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Revisiting the importance of non-tradable goods' prices in cyclical real exchange rate fluctuations*

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Abstract

In an influential paper Engel (1999. Accounting for U.S. Real Exchange Rate Changes, Journal of Political Economy 107, 507-538) argues that essentially all the fluctuations in the real exchange rate can be attributed to fluctuations in the relative price of traded goods, and that only a small part of the fluctuations can be attributed to changes in the relative price of non-tradables. We instead decompose the real exchange rate into three components: the relative price of traded goods at-the-dock, the difference in the relative price of non-traded to traded goods and the difference in the wedge between retail prices of traded goods and the prices of traded goods at-the-dock. Using data on US bilateral real exchange rates we find that the fluctuations in the relative wedge between retail prices and traded goods prices at-the-dock account for on average between 30 and 70 percent of the movements in the real exchange rate. These findings suggest that the relationship between traded goods prices at-the-dock and retail prices of traded goods is key to understanding real exchange rate fluctuations.

JEL Classification: F31, F41

Keywords: Real Exchange Rates

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1 Introduction

A key issue in international macroeconomics is whether fluctuations in the real exchange rate can be attributed to deviations from the law of one price of traded goods or to differential movements in the relative price of non-traded to traded goods across countries. In an influential paper, Engel (1999) finds that fluctuations in the relative price of non-traded to traded goods account for essentially none of the observed fluctuations in the real exchange rate based on consumer price indices (CPI). Specifically, using data for bilateral real exchange rates between several OECD countries and the US, he finds that over 90 percent of the fluctuations in the real exchange rate can be attributed to fluctuations in the relative price of traded goods.[1] Similar results are reported by Chari, Kehoe and McGrattan (2002). This evidence has motivated much research on macroeconomic models that focus exclusively on traded goods prices in explaining the cyclical fluctuations in the real exchange rate (see e.g., Betts and Devereux, 1996, 2000, and Chari et al., 2002).

Engel (1999) measures traded goods' prices at the retail level. A potential problem with this measure is that it is contaminated by non-traded components like distribution costs (e.g., transportation costs, advertising, and retail costs). Moreover, not all goods that are classified as tradables in the CPI are indeed traded (e.g., "local goods" that are produced for the domestic market). The use of retail prices may thus overestimate the importance of tradables. Using aggregate import prices and export prices at-the-dock, Burstein, Eichenbaum and Rebelo (2006) find that the non-traded component accounts for about half of the fluctuations in the real exchange rate. This result suggests that the distinction between non-traded and traded goods is indeed important for understanding real exchange rate fluctuations.[2]

In this paper we decompose the real exchange rate into three terms: the relative price of traded goods at-the-dock, the relative price of non-traded to traded goods, and the wedge between retail prices of traded goods and the prices of traded goods at-the-dock across countries. Variations in the third term could be caused by variations in distribution costs or time-varying mark-ups reflecting non-constant demand elasticities and/or price stickiness. Our decomposition highlights why Engel (1999) and Burstein et al. (2006) obtain different results: Engel attributes all the variation in the wedge between the retail prices and prices at-the-dock to variations in the relative price of traded goods, while Burstein et al. implicitly attribute the variation in the 'wedge' term entirely to variation in the relative price of non-tradables. In section 2 we derive the analytical decomposition.

[1] When Engel uses producer price indices (PPI) to measure traded goods' prices instead of retail prices, the relative importance of the fluctuations in the traded component in explaining fluctuations in the CPI-based real exchange rate is somewhat lower for Canada and some European countries. However, as Engel emphasises, there are several problems with using PPI.

[2] Using PPI to measure traded goods' prices, Betts and Kehoe (2006) find that the relative price of non-tradables accounts for about one-fourth of real exchange rate fluctuations between the US and a weighted average of five of its most important trading partners. They also find that the importance of traded goods' prices is positively related to trade intensity. Using bilateral real exchange rates between 50 countries over the period 1980-2005, Betts and Kehoe (2008) confirm the finding that trade intensity matters and find that about one-third of real exchange rate fluctuations are accounted for by the relative price of non-tradables.

The apparatus is applied in section 3 using quarterly data on bilateral US real exchange rates for Canada, Japan, Norway and the UK from 1989Q1 to 2006Q2. We find that movements in the wedge term account for between 30 and 70 percent of real exchange rate fluctuations. This finding suggests that the relationship between traded goods prices at-the-dock and retail prices of traded goods is key to understanding real exchange rate fluctuations, as conjectured by Engel (1999).

Burstein et al. (2005, 2006) raise the issue whether the movements in the aggregate import and export price indices used in their analysis are driven by prices of goods other than consumption goods, such as capital goods, intermediate goods and raw materials. To the extent that import and export prices of consumption goods display different cyclical properties than the aggregate indices this will bias the estimates of the importance fluctuations in traded goods at-the-dock prices for real exchange rate fluctuations. In section 4 we address this issue. A newly published dataset from Statistics Norway allows us to examine the size of this bias for the US-Norwegian real exchange rate.[3] Our findings suggest that using aggregate import and export price indices may underestimate the importance of tradables. However, our main result still holds: movements in the wedge between retail prices of traded goods and the prices of traded goods at-the-dock across countries are an important source of real exchange rate fluctuations. Section 5 concludes.

2 Real exchange rate decompositions

The bilateral CPI-based real exchange rate, RER_t^{CPI}, can be written as

$$RER_t^{CPI} = \frac{S_t P_t^*}{P_t}, \tag{1}$$

where S_t is the period t nominal exchange rate, and P_t and P_t^* are the CPI in the home and foreign country, respectively. Throughout, variables with a star superscript correspond to the foreign country.

Following Engel (1999) we assume that the CPI is defined as a geometric average of the price of traded goods, $P_{T,t}$, and the price of non-traded goods, $P_{N,t}$, i.e.,

$$P_t \equiv (P_{T,t})^{(1-\gamma)} (P_{N,t})^{\gamma}, \tag{2}$$

$$P_t^* \equiv \left(P_{T,t}^*\right)^{(1-\gamma^*)} \left(P_{N,t}^*\right)^{\gamma^*}, \tag{3}$$

where γ is the share of non-traded goods in the consumption basket.

Making a distinction between at-the-dock prices of traded goods, denoted $\overline{P}_{T,t}$ and $\overline{P}_{T,t}^*$, and the retail prices of those goods, we rewrite the real exchange rate as follows:

$$RER_t^{CPI} = \frac{\left(P_{N,t}^*/P_{T,t}^*\right)^{\gamma^*}}{(P_{N,t}/P_{T,t})^{\gamma}} \frac{S_t \overline{P}_{T,t}^*}{\overline{P}_{T,t}} \frac{\left(P_{T,t}^*/\overline{P}_{T,t}^*\right)}{\left(P_{T,t}/\overline{P}_{T,t}\right)}. \tag{4}$$

[3] To our knowledge, only few countries publish such data.

Letting lower case letters denote variables in logs, (4) implies

$$rer_t^{CPI} = rer_t^N + rer_t^T + rer_t^D, \tag{5}$$

where

$$\begin{aligned}
rer_t^N &\equiv \gamma^* \left(p_{N,t}^* - p_{T,t}^*\right) - \gamma \left(p_{N,t} - p_{T,t}\right), \\
rer_t^T &\equiv s_t + \overline{p}_{T,t}^* - \overline{p}_{T,t}, \\
rer_t^D &\equiv \left(p_{T,t}^* - \overline{p}_{T,t}^*\right) - \left(p_{T,t} - \overline{p}_{T,t}\right).
\end{aligned}$$

The real exchange rate can thus be decomposed into three terms: the (weighted) difference in relative prices of non-traded to traded goods (rer^N), the relative price of traded goods at-the-dock (rer^T), and the difference in the wedge between retail prices of traded goods and the prices of traded goods at-the-dock (rer^D).

Engel (1999) decomposes fluctuations in rer^{CPI} into the two terms rer^N and $\left(rer^T + rer^D\right)$, and finds that the latter term accounts for essentially all of the observed fluctuations in the US real exchange rate. Burstein et al. (2006) instead decompose fluctuations in rer^{CPI} into the two terms rer^T and $\left(rer^N + rer^D\right)$. They find that fluctuations in this measure of the relative price of non-traded to traded goods do indeed play an important role in explaining real exchange rate fluctuations.

The decomposition in (5) illustrates that whereas Engel classifies the movements in the relative wedge between retail prices of traded goods and the prices of traded goods at-the-dock (rer^D) as movements in the relative price of traded goods, Burstein et al. (2006) attribute the variation in the wedge term to variations in the relative price of non-traded to traded goods. Thus the results in the two papers are not necessarily inconsistent. At the same time, the results highlight the potential importance of the wedge term for understanding real exchange rate fluctuations.

We construct a measure of the importance of the different terms in (5) based on the variance decomposition of the CPI based real exchange rate. The variance of rer_t^{CPI} is given by

$$\begin{aligned}
var\left(rer_t^{CPI}\right) &= var\left(rer_t^N\right) + var\left(rer_t^T\right) + var\left(rer_t^D\right) \\
&\quad +2\left[cov\left(rer_t^N, rer_t^T\right) + cov\left(rer_t^N, rer_t^D\right) + cov\left(rer_t^T, rer_t^D\right)\right].
\end{aligned} \tag{6}$$

We compute a lower bound, L^D, and an upper bound, U^D, of the relative importance of fluctuations in the wedge term based on variance decomposition in the following way

$$L^D = \begin{cases} \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} + \frac{2\left[cov\left(rer_t^D, rer_t^T\right) + cov\left(rer_t^D, rer_t^N\right)\right]}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right),\ cov\left(rer_t^D, rer_t^N\right) < 0 \\ \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} + \frac{2cov\left(rer_t^D, rer_t^T\right)}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right) < 0 < cov\left(rer_t^D, rer_t^N\right) \\ \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} + \frac{2cov\left(rer_t^D, rer_t^N\right)}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right) > 0 > cov\left(rer_t^D, rer_t^N\right) \\ \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right), cov\left(rer^D, rer_t^N\right) > 0 \end{cases}$$

$$U^D = \begin{cases} \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} + \frac{2\left[cov\left(rer_t^D, rer_t^T\right) + cov\left(rer_t^D, rer_t^N\right)\right]}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right), cov\left(rer^D, rer_t^N\right) > 0 \\ \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} + \frac{2cov\left(rer_t^D, rer_t^T\right)}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right) > 0 > cov\left(rer_t^D, rer_t^N\right) \\ \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} + \frac{2cov\left(rer_t^D, rer_t^N\right)}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right) < 0 < cov\left(rer_t^D, rer_t^N\right) \\ \frac{var\left(rer_t^D\right)}{var(rer_t^{CPI})} & \text{if } cov\left(rer_t^D, rer_t^T\right), cov\left(rer_t^D, rer_t^N\right) < 0 \end{cases}$$

We compute the lower bound L^D by attributing the negative covariance terms to the fluctuations in the wedge term and the upper bound U^D by attributing the positive covariance terms to the fluctuations in the wedge term. We compute a lower bound, L^N, and upper bound, U^N, of the relative importance of fluctuations in non-traded goods' prices in an analogous way (i.e., substituting N for D and vice versa in the equation above). This measure is similar to that used by Burstein et al. (2006), except that, since we decompose the real exchange rate into three terms, we take account of three covariance terms.

3 Accounting for US real exchange rate changes using the new decomposition

In this section we estimate the importance of the wedge between retail prices of traded goods and prices of traded goods at-the-dock (rer^D) in explaining US real exchange rate fluctuations. We use quarterly data for bilateral real exchange rates between the US and Canada, Japan, Norway and the UK covering the period 1989Q1–2006Q2. Throughout, the US is treated as the foreign country. The CPI are from IMFs International Financial Statistics (IFS) database.[4] The retail prices of traded goods are based on detailed CPI data from national statistical agencies. We adopt the convention of treating the category 'goods' as traded, and 'services' as non-traded.[5] The indices of traded goods prices at-the-dock are constructed using aggregate import price indices (IPI) and aggregate export price indices (EPI) from IFS. The quarterly import and export weights are based on aggregate trade value data from IFS.[6,7]

We proceed to construct empirical measures of the following variables: the CPI-based

[4] CPI for UK is taken from OECD Main Economic Indicators (MEI).

[5] Since the OECD has changed the sub-indices, it is not possible to use exactly the same categorisation as Engel (1999) on more recent data. However, the classification of goods is similar.

[6] Burstein et al. (2006) use an equally weighted average of import and export prices to calculate traded goods' prices. Ideally, the weight on import prices and export prices in the construction of traded goods' prices should correspond to the weight on imported goods and domestically produced traded goods in the consumer basket. Unfortunately, the weight on imported goods in CPI is not available for most countries. We therefore use trade value data as a proxy.

[7] For details on the data sources and the methods used to construct the price indices, see appendix A and B.

Table 1. US bilateral real exchange rate fluctations
Quarterly data in logs 1989Q1-2006Q2 (HP-filtered)

	Canada	Japan	Norway	UK
Engel's decomposition				
Relative importance of variation in rer^N to rer^{CPI}				
L^N	0.0198	0.0047	0.0126	-0.0260
U^N	0.0834	0.0065	0.0373	0.0056
Burstein et al.'s decomposition				
Relative importance of variation in $\left(rer^N + rer^D\right)$ to rer^{CPI}				
L^N	0.6243	0.3579	0.2749	0.1932
U^N	0.8916	0.8213	0.6483	0.5238
Our decomposition				
Relative importance of variation in rer^N to rer^{CPI}				
L^N	0.0198	-0.0010	-0.0150	-0.0266
U^N	0.0834	0.0122	0.0649	0.0065
Relative importance of variation in rer^D to rer^{CPI}				
L^D	0.5797	0.3532	0.2100	0.1866
U^D	0.8330	0.8148	0.6633	0.5504

Notes:
L^N (U^N) = lower (upper) bound on the importance of the relative price of non-traded to traded goods
L^D (U^D) = lower (upper) bound on the importance of the wedge between retail prices of traded goods and at-the-dock prices of traded goods

real exchange rate, rer^{CPI}, the relative price of traded goods at-the-dock, rer^T, the relative retail price of traded goods, $\left(rer^T + rer^D\right)$, and the relative wedge between retail prices of traded goods and at-the-dock prices of traded goods, rer^D. On the basis of these series we construct two measures for the relative price of non-traded to traded goods, rer^N and $\left(rer^N + rer^D\right)$, where the former uses traded retail prices and the latter traded at-the-dock prices. The variance decomposition is only meaningful if the variables are stationary.[8] In order to ensure stationarity of the series we follow Burstein et al. (2006) and detrend the series using a Hodrick-Prescott (HP) filter with a smoothing parameter of 1600.

We first confirm that we obtain the same results as Engel (1999) and Burstein et al. (2006) when we use their respective decompositions. Specifically, we compute the upper and lower bounds on the importance of non-tradables using the formula in Burstein et al.

Decomposing rer^{CPI} according to Engel (1999), we find the same striking results: the relative price of non-traded to traded goods accounts for almost none of the cyclical US bilateral real exchange rate fluctuations, see Table 1. The upper bound for the importance of non-traded goods' prices is close to 8 percent in Canada, 1 percent in Japan, 4 percent in Norway, and 1 percent in the UK. The results obtained for Canada and Japan are similar

[8] None of the series were found to be stationary in levels at a 5 percent level of significance. The results are available upon request.

to the results reported by Engel using a mean-squared error decomposition on differenced data.[9]

When we instead follow Burstein et al. (2006) and decompose the variations in rer^{CPI} into variations in rer^T vs. $\left(rer^N + rer^D\right)$, the estimate of the importance of the relative price of non-traded to traded goods increases substantially for all countries, see Table 1. The upper bounds for the importance of non-tradables for Canada and Japan are 89 percent and 82 percent, respectively, while the upper bounds for Norway and the UK are 65 percent and 52 percent, respectively. For Japan and Canada the results are similar to the results reported by Burstein et al. (2006) using trade-weighted real exchange rates. For the UK our results suggest somewhat lower importance of non-tradables compared to Burstein et al. For all countries however, the results are in sharp contrast to the results obtained using retail prices, which suggested that only a small fraction of US real exchange rate fluctuations could be attributed to the relative price of non-tradables.

Using our three-term decomposition in equation (5), and hence making a distinction between retail prices of traded goods and at-the-dock prices of traded goods, we find that variation in the relative wedge between retail prices and at-the-dock prices of traded goods, rer^D, on average accounts for between 30 and 70 percent of the fluctuations in the real exchange rate, see Table 1. This finding is supportive of Engel's (1999) conjecture that understanding the relationship between prices at-the-dock and retail prices of traded goods is important for understanding real exchange rates. The results imply that the importance of the relative price of non-traded to traded goods in explaining real exchange rate fluctuations hinges on the assumption that variability in the wedge between traded goods prices at the retail level and at-the-dock is entirely due to variability in the prices of non-traded goods used in the distribution sector.

The results are illustrated in Figures 1 and 2. In panel (a) we use retail prices to measure the relative price of tradables. As is evident from the figures, there is a tight relationship between the movements in the traded component, $\left(rer^T + rer^D\right)$, and the real exchange rate, rer^{CPI}. Moreover, the non-traded component, rer^N, displays very little fluctuations. In panel (b), however, where rer^{CPI} is decomposed into rer^T and $\left(rer^N + rer^D\right)$, there appears to be less co-movement between the traded component, rer^T, and the real exchange rate. The fluctuations in the non-traded component, $\left(rer^N + rer^D\right)$, seem to explain a large share of the movements in the real exchange rate, consistent with the results above. From panel (c), which plots our three-terms decomposition, it is clear that the movements in the non-traded component, $\left(rer^N + rer^D\right)$ in (b) is almost entirely due to variation in the relative wedge term, rer^D.

4 Addressing the issue of (mis)measurement of traded goods' prices

A potential caveat to the results in Burstein et al. (2006) and the results reported above is the use of aggregate import and export price indices to measure traded goods' prices. Both

[9] In addition to Canada and Japan, Engel (1999) analyses the bilateral real exchange rate fluctuations between the US and France, Germany and Italy.

the export price index and the import price index contain goods that are not included in the CPI. Specifically, the EPI and the IPI include prices of raw materials, intermediate goods, and investment goods. As is evident in Figure 3, consumer goods account for a modest share of total trade in US and Norway.

The relative prices of raw materials, intermediate goods, and investment goods may display different cyclical properties than the relative prices of consumption goods. For example, since many raw materials are homogenous goods that are traded in a single world commodity market, a reasonable conjecture is that raw materials' prices are more likely to obey the law of one price than consumer goods. Thus, the inclusion of raw materials prices in the traded goods price index might reduce the aggregate deviations from the law of one price in traded goods, implying that the estimate of the importance of tradables in accounting for real exchange rate fluctuations will be biased downwards. There is also evidence to suggest that the degree of price stickiness is higher for consumer goods than for intermediate goods. Measuring price stickiness in traded goods prices at-the-dock in the US, Gopinath and Rigobon (2008) find large heterogeneity across goods: the median frequency of monthly price changes for 'Consumer Goods' is 7 percent, whereas the median frequency for 'Industrial Supplies and Materials' is 20 percent.[10]

A newly published dataset from Statistics Norway on import and export prices of consumption goods allows us to examine the size of this bias for the Norwegian-US real exchange rate.[11,12] The data series for US import and export prices and trade values for consumption goods are from the BLS.[13,14]

Our hypothesis is that the use of aggregate export and import price indices to measure traded goods' prices will bias the estimate of the importance of the relative price of tradables downward. As evidenced in Table 2, the hypothesis is confirmed for the Norwegian-US real exchange rate: when excluding all goods but consumer goods from the price index for traded goods, the upper bound for the importance of the non-tradables term in Burstein et al.'s decomposition, $\left(rer^N + rer^D\right)$, falls from 65 to 30 percent. Similarly the upper bound for the relative wedge term, rer^D, falls from 66 percent to 27 percent when we use our three-term decomposition. Hence, these estimates indicate that there are considerably larger deviations from the law of one price for consumer goods at-the-dock than for aggregate exports and imports. As a consequence, the use of aggregate export and import price indices will attribute too much of the real exchange rate fluctuations to movements in the relative price of non-tradables using the old decomposition, and to the

[10] The category 'Food, Feed and Beverages' is an exception. The monthly median frequency of price changes in this category is 40 percent.

[11] These data were published for the first time in the fourth quarter of 2005, with quarterly data from 2000 to 2006. In December 2006, the series was extended back to 1989.

[12] Statistics Norway publishes trade data classified according to Broad Economic Categories (BEC), a UN classification system that categorises imports and exports by their end-use.

[13] The BLS does not publish the data categorised by BEC, but with a similar end-use classification. Henceforth, we will for simplicity refer to this US end-use classification as BEC, since the classification of goods is similar.

[14] The export and import weights on each category, and overall trade weights, are calculated using average trade values from the period 1999-2005 for Norway and quarterly weights for the whole sample for the US. As mentioned above, this is used as a proxy for the importance of these goods in CPI. However, for Norway the weight on imported goods in the CPI closely resemble the weight on imported consumer goods at-the-dock.

Table 2. Norwegian-US bilateral real exchange rate
Quarterly data in logs 1989Q1-2006Q2 (HP-filtered)

	All goods	Consumer goods
Burstein et al.'s decomposition		
Relative importance of variation in $\left(rer^N + rer^D\right)$ to rer^{CPI}		
L^N	0.2749	0.2342
U^N	0.6483	0.2992
Our decomposition		
Relative importance of variation in rer^N to rer^{CPI}		
L^N	-0.0150	0.0126
U^N	0.0649	0.0373
Relative importance of variation in rer^D		
L^D	0.2100	0.2102
U^D	0.6633	0.2733

Notes:
L^N (U^N) = lower (upper) bound on the importance of the relative price of non-traded to traded goods
L^D (U^D) = lower (upper) bound on the importance of the wedge between retail prices of traded goods and at-the-dock prices of traded goods

relative wedge term using the new decomposition.

The downward bias in the estimates of the importance of tradables is likely to be particularly severe for a raw materials-based economy like Norway. However trade in consumer goods accounts for a relatively modest share of total trade in many countries[15], hence the exclusion of goods other than consumer goods from the traded goods prices could affect the estimates.

5 Concluding remarks

We decompose the movements in the real exchange rate into three terms: movements in the relative price of traded goods at-the-dock, movements in the relative price of non-traded to traded goods and movements in the wedge between retail prices of traded goods and the prices of traded goods at-the-dock across countries. Using data on four US bilateral real exchange rates we find that the relative wedge term accounts for 30 to 70 percent of US real exchange rate fluctuations. This finding suggests that modelling the relationship between traded goods' prices at-the-dock and retail prices of traded goods is key to understanding real exchange rate fluctuations and to building realistic macro models.

[15] E.g., consumer goods (including motor spirit and passenger motor cars) accounted for about 30 percent of UK imports and 25 percent of UK exports in 2005, according to eurostat.

References

[1] Betts, C.M. and M.B Devereux (1996): "The exchange rate in a model of pricing-to-market", *European Economic Review* 40, 1007-1021.

[2] Betts, C.M. and M.B Devereux (2000): "Exchange Rate Dynamics in a Model of Pricing-to-Market", *Journal of International Economics* 50, 215-244.

[3] Betts, C.M. and T.J. Kehoe (2006): "U.S. Real Exchange Rate Fluctuations and Relative Price Fluctuations", *Journal of Monetary Economics* 53, 1297-1326.

[4] Betts, C.M. and T.J. Kehoe (2008): "Real Exchange Rate Movements and the Relative Price of Non-traded Goods", NBER Working Paper 14437

[5] Burstein, A., M. Eichenbaum and S. Rebelo (2005): "Large Devaluations and the Real Exchange Rate", *Journal of Political Economy* 113, 742-784

[6] Burstein, A., M. Eichenbaum and S. Rebelo (2006): "The Importance of Nontradable Goods' Prices in Cyclical Real Exchange Rate Fluctuations", *Japan and the World Economy* 18, 247-253.

[7] Chari, V.V., P.J. Kehoe and E.R. McGrattan (2002): "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?", *Review of Economic Studies* 69, 533-563.

[8] Engel, C. (1999): "Accounting for U.S. Real Exchange Rate Changes", *Journal of Political Economy* 107, 507-538.

[9] Gopinath, G. and R. Rigobon (2008): "Sticky Borders", *Quarterly Journal of Economics* 123, 531-575.

A Data sources

Name	Database	Series
Canada		
Name	Database	Series
Aggregate CPI	IMF IFS	Q.15664...ZF
Goods in CPI	Statistics Canada	CANSIM Table 326-0001
Aggregate EPI*	IMF IFS	Q.15674...ZF
Aggregate IPI*	IMF IFS	Q.15675...ZF
Aggregate export, CAD	IMF IFS	Q.15670...ZF
Aggregate import, CAD	IMF IFS	Q.15671.V.ZF
Exchange rate, CAD/USD	OECD MEI	CAN.CCUSMA02.ST.Q
Japan		
Aggregate CPI	IMF IFS	Q.15864...ZF
Goods in CPI	Statistics Bureau	
Aggregate EPI	IMF IFS	Q.15876...ZF
Aggregate IPI	IMF IFS	Q.15876.X.ZF
Aggregate export, JPY	IMF IFS	Q.15870...ZF
Aggregate import, JPY	IMF IFS	Q.15871...ZF
Exchange rate, JPY/USD	OECD MEI	JPN.CCUSMA02.ST.Q
Norway		
Aggregate CPI	IMF IFS	Q.14264...ZF
CPI by delivery sector	Statistics Norway	Subject 8, table 3362 (L1,L2,L3,L4,L5,L6)
Aggregate EPI*	IMF IFS	Q.14274...ZF
Aggregate IPI*	IMF IFS	Q.14275...ZF
EPI by BEC, Consumer goods	NORMAP**	EKS.BEC_KONSUMVARER.IPR.Q.U
EPI by BEC, Passenger cars	NORMAP	EKS.BEC13.IPR.Q.U
IPI by BEC, Consumer goods	NORMAP	IMP.BEC_KONSUMVARER.IPR.Q.U
IPI by BEC, Passenger cars	NORMAP	IMP.BEC13.IPR.Q.U
Exports, NOK	IMF IFS	Q.14270...ZF
Imports, NOK	IMF IFS	Q.14271...ZF
Exports, Consumer goods, NOK	NORMAP	EKS.BEC_KONSUMVARER.VR.U
Exports, Passenger cars, NOK	NORMAP	EKS.BEC13.VR.U
Imports, Consumer goods, NOK	NORMAP	IMP.BEC_KONSUMVARER.VR.U
Imports, Passenger cars, NOK	NORMAP	EKS.BEC13.VR.U
Exchange rate, NOK/USD	OECD	MEI'NOR.CCUSMA02.ST.Q
UK		
Name	Database	Series
Aggregate CPI	OECD MEI	GBR.CPALTT01.IXOB.Q
Goods in CPI	Office for National Statistics	D7F4
Aggregate EPI	IMF IFS	Q.11276...ZF
Aggregate IPI	IMF IFS	Q.11276.X.ZF
Aggregate export values	IMF IFS	Q.11270...ZF
Aggregate import values	IMF IFS	Q.11271...ZF
Exchange rate, GBP/USD	OECD MEI	GBR.CCUSMA02.ST.Q
US		
Aggregate CPI	IMF IFS	Q.11164...ZF
CPI by end use	BLS	
All items	BLS	CUUR0000SA0
Commodities less food and beverages	BLS	CUUR0000SACL11
Food and beverages	BLS	CUUR0000SAF
Services less rent of shelter	BLS	CUUR0000SASL2RS
Rent of shelter	BLS	CUUR0000SAS2RS
Aggregate EPI	IMF IFS	Q.11176.X.ZF
Aggregate IPI	IMF IFS	Q.11176...ZF
EPI, Foods, Feeds and Beverages	BLS	EIUIQ0
EPI, Passenger cars, new and used	BLS	EIUIQ300
EPI, Consumer goods	BLS	EIUIQ4
IPI, Foods, Feeds and Beverages	BLS	EIUIR0
IPI, Passenger cars	BLS	EIUIR300
IPI, Consumer goods	BLS	EIUIR4
Exports, USD	IMF IFS	Q.11170...ZF
Imports, USD	IMF IFS	Q.11171...ZF
Export by end use, USD	U.S. Census Bureau	FT900
Import by end use, USD	U.S. Census Bureau	FT900

* Unit value index

** NORMAP is a FAME database of business cycle indicators produced by Statistics Norway

B Data construction

The real exchange rate, rer^{CPI}, is calculated using total CPI and the nominal exchange rate. Traded goods prices are calculated using three different price measures: retail prices, aggregate import and export prices, and import and export prices of consumption goods.

Retail prices: For the US we use series for CPI categorised by end use. For Canada, Japan and UK we use CPI data on 'goods' and 'services', where 'goods' are regarded as traded goods. And, for Norway we use CPI by delivery sector.[16]

The US CPI by end use specifies the following categories: 'all items' (ai), 'all commodities less food and beverages' (aclfb), 'food and beverages' (fb), 'services less rent' (slr), and 'rent'(r). Following Engel (1999), we construct a price index of traded goods for the US using the weights on the different categories, φ_i, from the following regression

$$\Delta(ai_t - r_t) = \varphi_1 \Delta(\log aclfb_t - \log r_t) + \varphi_2 \Delta(\log fb_t - \log r_t) + \varphi_3 \Delta(\log slr_t - \log r_t) + \epsilon_t.$$

The weights on the different categories found from the regression analysis are:

Category		Weight
All commodities less food and beverages	φ_1	0.264
Food and beverages	φ_2	0.168
Total	$(1-\gamma^*)$	0.432

The price index of traded goods is then constructed as

$$p^T = (\frac{\varphi_1}{\varphi_1 + \varphi_2}) \times \log aclfb + (\frac{\varphi_2}{\varphi_1 + \varphi_2}) \times \log fb.$$

The Norwegian data on CPI by delivery sector are classified into six main categories: 'agricultural products' (agr), 'fish products' (fish), 'other consumer goods produced in Norway', 'imported consumer goods' (imp.goods), 'rent', and 'other services'(slr). The category 'other consumer goods produced in Norway' contains three subcategories: 'other consumer goods produced in Norway, influenced by world market owing to large content of imported materials and raw-material prices fixed by the world market', 'other consumer goods produced in Norway, influenced by world market owing to competition from foreign countries', and 'other consumer goods produced in Norway, little influenced by world market prices'. The two first categories are treated as traded (norw.prod.xposed) while the latter is regarded as non-traded. Using quarterly CPI weights for the different categories, published by Statistics Norway, the Norwegian price index of traded goods is constructed

[16] Engel (1999) uses CPI series from OECD's database. He specifies five categories: 'all items', 'all goods less food', 'food', 'services less rent', and 'rent'. Unfortunately, OECD has changed the categories that are published, forcing us use other data series when applying Engel's decomposition.

as follows

$$\begin{aligned} p^T &= \left(\frac{\gamma_1}{\gamma_1+\gamma_2+\gamma_3+\gamma_4}\right) \times \log agr + \left(\frac{\gamma_2}{\gamma_1+\gamma_2+\gamma_3+\gamma_4}\right) \times \log fish \\ &+ \left(\frac{\gamma_3}{\gamma_1+\gamma_2+\gamma_3+\gamma_4}\right) \times \log norw.prod.xposed \\ &+ \left(\frac{\gamma_4}{\gamma_1+\gamma_2+\gamma_3+\gamma_4}\right) \times \log imp.goods, \end{aligned}$$

where the averages of the quarterly weights for the different sectors are:[17]

Category		Weight
Agricultural products	γ_1	0.0749
Fish products	γ_2	0.0092
norw.prod.exposed	γ_3	0.1703
Imported consumer goods	γ_4	0.2428
Total	$(1-\gamma)$	0.4972

Aggregate export and import price indices: The price of traded goods in each country is calculated as follows

$$\overline{p}^T = \alpha \log IPI_{agg} + (1-\alpha) \log EPI_{agg},$$

where α is the import weight, and IPI_{agg} and EPI_{agg} are the aggregate import and export price indices, respectively. Quarterly trade weights, α, are computed from trade value data. The averages of the quarterly weights for each country are summarised below:

Country	α
Canada	0.47
Japan	0.44
Norway	0.41
UK	0.55
US	0.59

Export and import price indices of consumer goods: The price of traded goods in each country is calculated as follows

$$\overline{p}^T = \alpha \log IPI_{con} + (1-\alpha) \log EPI_{con},$$

where

$$\log IPI_{con} = \tau_1^i \log IPI_{food} + \tau_2^i \log IPI_{pass.cars} + \tau_3^i \log IPI_{con.goods}$$

$$\log EPI_{con} = \tau_1^e \log EPI_{food} + \tau_2^e \log EPI_{pass.cars} + \tau_3^e \log EPI_{con.goods}.$$

Here, IPI_{con} and EPI_{con} denote export and import price indices of consumer goods, and τ_i is the weight on each category. The export and import weights on each category, and

[17] Sample average of monthly weights 1989M1-2006M6.

overall trade weights, α, are calculated using average trade values from the period 1999–2005 for Norway and quarterly weights for the whole sample for the US. The weights are summarised below:

	Food τ_1^e, τ_1^i	Passenger cars τ_2^e, τ_2^i	Consumer goods τ_3^e, τ_3^i	Export and import weights $(1-\alpha), \alpha$
Norway				
Export	*	0.00	1.00	0.32
Import	*	0.18	0.82	0.68
US[1]				
Export	0.35	0.13	0.52	0.30
Import	0.13	0.24	0.63	0.70

[1]Average of quarterly weights

* Food is included in ‘Consumer goods’

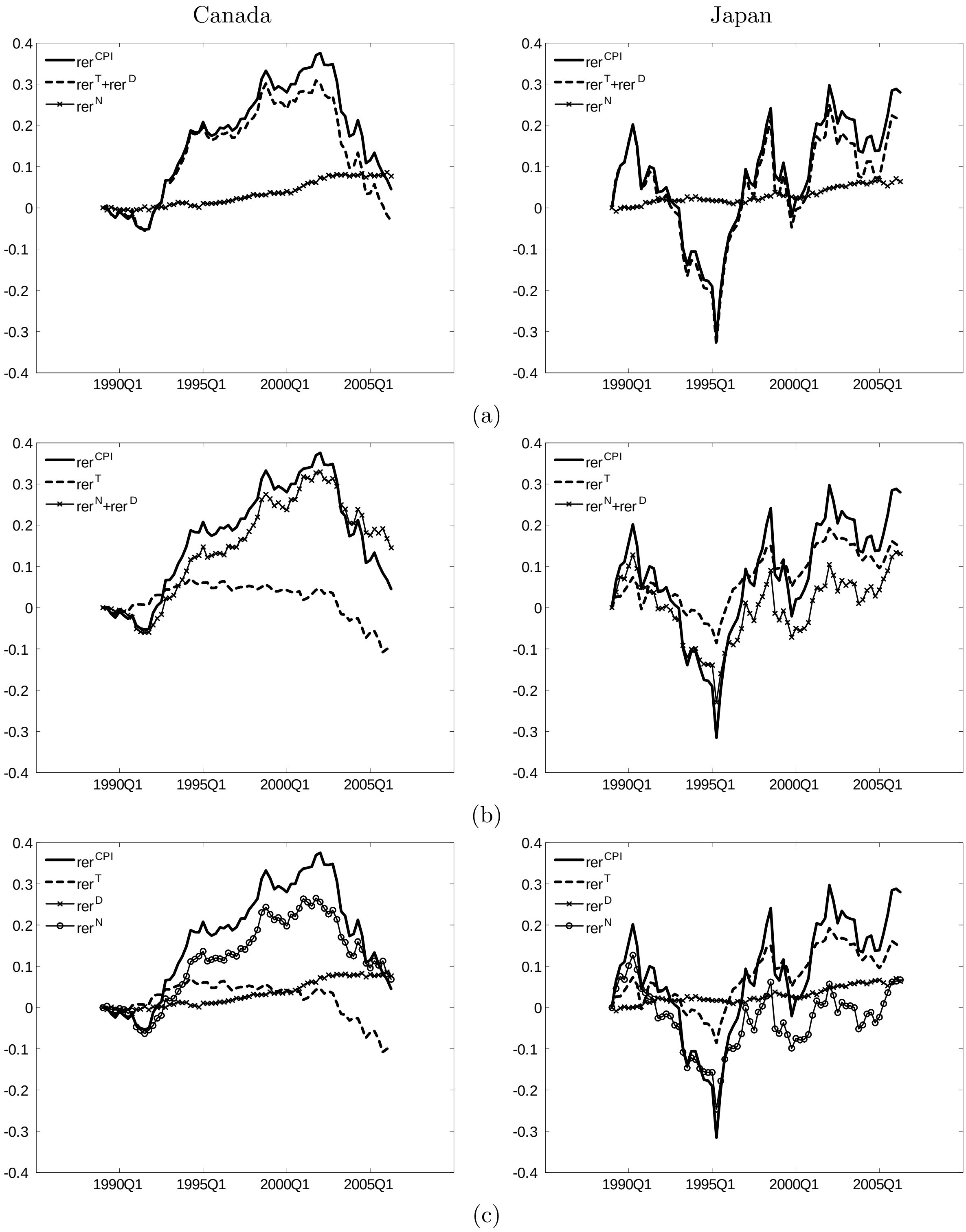


Figure 1. 1989Q1-2006Q2. Variables are in logs
(a) Engel's decomposition
(b) Burstein et al.'s decomposition
(c) Our three-term decomposition

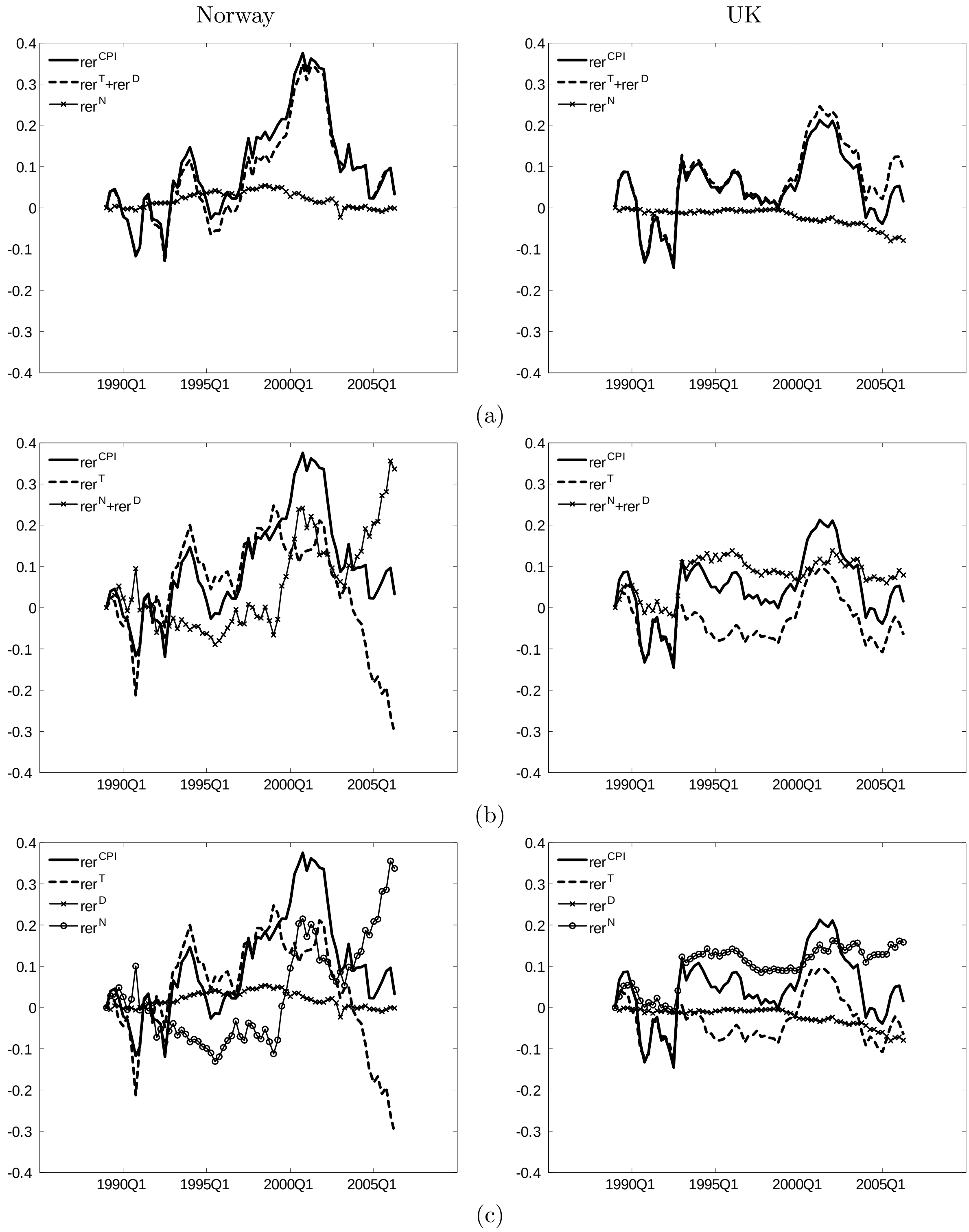
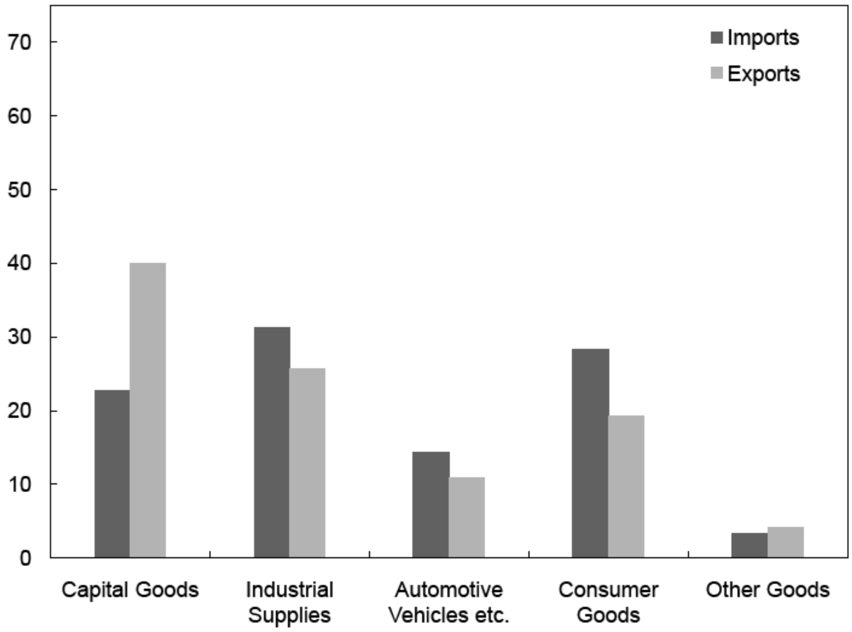


Figure 2. 1989Q1-2006Q2. Variables are in logs
(a) Engel's decomposition
(b) Burstein et al.'s decomposition
(c) Our three-term decomposition

US



Norway

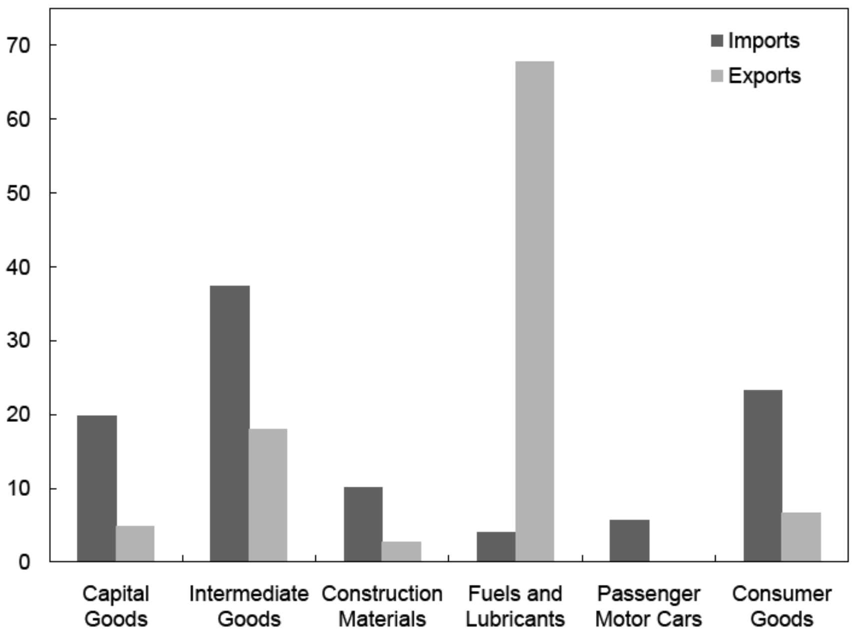


Figure 3. Imports and exports categorised by BEC. Percentage shares in 2005.