solid line is a simple average of the elasticities of each SITC group, and the blue dashed line is the median. The red solid line is a weighted average, using the SITC group's share of total imports as a weight. The red dashed line is the weighted average where elasticities of 30 are removed and the weights are rescaled.

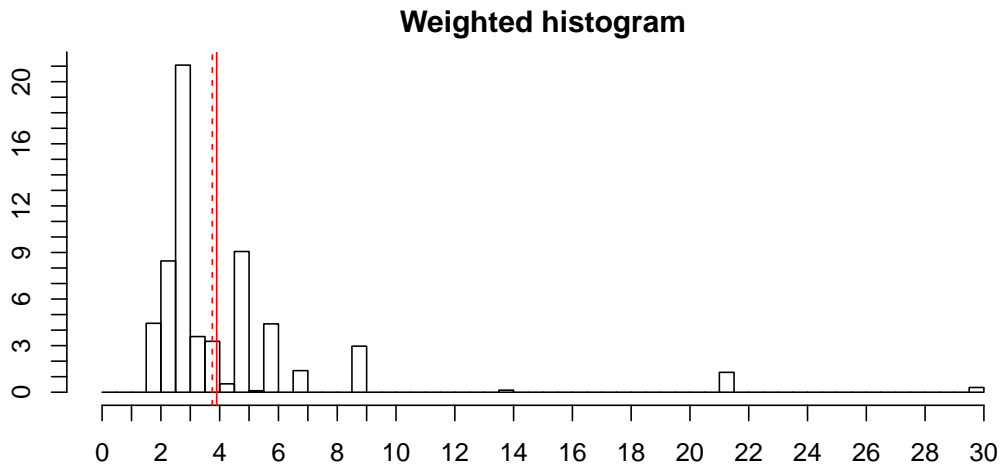
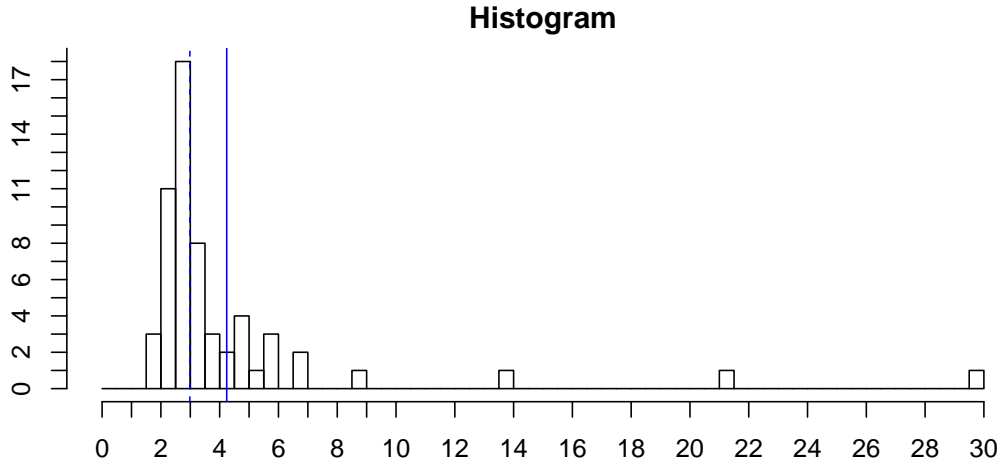


Figur 6: Import elasticities for MAKRO's manufacturing sector for two-digit SITC groups
Note: The blue solid line is a simple average of the elasticities of each SITC group, and the blue dashed line is the median. The red solid line is a weighted average, using the SITC group's share of total imports as a weight. The red dashed line is the weighted average where elasticities of 30 are removed and the weights are rescaled.

A5.2 Export elasticities, conditional on the assumption that all countries have identical import elasticities



Figur 7: Export elasticities for MAKRO's manufacturing sector for one-digit SITC groups
Note: The blue solid line is a simple average of the elasticities of each SITC group, and the blue dashed line is the median. The red solid line is a weighted average, using the SITC group's share of total exports as a weight. The red dashed line is the weighted average where elasticities of 30 are removed and the weights are rescaled.



Figur 8: Export elasticities for MAKRO's manufacturing sector for two-digit SITC groups
Note: The blue solid line is a simple average of the elasticities of each SITC group, and the blue dashed line is the median. The red solid line is a weighted average, using the SITC group's share of total exports as a weight. The red dashed line is the weighted average where elasticities of 30 are removed and the weights are rescaled.

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