

## Supply factors in trade determination

### Resumé:

*The paper provides a motivation for including supply factors in the determination of exports in ADAM. Using a gravity equation, we document a significant supply effect on Danish exports with a magnitude of 0.7. Given that the supply elasticity estimate from the gravity equation is robust and in line with the literature, we can choose to use this value in ADAM.*

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DSI080816

Nøgleord: Exports, demand factors, supply factors

*Modelgruppepapirer er interne arbejdsrapporter. De konklusioner, der drages i papirerne, er ikke endelige og kan være ændret inden opstillingen af nye modelversioner. Det henstilles derfor, at der kun citeres fra modelgruppepapirerne efter aftale med Danmarks Statistik.*

## 1. Introduction

Empirical modelling of international trade flows is dominated by a standard workhorse model where the volume of imports (exports) are related to domestic (foreign) income and relative prices. Numerous empirical models have been estimated with notable empirical success. The empirical success has contributed to the lack of renowned interest in other factors determining trade. The estimated income and price elasticities vary among different studies owing to differences in the countries considered, the time periods covered, the commodities modeled, the methodologies used and whether or not additional explanatory variables are included.<sup>1</sup>

The standard model tells us that a country with favorable domestic growth experiences a trade deficit through higher imports, a corresponding offset through higher exports requires that country to cut the relative price of its exports in order to be able to sell its expanding exports. This implication of the standard model has been subjected to a number of critics. The strong objection comes from Krugman (1989). Krugman's observation is based on the earliest and most well-known finding of Houthakker and Magee (1969). Houthakker and Magee estimated income elasticities of imports and exports for a number of industrial countries and found large differences among countries in their income elasticities. They estimated a high income elasticity of demand for exports and low income elasticity of demand for import for Japan, and they found the reverse for US and UK. In their sample Japan was the fastest growing country and US and UK were the slowest growing countries. The close correspondence between estimated income elasticities for exports and real domestic growth suggests some form of misspecification in the standard trade equations.

According to Krugman this difference in income elasticities is not a coincidence rather it is an empirical regularity. Fast-growing countries face a high income elasticity of demand for their exports and low income elasticity of demand for their imports, i.e. there is a positive relationship between growth rates and the ratio between export and import income elasticities, which is known as the 45-degree rule. Japanese exports grew without a corresponding decline in the terms of trade, neither did the UK experienced an appreciation of its currency.

Krugman relates the 45-degree rule to the new theory of trade where similar countries trade because of increasing returns and not comparative advantage. Fast growing countries expand their share of the world market by *expanding the range of goods* they produce (not by reducing prices), and as product varieties expand the demand curve for its exports shifts outward resulting in a favorable income elasticity for exports that leads to expansion of the economy without corresponding depreciation of the real exchange rate. There is a supply side element in the apparent difference in demand that countries face.

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<sup>1</sup>For a review of the literature, see for example Hooper and Mann (1989), Hooper, Johnson and Marquez (2000), Gagnon (2007) and Imbs and Mejean (2015).

The empirical study that followed have mixed findings. Schatz (1989) declares Houthakker and Magee's finding fragile. By excluding Japan, UK and US from the sample, he shows that the  $R^2$  shrinks to 0.05 from 0.75. Ghatak and Price (1996), as cited in Wu (2005), document the absence of such relationship between growth and income elasticities for 9 East Asian economies. On the contrary, Caporale and Chui (1999) using a cointegration analysis for 21 countries for the period 1960-1992 found evidence for the 45-degree rule. Wu (2005) provides a theoretical justification and empirical support for the 45-degree rule.

Feenstra (1994), on the other hand, relates the high income elasticity of demand for US imports to measurement errors in import price indices. Conventional price indices do not capture the increasing varieties of US imports and the associated decrease in aggregate prices. Feenstra provides a way of incorporating new varieties in the construction of aggregate prices, he shows that the corrected indices are able to account for part of the high import elasticity in US imports.

Constructing price indices that account for changes in the product mix is costly, Feenstra applies it to a narrow definition of 6 import groups. Other studies focus on adding additional explanatory variables to the standard workhorse model to account for supply effects. The sign and size of such variables is not clear, Mann and Plück (2007) provide a review of such studies.

The earliest of such studies comes from Sato (1977). Sato used manufacturing capacity in the exporting countries as a proxy for supply effects and found significant effects. Helkie and Hooper (1988) augment the standard model by the ratio of home to foreign productive capital stocks to capture exporters' increased capacity to supply more new products to the U.S. market. They were able to significantly reduce the gap between export and import demand elasticities for US. Mann and Plück (2007) document the insignificance of this additional variable in estimations using more recent data. Marquez (2002) uses Feenstra's approach to construct price variables and includes a relative capital stock term as in Helkie and Hooper, his estimation reduced the income elasticity for imports. Marquez also used immigration to the US as a proxy for US consumers taste for varieties from abroad. His estimation reduces the income elasticities for imports.

Bayoumi (1999) run pooled bilateral time-series regression on 21 industrial countries and includes exporters' GDP to capture supply effects. He finds an elasticity of 0.8 on domestic output. The coefficient on exporter's output increases with increasing lags indicating that it is potential growth, not short-term fluctuations in growth, that determines exporters' capacity to supply varieties. Gagnon (2003, 2007, 2008) builds on Bayoumi and uses potential output growth of the exporting country to account for supply effects. He estimates a coefficient approximately half the magnitude of the estimated import income elasticity of 1.5. Including supply factors reduces the coefficient on income elasticity for US imports, but his results for exports are less robust. Mann and Plück (2007) modeled US trade flows by using a disaggregated bilateral data, they augment the standard demand equation with alternative

measures of global supply and variety and found evidence for supply effects.<sup>2</sup> In the rest of the paper, we present a gravity model for Danish exports which has long recognized the role of supply factors in the determination of trade.

## 2. Gravity equation

The gravity approach, introduced first in Tinbergen (1962), relates bilateral trade flows to incomes of the exporting country (supply effect), incomes of the importing country (demand effect), distance and contiguities. It is one of the most widely used and more rewarding empirical model in international economics, we apply this model for Danish exports without further motivation, cf. Anderson (1979) and Anderson and van Wincoop (2003) for a theoretical derivation of the model. The standard gravity model takes the form:

$$\log(E_{jt}) = \alpha + c_i + \beta_1 \cdot \log(Y_t) + \beta_2 \cdot \log(Y_{jt}) + \beta_3 \cdot \log(\text{Dist}_j) + \sum_k \gamma_k \cdot \text{Dum}_k + \epsilon_{jt}$$

$$t = 1, 2, \dots, T \text{ \& } j = 1, 2, \dots, N \quad (1)$$

Where	$E_{jt}$	Danish exports to $j$ in value
	$Y_t$	Danish GDP
	$Y_{jt}$	partner $j$ 's GDP
	$\text{Dist}_{jt}$	distance between Denmark and $j$
	$\text{Dum}_k$	list of control dummies
	$c_i$	time invariant unobserved effect
	$\epsilon_{jt}$	error term

The use of panel dataset allows us to estimate the coefficients of interest more precisely.<sup>3</sup> Different studies use per capita income of the exporting and importing countries together with either aggregate income or population size to capture purchasing power and size effects separately. For simplicity, here we use income only. The income elasticities are expected to lie between 0 and 1, the coefficient on distance is expected to be negative, as the further apart  $j$  is from Denmark the less will be trade between the two. There are various ways of estimating (1), pooled OLS, Fixed Effect (FE) and Random Effect (RE) are the most common ones. The techniques in general differ in their treatment of the unobserved effect  $c_i$ , we do not wish to discuss details here, an interested reader is referred to Wooldridge (2002). Table 1 presents the estimation result.

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<sup>2</sup>Further evidence on supply effects can be found in Muscatelli and Antonio (1995), and Muscatelli, Stevenson and Montagna (1995).

<sup>3</sup>The data is obtained from different sources. Nominal bilateral trade flows are taken from Statistics Denmark's *StatBank*; GDP data is from IMF's economic outlook; and the distance measures are taken from Jon Haveman's website:

<http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/Data/Gravity/dist.txt>

**Table 1. Estimation result: dependent variable Danish industrial exports in value**

Variable	OLS	FE	RE
$\log(Y_t)$	0.575 [ 5.71]	0.713 [ 5.03]	0.720 [ 17.1]
$\log(Y_{it})$	0.640 [ 10.3]	0.675 [ 7.11]	0.668 [ 24.5]
$\log(\text{Dist}_j)$	-0.792 [-8.10]	-	-0.789 [-9.11]
Const	11.925 [ 11.2]	-	10.635 [ 15.1]
$c_i$	-	-	-

No. obs = 1329, N = 43, longest T = 1980-2015, shortest T = 1995-2015; t-values in square bracket. OLS is simple pooled OLS; FE is Fixed Effect model; RE is Random Effect model. The partner countries are: Australia, Austria, Belgium, Germany, Spain, Finland, France, United Kingdom, Greece, Ireland, Island, Italy, Netherland, Portugal, Sweden, United States, Canada, New Zealand, Norway, Japan, Chile, Israel, South Korea, Mexico, Brazil, China, India, Indonesia, Russia, South Africa, Turkey, Poland, Hungary, Czech Republic, Estonia, Slovakia, Slovenia, Romania, Lithuania, Latvia, Bulgaria, Malta, and Cyprus.

The coefficients have the expected sign and are significant. The sum of the two income elasticities is greater than one, indicating that trade grows faster than income. We should not attach much significance to the simple OLS estimate as it does not explicitly model unobserved effects that are very common in panel data. The choice often boils down to FE or RE. If the unobserved effects and the explanatory variables are correlated, the FE model is consistent as it removes the unobserved effect from the outset by subtracting the time averages of the variables in (1) from the original series. If the unobserved effect is uncorrelated with the explanatory variables, the RE model is consistent. Hausman (1978) provides a formal test based on the differences between the RE and FE estimates. However, the estimates are here very close to each other, that makes the distinction between RE and FE irrelevant.

The elasticity on domestic income is the coefficient of interest which is our measure for supply effects. The estimated value is approximately 0.7 based on the FE and RE models. We have experimented with different control dummies, such as dummies for EU countries, BRIICS, Euro, East European countries and time dummies. We found no significant contributions and in some instances the coefficients display the wrong sign, hence we only included dummies for individual effects.

### 3. Conclusion

The paper provided a review of the literature on the role of supply factors in the determination of trade. We applied the gravity equation for Danish exports that has long recognized the role of both supply and demand factors in the determination of trade flows. Using the gravity approach, we estimated a supply effect close to 0.7, which is in line with the estimates in Bayoumi (1999) and Gagnon (2003, 2007, 2008). Given that a significant supply effect is documented using a gravity approach, we can choose to use these coefficient for modelling supply effects in ADAM.

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