OESTERREICHISCHE NATIONALBANK
EUROSYSTEM

WORKING PAPER 175

How Does Quality Impact on Import Prices?

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Imprint: Responsibility according to Austrian media law: Günther Thonabauer, Communications Division, Oesterreichische Nationalbank.

Published and printed by Oesterreichische Nationalbank, Wien.

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Editorial

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December 31, 2011

How Does Quality Impact on Import Prices?[1]

Konstantins Benkovskis[2], Julia Wörz[3]

Abstract

Understanding the dynamics of import price developments is an important but challenging issue which affects the way we look on consumers' welfare, real exchange rates and exchange rate pass-through. In this paper we propose an exact import price index which extends the approach by Broda and Weinstein (2006) who adjust price developments for changes in varieties of imported products. We relax two assumptions still underlying the Broda and Weinstein (2006) approach, thus allowing the set of imported goods and the quality to vary. This variety-, set-of-products-, and quality-adjusted import price index shows that gains from variety in European G7 countries, although positive, are rather small compared to calculated gains from quality. Using HS 07 (vegetables) as our benchmark group of products with unchanged quality, we find significant gains from quality for Germany, France, Italy and the UK between 1995 and 2010. Although these results are not invariant to the choice of the benchmark category, they clearly stress the importance of incorporating the quality issues in empirical literature. Ignoring changes in import quality can give misleading estimates of import prices and consumers' welfare.

JEL-codes: C43, D60, F12, F14, L15

Keywords: import variety, price index, quality, welfare gains from trade

1. Introduction

In open economies, the developments of import prices are of great importance in many respects. In the presence of imports in the consumption bundle, price developments are not only influenced by domestic inflation, but also by the average price of imported goods. Thus, apart from the impact of domestic inflation, also the welfare of consumers is heavily affected by the price of imported products. Further, evaluations of competitiveness, which rely crucially on the use of real exchange rates, are affected by the measurement of price changes

[1] We thank Vesna Corbo, David Hummels, Mihaly Andras Kovacs, William Powers, the participants of an internal OeNB research seminar, of the 13th ETSG conference in Copenhagen and an ECB Expert Meeting on "Assessing Competitiveness" in September 2011 as well as an anonymous referee for their valuable comments and recommendations. The authors assume responsibility for any errors and omissions.

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in traded goods. However, the measurement of these price developments is not straightforward as unlike for domestically consumed goods, there is no census directly measuring import prices. As a result, traditional import price deflators are derived from trade statistics and as such plagued with the omission of largely unobservable factors of influence such as changes in the set of imported products, in the variety of imports and in the quality of imports. The explicit consideration of unobservable quality-adjustments in import prices can have major consequences for economic analysis. For example, changes in quality can affect trade-price based real exchange rates and therefore also conclusions with respect to price competitiveness. Another important topic which immediately comes to mind is exchange rate pass-through on import prices. Obviously, researchers are interested in pass-through to quality-adjusted prices as quality is assumed to be a fundamental factor, not related to exchange rate movements. In this paper we relax the common assumption of unchanged quality to calculate a "pure" or quality-adjusted import price index. This should yield estimates of welfare gains from changes in quality of imports and allow us to determine how important this factor is for consumers.

According to theoretical trade models, increasing the variety and quality of a country's imports should lead to welfare gains of consumers, at the same time reducing minimum cost of one unit of utility. Monopolistic competition models, like the one developed by Krugman (1979, 1980), put emphasis on the role of extensive margin, maintaining that trade can be boosted by a greater variety of products. The seminal paper of Feenstra (1994) shows how to incorporate new product varieties into a constant-elasticity-of-substitution aggregate of import prices. This approach was further extended by Broda and Weinstein (2006), who include a proxy for unobservable growth in product variety in their calculations of import price inflation and evaluate gains from variety in the US. According to their results, ignoring changes in variety accounted for a significant upward bias in the estimates of the US import prices. The welfare gains of US consumers from a broader range of variety accounted for about 0.1 percent of GDP every year. However, this approach is based on rather restrictive assumption that the taste or quality parameter is constant over time for all import varieties. As such, vertical product differentiation, emphasized by Flam and Helpman (1987), is ignored when calculating the exact import price index. Taking into account rapid technological changes in many sectors of the economy this assumption may become increasingly problematic. In addition, this methodology does not allow for changes in the set of imported products.

In this paper we try to overcome the abovementioned drawbacks with a special focus on the role of quality. We show that it is in fact possible to evaluate the unobservable quality or taste parameters using the same theoretical framework as in Broda and Weinstein (2006). After solving the optimisation problem, relative quality could be defined as a function of observable unit values and volumes of imports as well as unobservable elasticities of substitution between varieties and between products. We can allow for changes in quality relative to a benchmark sector which is obviously much less restrictive than assuming quality to remain constant over time. We therefore have to define one product category for which we assume no major shifts in quality over time as our benchmark. A similar price index decomposition is proposed by Sheu (2011). However her method, based on product characteristics for a specific product derived from micro-data, differs from our more general approach with respect to the evaluation of the quality parameter.

Our goal here is to evaluate the exact import price index of four European countries (Germany, France, Italy and the UK)[4] taking into account changes in variety, product set and quality of imports. This is done by using highly disaggregated import data (eight-digit CN classification level from *Eurostat Comext* database) from 50 major trading partners between 1995 and 2010. In this paper we restrict ourselves to the description of the methodology, the estimation of variety, set of products and quality-adjusted import prices, the calculation of welfare gains and the discussion of possible factors behind the changes in quality, while calculations of the adjusted real exchange rate and exchange rate pass-though are left for further research.

The article is structured as follows. Section 2 describes the theoretical framework based on the household utility maximization problem, outlines the main assumptions behind the conventional methodology and shows the way in which we propose to relax some of these assumptions. Section 3 briefly describes the database and reports some stylized facts. Section 4 is devoted to the estimation of substitution elasticities. In section 5 we discuss the choice of a benchmark product group and calculate an exact import price index and related welfare gains. It also includes an assessment of the robustness of our results. Section 6 concludes.

[4] We choose four European G7 countries as an object of our investigation.

2. Theoretical framework

In this paper we follow closely the theoretical model used by Broda and Weinstein (2006). At first, we describe their definition of exact price index and outline the assumptions underlying their methodology to quantify the gains from variety. We then show that it is possible to relax some of these assumptions within the same theoretical framework. Thus, our approach allows for changes in quality and in set of imported products.

2.1 Description of Broda-Weinstein framework

The traditional way to specify how consumers value variety is a Dixit and Stiglitz (1977) framework where utility is given by CES function with a single elasticity of substitution. However, this creates several problems as, obviously, elasticities of substitution are not the same for different goods or even varieties of different products. To overcome this problem Broda and Weinstein (2006) denote the preferences of a representative agent by a three-level utility function which we specify in the form of a nested CES. First, imported varieties are aggregated into import goods. We identify variety with products from different origin within the same product category, i.e. we adopt the Armington assumption (Armington, 1969) as in Broda and Weinstein (2006). In other words, an import good corresponds to a specific product, like beer, while imported varieties are German beer, Irish beer, Belgian beer etc.[5] At the second level of the utility function, various imported goods (beer, wine, apples, computers etc.) are aggregated into a composite import good, which represents the utility gained from all imported products. Total utility at the upper level then includes the composite import good and the composite domestic good. This upper level utility function is thus defined as:

$$U_t = \left(D_t^{\frac{\kappa-1}{\kappa}} + M_t^{\frac{\kappa-1}{\kappa}} \right)^{\frac{\kappa}{\kappa-1}}; \quad \kappa > 1 \tag{1}$$

[5] This assumption implies that either the number of brands imported from each country is constant over time, or different brands imported from one country are perfect substitutes. The assumption is rather restrictive and often criticised. For example Bloningen and Soderbery (2010) argued that the Armington (1969) assumption hides substantial variety changes. According to their results the additional introduction of new varieties by foreign affiliates adds gains that are around 70 percent larger than those calculated only from country of origin. However, to assess the number of imported brands we need firm-level data, which is not available for a broad range of products; therefore we are forced to keep the Armington (1969) assumption.

where D_t is the composite domestic good, M_t are composite imports, and κ is the elasticity of substitution between domestic and foreign composite good. The second level utility function defines composite imports as

$$M_t = \left(\sum_{g \in G} M_{gt}^{\frac{\gamma - 1}{\gamma}} \right)^{\frac{\gamma}{\gamma - 1}} ; \quad \gamma > 1 \tag{2}$$

where M_{gt} is the subutility from consumption of imported good g, γ is elasticity of substitution between different import goods, while G denotes the set of imported goods. Finally, M_{gt} is defined by the third level utility function, which is represented by a non-symmetric CES function

$$M_{gt} = \left(\sum_{c \in C} d_{gct}^{\frac{1}{\sigma_g}} m_{gct}^{\frac{\sigma_g - 1}{\sigma_g}} \right)^{\frac{\sigma_g}{\sigma_g - 1}} ; \quad \sigma_g > 1 \quad \forall \quad g \in G \tag{3}$$

where m_{gct} denotes quantity of imports g from country c, C is a set of all partner countries, d_{gct} is a taste or quality parameter for good g from country c, and σ_g is elasticity of substitution among varieties of good g. The third level utility function is the place where variety and quality are introduced into the model. The taste or quality parameter denotes the quality that consumers attach to a product, while the inclusion of different origins for the same product in the CES function ensures a role for product variety. For example, the utility gained from consuming imported beer could increase not only from a higher volume of beer available, but also due to access to new varieties, e.g. Czech and Belgian beer, or due to changes in taste for already existing varieties.[6]

After solving the utility maximization problem subject to the budget constraint, the minimum unit-cost function of import good g can be represented by

[6] We use the terms taste and quality interchangeably since this parameter can be defined as any tangible or intangible attribute of a good that affects consumers' valuation of it. This corresponds to the definition by Hallak and Schott (2008). Hence this parameter encompasses physical attributes of a product (e.g. size, a set of available functions, durability, etc), which can be summarized as quality, as well as intangible attributes (e.g. product image, brand name, etc), which can be summarized as taste. In the following we will only use the term quality for the ease of reading.

$$\phi_{gt}^{M}\left(I_{gt},d_{gt}\right)=\left(\sum_{c\in I_{gt}} d_{gct}\, p_{gct}^{1-\sigma_g}\right)^{\frac{1}{1-\sigma_g}} \tag{4}$$

where ϕ_{gt}^{M} denotes minimum unit-cost of import good g, $I_{gt}\subset C$ is the subset of all varieties of goods consumed in period t, p_{gct} is the price of imported good g from country c, and d_{gt} is the vector of taste or quality parameters. Equation (4) shows that the minimum unit-cost of an import good depends not only on prices, but also on the quality or taste parameter, whereby higher quality implies lower minimum unit-costs. The minimum unit-cost function of the composite import good is then given by

$$\phi_{t}^{M}\left(J_{t}\right)=\left(\sum_{g\in G_t} \phi_{gt}^{M}\left(I_{gt},d_{gt}\right)^{1-\gamma}\right)^{\frac{1}{1-\gamma}} \tag{5}$$

where ϕ_{t}^{M} denotes minimum unit-cost of a composite import good, $J_t\subset G$ is the subset of all imported goods in period t.

The import price index can be defined as a ratio of minimum unit-costs in the current period to minimum unit-costs in the previous period.[7] Assuming unchanged quality, constant variety and a constant set of products, the price indices for imported good g and the composite import good M are

$$P_{g}^{M}\left(I_{g}\right)=\frac{\phi_{gt}^{M}\left(I_{g},d_{g}\right)}{\phi_{gt-1}^{M}\left(I_{g},d_{g}\right)} \text{ and } P^{M}\left(J\right)=\frac{\phi_{t}^{M}\left(J\right)}{\phi_{t-1}^{M}\left(J\right)} \tag{6}$$

where $I_g = I_{gt}\cap I_{gt-1}$ is the set of varieties consumed in periods t and $t-1$, $J = J_t \cap J_{t-1}$ is the set of goods consumed in periods t and $t-1$, while taste parameters are constant over time, ($d_{gt}=d_{gt-1}=d_g$). Sato (1976) and Vartia (1976) proved that for the CES utility function the exact price index will be given by

$$P_{g}^{M}\left(I_{g}\right)=\prod_{c\in I_g}\left(\frac{p_{gct}}{p_{gct-1}}\right)^{w_{gct}} \tag{7}$$

$$P^{M}\left(J\right)=\prod_{g\in J} P_{g}^{M}\left(I_{g}\right)^{w_{gt}} \tag{8}$$

[7] see Diewert (1993) for more details.

where w_{gct} and w_{gt} are ideal log-change weights, which are computed using cost shares s_{gct} and s_{gt} in the two periods as follows:

$$w_{gct} = \frac{\left(s_{gct} - s_{gct-1}\right)/\left(\ln s_{gct} - \ln s_{gct-1}\right)}{\sum_{c \in I_g}\left(\left(s_{gct} - s_{gct-1}\right)/\left(\ln s_{gct} - \ln s_{gct-1}\right)\right)}; \; s_{gct} = \frac{p_{gct}x_{gct}}{\sum_{c \in I_g} p_{gct}x_{gct}}$$

$$w_{gt} = \frac{\left(s_{gt} - s_{gt-1}\right)/\left(\ln s_{gt} - \ln s_{gt-1}\right)}{\sum_{g \in J}\left(\left(s_{gt} - s_{gt-1}\right)/\left(\ln s_{gt} - \ln s_{gt-1}\right)\right)}; \; s_{gt} = \frac{\sum_{c \in C} p_{gct}x_{gct}}{\sum_{g \in J}\sum_{c \in C} p_{gct}x_{gct}}$$

and x_{gct} is the cost-minimizing quantity of good g imported from country c.

The underlying assumption of unchanged variety in equation (6) was relaxed by Feenstra (1994), who modified the price index for the case when the set of varieties is different, although overlapping in the two periods. Broda and Weinstein (2006) developed it further and assumed different elasticities of substitution between varieties (see Proposition 1 in their paper). According to them, if $d_{gct} = d_{gct-1}$ for $c \in I_g = \left(I_{gt} \cap I_{gt-1}\right)$, $I_g \neq \emptyset$, then the exact price index for good g is given by

$$\pi_g^M\left(I_{gt}, I_{gt-1}\right) = \frac{\phi_{gt}^M\left(I_{gt}, d_g\right)}{\phi_{gt-1}^M\left(I_{gt-1}, d_g\right)} = P_g^M\left(I_g\right)\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{\frac{1}{\sigma_g - 1}} \tag{9}$$

where $\lambda_{gt} = \frac{\sum_{c \in I_g} p_{gct}x_{gct}}{\sum_{c \in I_{gt}} p_{gct}x_{gct}}$ and $\lambda_{gt-1} = \frac{\sum_{c \in I_g} p_{gct-1}x_{gct-1}}{\sum_{c \in I_{gt-1}} p_{gct-1}x_{gct-1}}$

Therefore, the price index derived in equation (7) is multiplied by an additional term, which captures the role of new and disappearing variety. This approach is not limited only to the number of varieties, but also takes into account the expenditure, therefore giving higher weight to varieties with a higher share in total trade value. If the expenditure share of new varieties exceeds that of disappearing varieties, the additional term is below unity and lowers the exact price index in equation (9). Consequently, this increases consumers' utility. However, the effect from increasing variety also depends on the elasticity of substitution between varieties. If varieties are close substitutes, the additional term is close to unity and changes in variety only show a marginal effect on the exact price index and on overall utility.

Although this approach allows us to evaluate the effect of changes in variety on consumers' welfare and on import prices, several drawbacks remain. First, also the set of imported goods can change in addition to the set of varieties (or the set of countries of origin). Proposition 2 in Broda and Weinstein (2006) implies that the set of goods is the same in both periods and the price index of the composite import good is calculated using equation (8), although π_g^M is used instead of P_g^M. However, the set of imported products is not fixed. Many products, e.g. personal computers and mobile phones, appeared relatively recently, while some others disappeared. Second, Broda and Weinstein (2006) assume that taste or quality parameters are unchanged for all varieties of all goods ($d_{gct} = d_{gct-1}$), i.e. vertical product differentiation is ignored. This is obviously a rather restrictive assumption both in terms of physical quality (think about the processor speed and memory of personal computers now and ten years ago) as well as tastes and preferences.

In this paper we extend Broda and Weinstein's (2006) approach in both of these two dimensions. We allow for changes in the set of imported products by adding an adjustment term which captures this process. More importantly, we allow for changes in taste or quality and make an attempt to estimate this unobservable parameter.

2.2 Allowing for changes in quality or taste

The main difficulty with evaluating the effect from quality on international trade is the fact that quality is unobservable. For a long time, the usual way to assess unobserved quality was to use observed unit values. Even though this proxy has a clear advantage of simplicity in calculations, it has always been argued that such a measure is unsatisfactory because export prices may vary for reasons other than quality, for example different production costs. Another approach is to use information on individual characteristics of products and use them as a proxy for quality parameter – such an approach was used by Sheu (2011). Although this can be regarded as a "first-best" solution, it requires very detailed micro data not available for all imported products. Moreover, individual characteristics of products may not reflect intangible attributes of products, or consumers' tastes adequately.

Here we follow Hummels and Klenow (2005) and evaluate the unobserved quality from the optimization problem, which was already described above in equations (1)-(3). After taking the first order conditions[8] and transformation into log-ratios we can express relative quality in terms of relative prices, volumes and elasticity of substitution between any two varieties as:

$$\ln\left(\frac{d_{gct}}{d_{gkt}}\right) = \sigma_g \ln\left(\frac{p_{gct}}{p_{gkt}}\right) + \ln\left(\frac{x_{gct}}{x_{gkt}}\right) \tag{10}$$

where k denotes a benchmark country (variety). This expression is similar to equation (7) in Hummels and Klenow (2005), although in our paper the elasticity of substitution between varieties differs for individual goods and the right hand side is multiplied by the inverted elasticity of substitution, due to subtle differences in the utility function. Equation (10) shows that relative quality is to a large extent reflected in relative prices. If the price of a specific good imported from country c is higher than the price of the same good imported from country k, this is an indication of a higher quality of the former, moreover, when different varieties are close substitutes, the role of relative prices increases. It has to be noted, however, that relative price is not the only indicator of relative quality. The relative quantity of a single variety in total consumption also attributes to the evaluation of relative quality. For example, the relative quality of Belgian beer relative to German beer can be proxied by relative prices, as well as by relative consumption measured in pints. More consumption of a certain variety is a clear sign of better quality and relative quantity is a more important indicator of relative quality when the elasticity of substitution is small.

Equation (10) already gives us the possibility to evaluate the unobservable quality parameter. All we need is the elasticity of substitution between varieties (this issue will be discussed below), and an assumption on d_{gkt} – the quality of a benchmark variety. This approach was used in Benkovskis and Rimgailaite (2011), who evaluated the relative quality with respect to a benchmark – quality of imports from Germany. However, if one needs to obtain the measure of absolute quality, such an assumption would be overly restrictive. Equation (10) requires to define a benchmark for every product g, therefore we also need an indicator of relative quality between goods (e.g. between beer and apples). The latter can be assessed using first order conditions, combining them with equation (4) and obtaining the relative demand function given in equation (11):

[8] First order conditions are $U_t^{\frac{1}{\kappa}} M_t^{\frac{1}{\gamma}-\frac{1}{\kappa}} M_{gt}^{\frac{1}{\sigma_g}-\frac{1}{\gamma}} d_{gct}^{\frac{1}{\sigma_g}} = \mu_t x_{gct}^{\frac{1}{\sigma_g}} p_{gct}$, where μ_t is Lagrange multiplier.

$$\frac{M_{gt}}{M_{jt}} = \left(\frac{\phi_{gt}^{M}\left(I_{gt}, d_{gt}\right)}{\phi_{jt}^{M}\left(I_{jt}, d_{jt}\right)} \right)^{-\gamma} \tag{11}$$

where j denotes a benchmark good. This equation states that the ratio of sub-utilities from goods g and j negatively depends on relative prices of those goods and the reaction of relative sub-utility on changes in relative price is stronger in case of high substitability between goods. From equations (3), (4) and (11) it follows that

$$\frac{\left(\sum_{c \in I_{gt}} d_{gct}^{\frac{1}{\sigma_g}} x_{gct}^{\frac{\sigma_g - 1}{\sigma_g}} \right)^{\frac{\sigma_g}{\sigma_g - 1}}}{\left(\sum_{c \in I_{gt}} d_{jct}^{\frac{1}{\sigma_j}} x_{jct}^{\frac{\sigma_j - 1}{\sigma_j}} \right)^{\frac{\sigma_j}{\sigma_j - 1}}} = \left(\frac{\left(\sum_{c \in I_{gt}} d_{gct} p_{gct}^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}}{\left(\sum_{c \in I_{gt}} d_{jct} p_{jct}^{1-\sigma_j} \right)^{\frac{1}{1-\sigma_j}}} \right)^{-\gamma} \tag{12}$$

While equation (10) is determining relative quality of the same good imported from different countries, equation (12) determines relative quality of different goods. Combining these two equations gives an opportunity to evaluate unobservable quality. The only assumption we need in this framework is on quality of one benchmark product imported from one benchmark country. For example, we can assume that $d_{jkt} = d_{jkt-1} = 1$, in other words quality or taste parameter of imports of good j from country k is stable over time. Note that this assumption is much less restrictive than the assumption of constant quality made in Broda and Weinstein (2006).

After we evaluated quality d_{gct} for all varieties of all goods, it is possible to derive a variety- and quality-adjusted price index. The exact price index for good g, which allows for changes in variety and quality is given by

$$\pi_{g}^{M}\left(I_{gt}, I_{gt-1}, \Delta d_{gt}\right) = P_{g}^{M}\left(I_{g}\right) \Delta d_{gt}^{\frac{1}{1-\sigma_g}} \left(\frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{\frac{1}{\sigma_g - 1}} \tag{13}$$

where $\Delta d_{gt} = \prod_{c \in I_g} \left(\frac{d_{gct}}{d_{gct-1}} \right)^{w_{gct}}$ and denotes the weighted change of the quality parameter for good g.

The recent paper by Sheu (2011) shows similarities to our paper by using a nested constant elasticity of substitution framework, but combines it with a standard industrial organization model (nested logit). Based on micro-level data on Indian import for computer printers, Sheu (2011) uses product characteristics information as a proxy for unobserved quality of imports and concludes that aggregated data mask product-level improvements and underreport the welfare gains. Despite the clear advantage of such a solid micro-data basis, this approach has its limitations. Obviously, it is not possible to use this method for evaluating overall import prices. As such it does not allow macroeconomic conclusions. Also, information on product characteristics is a good proxy for physical quality, but does not necessarily reflect consumers' tastes that also affect utility. While the approach presented in our paper is less data-driven and more sensitive to model assumptions, it is more general and yields macro-economic relevant results.

Equation (13) could be seen as a modified version of equation (9) and the additional term ($\Delta d_{gt}^{\frac{1}{1-\sigma_g}}$) captures changes in the quality parameter. This term states that a rise in quality reduces the exact price index and increases the utility of consumers. The additional term also depends on the product-specific elasticity of substitution between varieties. If σ_g is high, the term $\Delta d_{gt}^{\frac{1}{1-\sigma_g}}$ goes to unity. In other words, changes in quality for close substitutes have only small effects on import prices and welfare, while for imperfect substitutes quality plays an important role.

2.3 Allowing for changes in the set of imported goods

We now turn to the assumption of a constant set of imported products. The second level utility function in equation (2) states that consumers value the differentiation of products in a similar way as they value variety within a product. Therefore, changes in the set of products may have significant consequences for the calculation of aggregate import prices and welfare. To take this effect into account we propose the following equation:

$$\Pi^M\left(I_{gt}, I_{gt-1}, \Delta d_{gt}, J_t, J_{t-1}\right) = \prod_{g \in G} \pi_g^M\left(I_{gt}, I_{gt-1}, \Delta d_{gt}\right)^{w_{gt}} \left(\frac{\Lambda_t}{\Lambda_{t-1}}\right)^{\frac{1}{\gamma-1}} \tag{14}$$

where $\Lambda_t = \frac{\sum_{g\in J}\sum_{c\in C} p_{gct}x_{gct}}{\sum_{g\in J_t}\sum_{c\in C} p_{gct}x_{gct}}$ and $\Lambda_{t-1} = \frac{\sum_{g\in J}\sum_{c\in C} p_{gct-1}x_{gct-1}}{\sum_{g\in J_{t-1}}\sum_{c\in C} p_{gct-1}x_{gct-1}}$

It is easy to note, that we simply added one term to equation (8). The logic behind this term is similar as before in equation (9) for varieties: it captures changes in the set of imported and consumed products. Again changes in expenditure shares as a result of new and disappearing products as well as the elasticity of substitution between goods are taken into account. Equation (14) states that access to a broader set of imported goods decreases Λ_{gt} over time and thus reduces the additional adjustment term. Again, it lowers the exact price index and increases consumers' utility in the same way as improvements in quality. As before, the additional term approaches unity if products are close substitutes and γ is high. In this case, consumers do not care about product differentiation and consequently changes in the set of products have almost no effect on prices and welfare.

3. Database

For the empirical analysis, we use the trade data available from Eurostat's *Comext* database. The rationale behind our choice was the time of data release – annual figures in *Comext* database are available in approximately three months after the end of the year. This gives us an opportunity to include recent data for the crisis and post-crisis year. As we need to decompose nominal trade flows into prices and volumes, the analysis has been carried out at the most detailed eight-digit level of the CN classification. The dataset contains annual data on imports of Germany, France, Italy and the UK between 1995 and 2010. To avoid calculation burden we restrict the list of trading partners to 50 different countries inside and outside EU. The list of partner countries includes all EU member states, several CIS countries (Russia, Ukraine, Belarus, Kazakhstan) and other important trade partners (US, Japan, Canada, Australia, China, India, Brazil).[9] We use unit values (euro per kg) as a proxy for prices and trade volume (mainly in kg) as the proxy for quantities.

The use of the most detailed eight-digit CN classification has one significant drawback that can affect final results – Combined Nomenclature is regularly revised. Each year a significant

[9] This sample of partners provides a representative picture of the overall imports, as it covers between 87.7 percent of total imports in the UK and 95.6 percent of total imports in Germany in 2010.

amount of CN codes is subject to reclassification whereby some product codes are simply relabelled and moved between sections while others are split or merged.[10] Pierce and Schott (2009) analysed the reclassifications in the ten-digit US Harmonized System and illustrated the importance of tracking these changes when conducting empirical research, therefore we cannot ignore this issue. The most problematic cases are splits or merges of product codes. One feasible solution is to merge values and volumes of respective categories. Although this leads to a broadening of several categories and related problems in the interpretation of unit values, it helps to retain the consistency of the analysis over time.

During the period between 1995 and 2010 we observe around 15300 eight-digit CN product codes (this figure differs slightly for each if the four countries in our sample). Only slightly more than 5500 of them were not subject to reclassification issues. After the implementation of the algorithm described above, we were left with around 7700 product codes. Obviously, a fraction of these codes refers to more than one product. However, according to the Eurostat information, the total number of CN eight-digit subheadings in 2010 was 9443, therefore only about 1400 are not directly observable because they are merged with other products.

We made two further adjustments to our database. First, we ignored and removed incomplete observations from the database where either values or volumes were missing and therefore it was not possible to calculate the unit value indices. The second adjustment is related to structural change within goods categories. Although we use the most detailed classification available, there remains a great deal of heterogeneity in some categories. This is indicated by large price level differences. Consequently, all observations with outlying unit value indices were excluded from the database.[11]

Before we turn to an analysis of import quality, we give a brief description of the disaggregated import data here with respect to the differentiation of goods and the number of varieties imported. Table 1 describes the degree of product differentiation as measured by the number of imported goods (after taking into account the abovementioned reclassification issues). The number of products is similar for all four countries and ranges between 7,000 and 8,000 in all years. In all cases, the amount of imported products in 2010 was slightly higher

[10] More information on reclassifications of Combined Nomenclature can be found in http://ec.europa.eu/eurostat/ramon/nomenclatures/.

[11] An observation is treated as an outlier if its unit value index deviates from the category mean in a particular year by more than three standard errors. The exclusion of outliers does not significantly reduce the coverage of the database. For example, in 2010 outliers accounted for only 0.2 percent of total value in Germany, 0.9 percent in France, 0.8 percent in Italy and 1.0 percent in the UK.

than in 1995. However, for all countries except the UK a temporary decline in the number of imported products was observed between 2004 and 2007.[12] These figures point to an increase of product differentiation over the sample period, although we cannot make any conclusions about the effect on import prices and consumer welfare, as equation (14) states that expenditure shares of new and disappearing products are important in addition to the number of products.

Table 1. Number of imported products

	1995	1998	2001	2004	2007	2010
Germany	7282	7329	7357	7281	7174	7322
France	7433	7464	7468	7462	7317	7471
Italy	7300	7347	7317	7311	7200	7355
UK	7175	7233	7230	7262	7291	7240

Source: *Eurostat Comext*, authors' calculations.

Notes: Reports the number of eight-digit CN categories, for which there were registered non-zero imports from at least one of 50 partner countries.

Table 2. Average number of origins per imported good

	1995	1998	2001	2004	2007	2010
Germany	15.4	15.8	16.6	16.9	17.1	16.4
France	11.5	12.4	13.1	13.4	11.5	13.1
Italy	11.0	12.3	12.8	13.1	11.3	13.5
UK	12.4	13.1	13.4	13.8	13.8	13.3

Source: *Eurostat Comext*, authors' calculations.

Notes: Calculated as total number of varieties (non-zero imports in particular eight-digit CN category from a particular country) divided by number of imported goods.

Another indicator, which can be calculated immediately, is the average number of origins (countries) per imported product, which serves as a proxy for the variety of imports. Table 2 indicates that there was a clear upward trend in this proxy during the analysed period,[13]

[12] Similar results about the decline of the number of imported products were made by Mohler and Seitz (2010), who analysed the disaggregated imports of EU-27 countries between 1999 and 2008.

[13] These results are also confirmed by Mohler and Seitz (2010), who reported an increase in the mean number of countries for all EU-27 members between 1999 and 2008.

although there were some one-off declines in several years. The highest variety of imports was observed for Germany (around 16 different origins per imported product out of a possible maximum of 50). As before, we should remember that it is just a proxy and it is not possible to make conclusions about prices and gains from variety, as equation (9) requires expenditure shares.

4. Estimation of elasticities

To apply the methodology described in section 2, we first need to evaluate elasticities of substitution between varieties, σ_g. As our theoretical framework follows the one described in Broda and Weinstein (2006), we also apply their estimation strategy for the elasticities of substitution. Here we only briefly remind the main idea behind the methodology, describe the system of demand and supply equations, discuss the problems that appear during the estimation of the parameters of the system. Afterwards, we present our main findings on elasticities of substitution in Germany, France, Italy and the UK and compare our results to those in other papers.

4.1 System of demand and supply equations, GMM estimates

To derive the elasticity of substitution, one needs to specify demand and supply equations. The demand equation is defined by re-arranging the minimum unit-cost function in terms of the market shares, taking first differences and ratios to a reference country:[14]

$$\frac{\Delta \ln s_{gct}}{\Delta \ln s_{gkt}} = -(\sigma_g - 1)\frac{\Delta \ln p_{gct}}{\Delta \ln p_{gkt}} + \varepsilon_{gct} \tag{15}$$

The export supply equation relative to country k is given by:

$$\frac{\Delta \ln p_{gct}}{\Delta \ln p_{gkt}} = \frac{\omega_g}{1+\omega_g}\frac{\Delta \ln s_{gct}}{\Delta \ln s_{gkt}} + \delta_{gct} \tag{16}$$

where $\omega_g \geq 0$ is the inverse supply elasticity assumed to be the same across partner countries. The unpleasant feature of the system of equations (15) and (16) is the absence of exogenous variables which would normally be needed to identify and estimate elasticities. To get the

[14] Similar to Broda and Weinstein (2006) $\varepsilon_{gct} = \Delta \ln d_{gct}$, which means that $\ln d_{gct}$ follow the random walk.

estimates one needs to transform the system of two equations into a single equation by exploiting Leamer's (1981) insight and independence of errors ε_{gct} and δ_{gct}.[15] This is done by multiplying equations (15) and (16). After such transformations, the following equation is obtained:

$$\left(\frac{\Delta \ln p_{gct}}{\Delta \ln p_{gkt}}\right)^2 = \theta_1 \left(\frac{\Delta \ln s_{gct}}{\Delta \ln s_{gkt}}\right)^2 + \theta_2 \left(\frac{\Delta \ln p_{gct}}{\Delta \ln p_{gkt}}\right)\left(\frac{\Delta \ln s_{gct}}{\Delta \ln s_{gkt}}\right) + u_{gct} \qquad (17)$$

where

$$\theta_1 = \frac{\omega_g}{(1+\omega_g)(\sigma_g - 1)};\ \theta_2 = \frac{1-\omega_g(\sigma_g - 2)}{(1+\omega_g)(\sigma_g - 1)};$$

$$u_{gct} = \varepsilon_{gct}\delta_{gct}$$

It should be noted that the evaluation of θ_1 and θ_2 leads to inconsistent estimates, as relative price and relative market share are correlated with the error u_{gct}. However, it is still possible to obtain consistent estimates by exploiting the panel nature of data. Broda and Weinstein (2006) argue that one needs to define a set of moment conditions for each good g, by using the independence of the unobserved demand and supply disturbances for each country over time:

$$G(\beta_g) = E_t(u_{gct}(\beta_g)) = 0 \quad \forall c$$

where $\beta_g = (\sigma_g, \omega_g)$ represents the vector of estimated elasticities. For each good g the following GMM estimator is obtained:

$$\hat{\beta}_g = \arg\min_{\beta \in B} G^*(\beta_g)' W G^*(\beta_g) \qquad (18)$$

where $G^*(\beta_g)$ is the sample analog of $G(\beta_g)$ and B is the set of economically feasible values of β ($\sigma_g > 1$ and $\omega_g \geq 0$). W is a positive definite weighting matrix which weights the data such that the variance depends more on large shipments and becomes less sensitive to

[15] It can be argued, however, that the quality or taste parameter can implicitly enter the residual of both, the demand equation (15) as well as the supply equation (16). This is more likely when quality reflects some tangible properties of a product and as such increases the production costs of the high-qualitative product. This problem cannot be addressed without a well derived supply side in the model therefore we leave this question to further research.

measurement error. Broda and Weinstein (2006) first estimate θ_1 and θ_2 by solving unconstrained minimization problem and then apply a grid search in case this produces imaginary numbers or the wrong sign for elasticities. We use a direct approach and solve equation (18) as a constrained minimization problem.

4.2 Results for Germany, France, Italy and the UK

The elasticity of substitution between varieties is estimated using equation (18) for all products g where data on at least 3 countries of origin were available.[16] Table 3 displays the main characteristics of our estimated elasticities of substitution between varieties. The mean elasticities are very high, close to 25, although it is not very informative, as the distribution is skewed to the right. The median elasticity of substitution between varieties for Germany is 6.19. Since mark-up over marginal costs equals $\sigma_g / (\sigma_g - 1)$, the median mark-up becomes 19.3 percent in this case. The median elasticity and mark-up are of similar magnitude for other countries: France – 5.70 and 21.3 percent, Italy – 5.79 and 20.9 percent, UK – 4.95 and 25.3 percent. Figure A1 in the appendix shows striking similarities for the whole distribution of substitution elasticities for all four countries.

It is quite natural to expect such similarities not only for the overall distribution of elasticities, but also for individual products among European countries. First, these countries are highly similar in terms of their demand characteristics, and second, elasticities are structural parameters and as such to a large extent driven by product characteristics. Nevertheless, we find very low levels of correlation between different mark-ups across countries.[17] The largest correlation was found between mark-ups in France and UK (0.0269), while the smallest was observed between Italy and Germany (0.0027). This could be a cautious signal for the reliability of the estimates, although we should mention that all 6 pairwise correlation coefficients were positive.

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[16] The number of products for which this condition was met can be read from table 3. Although the coverage is reduced, it still remains reasonably high and ranges between 83.6 percent of total aggregated imports for Italy and 90.6 percent for Germany in 2010 although we restricted ourselves only to 50 partner countries, excluded outliers and need at least 3 countries of origin.

[17] We did not calculate correlations between elasticities of substitution themselves due to the skewness of the distribution. The use of mark-ups helped to eliminate this problem at least partially.

Table 3. Elasticities of substitution between varieties

	Germany	France	Italy	UK
Elasticities estimated	7068	7131	6863	6838
Mean	23.67	24.50	22.39	22.05
Standard Deviation	69.6	62.4	62.1	57.1
Maximum	3672.2	1994.8	2911.1	1736.6
Minimum	1.08	1.03	1.01	1.01
Median	**6.19**	**5.70**	**5.79**	**4.95**

Source: *Eurostat Comext*, authors' calculations.

Notes: Elasticities of substitutions estimated using equation (18) for all products where data on at least 3 countries of origin were available.

The elasticities given in table 3 are roughly comparable albeit somewhat higher than those reported in Broda and Weinstein (2006) for the US.[18] To our knowledge, the only papers containing similar estimates for European countries are Mohler (2009, for Switzerland) and Mohler and Seitz (2010, for all EU-27 countries). Compared to Mohler and Seitz (2010), our estimates of the mean elasticity are by 25-30 percent higher.[19] This could be attributed to differences in the sample period. Mohler and Seitz (2010) cover the period between 1999 and 2008, so 2009 – the year of a significant collapse in international trade due to the financial crisis – was not analysed. Also, Mohler and Seitz (2010) use the estimation methodology proposed by Feenstra (1994). They take the sample mean of the variables in equation (17) and then estimate the equation using GMM. It is interesting to note that we obtain the same ranking, i.e. the highest mean elasticity in Germany and the lowest in the UK.

Up to this point we focused solely on the elasticity of substitution between varieties of the same good, while in our extended methodology in equations (12) and (14) we also need γ, the elasticity of substitution between goods. Theoretically, it is possible to apply a similar estimation methodology as one explained in section 4.1, by deriving supply and demand equations and solving the system using the panel nature of the data. However, we do not think that this approach will be appropriate here. The assumption of a single elasticity of substitution between varieties for a single good is reasonable, while the assumption of a single

[18] They report a median elasticity of 3.7 for the period between 1972 and 1988 for seven-digit (TSUSA) goods and 3.1 for the period between 1990 and 2001 for ten-digit (HTS) goods.

[19] Mohler and Seitz (2010) report a mean elasticity of 4.68 for Germany, 4.22 for France, 4.60 for Italy and 3.84 for the UK.

elasticity between all products is too restrictive. One would expect a high elasticity of substitution between highly similar products (e.g. vegetables and fruits) and a rather low substitution elasticity between radically different products (e.g. vegetables and fuel). We cannot solve this problem within the existing theoretical framework based on a CES utility function. Therefore, we calibrate the elasticity of substitution between goods in this paper. Obviously, the substitutability between different products is lower than between varieties, therefore γ should not exceed 5. In our calculations we assume that γ is equal to 2, almost three times lower than our estimated median elasticity of substitution between varieties. This also corresponds to the elasticity used by Romer (1994).

5. Evaluation of an exact import price index

Before being able to calculate a variety-, set-of-products-, and quality-adjusted import price index based on our estimated substitution elasticities, we still need to define a benchmark product for which we assume quality to remain constant over time. Our exact import price index will then control for possible changes in the quality of imports relative to this benchmark and for changes in variety and as well as in the set of imported goods. This allows us to evaluate the effect of relative quality on import prices and quantify the welfare gains from changes in quality. Finally, we should check how robust these results are with respect to the choice of a benchmark product.

5.1 Choice of a benchmark product

In section 2.3 we demonstrate that the only assumption we need to evaluate unobserved quality is the definition of one single benchmark product imported from one benchmark country (d_{jk}). The natural and most simple assumption could be that the quality of the benchmark variety is constant over time ($d_{jkt} = d_{jkt-1}$). However, the choice of this benchmark variety is plagued by several difficulties in practice. First, the benchmark variety should feature prominently in overall trade value as this minimizes measurement error. Second, the set of products, for which one can plausibly assume constant quality, is rather small and mainly includes various food products and low-tech goods. Third, it is not fully clear how to choose the benchmark country of origin. All in all, our calculations show that the results can easily be non-robust and in many cases counterintuitive, which is perhaps driven by product-specific effects.

Thus, we modify our approach slightly. To avoid ambiguity related to the choice of one particular country and one particular product, the benchmark can be broadened. We can assume that the average quality of a single product imported from all countries is unchanged, or, even broader, the average quality of a product group imported from all countries is unchanged. This solution has several advantages: First of all it maintains the concept of relative quality, benchmarking to the average quality from all origins. As such, the benchmark becomes simple and interpretable. Moreover, it increases the robustness of empirical results. By broadening the benchmark, product-specific effects are cancelled out. Technically we assume that the contribution of quality changes in a particular group of goods into the exact price index is zero:

$$\prod_{g \in G_i} \left(\left(\prod_{c \in I_g} \left(\frac{d_{gct}}{d_{gct-1}} \right)^{w_{gct}} \right)^{\frac{1}{\sigma_g - 1}} \right)^{w_{gt}} = 0 \quad \forall t \tag{19}$$

where G_i is a set of goods belonging to a benchmark group i.

In our search for a benchmark set of products for which the assumption of unchanged quality is plausible, we analysed two-digit HS classification groups. From the very beginning we started our search among food products, as this is a rather conservative category of products in terms of quality and tastes. We also took into account the value of imports, to minimize the above mentioned measurement problem. In our calculations we choose HS 07 group – "Edible vegetables and certain roots and tuber", as quality and consumer tastes of this category could be regarded as rather stable.[20] Of course, our choice is subjective and even for HS 07 (vegetables) it could be argued that quality is not constant, for example due to changing preferences for organically grown, fair traded or genetically modified products.[21] At the end of this section we will check the robustness of our results to the choice of the benchmark product group.

[20] This product group also has one of the highest shares in total imports among food products in 2010: 0.60 percent in Germany, 0.52 percent in France, 0.36 percent in Italy and 0.69 percent in the UK.
[21] Perhaps the proper choice of the benchmark is a topic for a separate research and should be done together with sectoral experts on the basis of firm-level data. Here we just demonstrate the essence of the methodology and empirical results under reasonable assumptions.

5.2 Results

Having collected all necessary ingredients for the calculation of an exact import price index - i.e. elasticities of substitutions and an assumption on a benchmark group of products with unchanged quality - we are now able to derive a variety-, set-of-products-, and quality-adjusted measure of import price inflation. Beyond that, this measure also allows us to assess the impact from changes in variety, the product set and quality on prices and welfare in terms of sign and magnitude. In order to assess the impact of each of these three factors (variety, set of products, quality) we will calculate four different import price indices: The first is the conventional index using equations (7) and (8). The second index is adjusted for changes in variety (as in Broda and Weinstein, 2006) using equations (9) and (8), where $\pi_g^M\left(I_{gt}, I_{gt-1}\right)$ is used instead of $P_g^M\left(I_g\right)$ in (8). The third index is adjusted for changes in variety and the set of products calculated using equations (9) and (14), where $\pi_g^M\left(I_{gt}, I_{gt-1}\right)$ is used instead of $\pi_g^M\left(I_{gt}, I_{gt-1}, \Delta d_{gt}\right)$ in (14). Finally, a variety-, set-of-products-, and quality-adjusted price index is calculated using equations (13) and (14). The comparison of these four indices allows to extract the contribution of each factor and to evaluate the bias introduced by neglecting it in the import price index.

Before starting this analysis, we compare our estimates of the conventional import price index to officially released import price deflators from *Eurostat.*[22] The results are depicted in figure A2 in the appendix. We compare annual growth of import prices between 2000 and 2010, since official figures for import prices are available only from 1999 onwards. Although the coverage of our database is only around 85 percent[23], our estimates of annual changes in import prices for goods are extremely close to the figures released by *Eurostat* for Germany, France, Italy and the UK. There are only four instances with diverging signs in the growth rate (France in 2002 and 2003, UK in 2001 and 2008) which are, however, close to zero in magnitude. Our estimates capture appropriately the rapid increase in import prices in 2000, 2006, 2008 and 2010, as well as severe price drop in 2009.

[22] We want to ensure that we are able to reproduce these figures using highly disaggregated trade data. Due to confidentiality and other statistical issues, the aggregation of highly disaggregated data does not yield total imports, however the coverage is rather high.
[23] In 2006-2009 it even decreases to approximately 65-70 percent for France and Italy.

Figure 1 compares the conventional import price index, an import price index adjusted for changes in variety, an index adjusted for changes in variety and set of products and finally a variety-, set-of-products-, and quality-adjusted import price index (we can also call it quality-adjusted import price index for simplicity).

[Figure 1 approximately here]

The effect of changes in variety on the measurement of import prices appears to be marginal in the case of Germany, France, Italy and the UK.[24] The upward bias in the conventional import price index over the period between 1995 and 2010 is estimated to range between 0.03 percent for Italy and 1.34 percent for Germany (see table 4). Thus, despite evidence of an increasing number of origins per imported goods (which we took as a proxy for variety in table 2) the upward bias in the conventional import price index due to increasing variety appears to be rather small. The explanation of this inconsistency lies in the fact that the average number of origins per imported good was mostly growing for products with a relatively high elasticity of substitutions between varieties and a small share of overall imports while variety was growing only marginally for important product groups such as clothing. In this respect, our results for European G7 countries differ substantially from the Broda and Weinstein (2006) results for the US, indicating a bias of 28 percent between 1972 and 2001 or 1.2 percentage points per year. On the other hand, our figures are more in line with the results by Mohler and Seitz (2010), who report only a small bias and hence negligible gains from variety for Germany, France, Italy and the UK. Likewise, we also estimate gains from variety to be small – between 0.01 percent of GDP for Italy and 0.45 percent of GDP for Germany.[25]

In addition to variety, also changes in the set of imported products affect import prices and welfare. We can read from both, figure 1 and table 4 that this factor has a slightly larger impact on European G7 countries compared to changes in variety. Changes in the differentiation of goods produce an upward bias in the import price index in all countries.[26] This implies that the set of imported goods was actually increasing between 1995 and 2010. This is in line with our earlier observation that the number of imported products shows an

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[24] The bias from changes in variety is calculated as $\prod_{g\in J}\left(\lambda_{gt}/\lambda_{gt-1}\right)^{\frac{w_{gt}}{1-\sigma_g}}-1$.

[25] Again, these figures are rather low compared to the estimates for the US, where gains from varieties were found to be 2.6 percent of GDP (between 1972 and 2001) or about 0.1 percent of income each year.

[26] The bias from changes in the set of goods is calculated as $\left(\Lambda_t/\Lambda_{t-1}\right)^{-1}-1$.

upward tendency for all four countries (see table 1). A comparison between the impact of changes in variety to changes in product differentiation points towards a slightly greater importance of the second source of bias (up to 7.09 percent for Italy). Hence, we conclude that at least for European G7 countries the omission of changes in the product set creates a significant positive bias in the estimation of import prices and leads to an underestimation of the welfare gains of consumers. According to our calculations, changes in product differentiation increased consumers' welfare in the range of 1.7 percent of GDP in Italy and 0.2 percent of GDP in Germany between 1995 and 2010.

Table 4. Import price index bias and welfare gains between 1995 and 2010 (percent and percent of GDP)

	Germany	France	Italy	UK
Imports of goods to GDP	0.334	0.227	0.231	0.250
Import price bias:				
changes in variety	1.34	0.25	0.03	0.61
changes in the set of products	0.45	1.14	7.09	1.48
changes in quality	33.15	14.09	17.71	31.38
Welfare gains:				
changes in variety	0.45	0.06	0.01	0.15
changes in the set of products	0.15	0.26	1.73	0.37
changes in quality	14.26	3.51	4.64	9.87

Source: *Eurostat Comext*, authors' calculations.

Notes: Import price bias denotes the effect of the corresponding factor on the conventional import price index in percent. Welfare gains denote the effect of the corresponding factor on consumers' welfare in percent of GDP. Import shares are calculated using data on 2010.

Finally, we highlight the role of changes in quality for the measurement of import prices and welfare. This is a more challenging task, as we crucially rely on the assumption of unchanged quality in our benchmark HS 07 category (vegetables). The quality-adjusted import price index based on this benchmark product is also given in figure 1, while the bias introduced by the conventionally measured import price index and welfare gains from rising quality are reported in table 4.[27]

Several conclusions can be drawn. First, our results suggest that changes in quality affect import prices more than the factors mentioned above. The issue of quality can certainly not be ignored and the conventional assumption of unchanged tastes or quality introduces a huge bias in the measurement of import prices and leads to misleading estimates of consumers' welfare. The potential magnitude of these biases can be read from table 4: the upward bias on import prices is 33 percent in the case of Germany, while welfare gains from increasing quality were up to 14 percent of GDP. Second, the four European G7 countries can be divided into two groups: countries in which quality of imports was increasing during the whole sample period (excluding the latest years) and therefore gains from quality were higher (Germany and the UK) and countries, where the quality of imports was increasing before 2000 and decreasing or staying unchanged afterwards, therefore overall gains are less pronounced (France, Italy). Third, the expenditure share of the baseline product group, for which the assumption of unchanged quality is made, is important. This is reflected in the greater volatility of the quality-adjusted price index in Italy and France where imports of HS 07 products (vegetables) have the smallest share in overall imports out of the four countries.

Another interesting observation concerns quality changes during the financial and economic crisis (2008-2010). The comparison of the quality-adjusted price index to the other variants suggests the quality of imports fell in all four countries in 2009 and recovered in 2010. This can be read from the decrease in import prices adjusted for changes in variety and set of goods and the joint increase in the quality-adjusted import price index. We can interpret this as a temporary shift towards lower quality (and lower price) production during the time of a sharp drop in income. In other words, the decrease of prices after the financial crisis was actually less pronounced, but associated welfare losses were higher when accounting for changes in quality.

Although these results seem plausible, they should be taken with a pinch of salt. First, our estimation procedure is limited to a common elasticity of substitution between all products. We choose γ to be equal to 2 which may still be too high for several inelastic product groups like mineral fuels and oils, metals, pulp of wood. In fact, the substitution elasticity could be

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[27] The bias from changes in quality is calculated as $\prod_{g \in J} \Delta d_{gt}^{\frac{w_{gt}}{\sigma_g - 1}} - 1$.

even lower than unity for such groups. Overestimating the elasticity of substitution leads to excessive volatility of estimated quality for such groups and may affect the results. One way to overcome this problem is to increase the number of levels in the consumers' utility function. This would allow for different elasticities of substitution between different products. However, it is not clear how to group different products. Trade classifications were developed for custom purposes and do not necessarily reflect the similarity between goods (rather between materials used). Alternatively, one could specify a different functional form that allows for various elasticities of substitution.

Second, we already mentioned that due to the absence of firm-level data we have to adopt the Armington (1969) assumption. In other words we ignore the possibility that more than one brand could be imported from each country and thus possibly underestimate variety changes. This may lead to a significant bias in quality estimates. However, according to Hummels and Klenow (2005), it is not possible to disentangle quality from within-category variety unless there are detailed data on the precise number of varieties per good from another source.

Third, and more importantly, all our calculations of quality are relative and based on the assumption of constant quality inside the HS 07 group (vegetables). Thus, an overall upward trend in quality may be introduced by an absolute reduction in the quality of the benchmark.[28] If this is the case, it significantly reduces the estimated bias of import prices and welfare gains from quality. However, it does not disapprove of the methodology itself since it nevertheless improves on the assumption of unchanged quality for all products. This is corroborated by our finding of rather large changes in relative quality between products. However, the definition of an accurate benchmark product or a group of products is crucial and there should possibly be room for a more sophisticated assumption on changes in quality of this benchmark. Ideally this should be done on the basis of scrupulous expert judgement using firm-level information. Here we do not have such information and restrict ourselves to a simple robustness check.

5.3 Robustness check

To check the robustness of our results with respect to the chosen benchmark we calculate four different quality-adjusted import price indices, assuming in turn constant quality for imports

[28] For example, in the case of food products, an increased concern about the safety of genetically modified food may introduce such a shift. Phillips and McNeil (2000) indicate that this concern intensified since 1998, when we observe a radical upward shift in quality in all four countries. In this case decreasing quality of the benchmark refers to consumers' tastes and perceptions of vegetables.

of meat and edible meat offal (HS 02), fish and crustaceans (HS 03), edible fruits and nuts; peel of citrus fruit or melons (HS 08) and a broader group of all food products (HS 01-24). The results of this comparison are summarized in figure 2.

[Figure 2 approximately here]

Figure 2 confirms our anxiety about the choice of a benchmark product group. All four baseline groups are taken from the food section (assumed to be characterized by conservative quality and tastes) and have reasonably high expenditure shares. In fact we cannot tell for which of these groups the assumption of constant quality fits the best. However, the difference in various quality-adjusted indices is quite significant.

Despite these differences, we still insist on the usefulness of our described methodology. Results, although non-robust in terms of absolute magnitude, have some underlying regularity. Thus, the lowest quality-adjusted index is almost always based on HS 02 (meat) as a benchmark, while the highest index results with either HS 08 (fruits and nuts) or HS 03 (fish) as the benchmark. Therefore, we can conclude that in all four countries there is evidence for a decreasing quality of or falling preferences for meat imports relative to fruit and fish imports. One of the possible interpretations of these results could be a shift in tastes from meat towards fish products due to health concerns and rising popularity of vegetarianism. This definitely contradicts the traditional assumption on unchanged quality for all products. Our results could be viewed as robust in relative, although not in absolute terms. We clearly miss a clear choice of benchmark – a problem that cannot be addressed with the data at hand. As mentioned before this is a topic for additional research, ideally on the micro level.[29]

6. Conclusions

Understanding the dynamics of import prices is an important, albeit challenging task. The importance arises from the influence of import prices on domestic inflation (also influenced by the degree of exchange-rate pass through), on the welfare of consumers and for evaluations of competitiveness. The task is challenging as the conventional way of measuring import

[29] Here we see the possibility to join our approach with abovementioned method of Sheu (2011). Information on product characteristics will give an opportunity to evaluate quality changes for several product groups using logit regression from Sheu (2001). These groups can then serve as the benchmark, while the quality of other products relative to the benchmark could be assessed by equations (11) and (12).

prices ignores the effects arising from changes in the set of imported products, in variety and in quality. However, welfare is crucially affected by changes in quality as we show in this paper. Since quality or taste is an unobservable variable it has often been ignored or been replaced by some simple proxy. In this paper we demonstrate how the seminal approach by Broda and Weinstein (2006) who introduced changes in variety into the calculation of the import price index can be deepened further to allow for changes in the set of imported products and in relative quality. Extending the approach by Hummels and Klenow (2005), we relax the overly restrictive assumption of constant quality for all goods and replace it by a more reasonable assumption of constant quality for only one product group. All other products are then allowed to show changes in quality relative to this benchmark over time.

Thus, we construct a variety-, set-of-products-, and quality-adjusted import price index based on estimated substitution elasticities between varieties and assumptions on the substitution elasticity between different products on the one hand and on a benchmark category in terms of quality on the other hand. This index explicitly controls for three sources of bias not addressed by traditionally measured import price indices. The first one is the effect from changes in variety, whereby we adopt the Armington assumption and define variety as imports within the same product line but from different origins. The second source of bias comes from changes in the set of imported products, also referred to as product differentiation. The third bias is introduced by changes in the underlying quality of imported varieties. Clearly, price increases can be more than offset by higher quality in terms of utility and consequently consumer welfare.

We apply this quality-adjusted price index to imports of the four largest European economies, Germany, UK, France and Italy over the time period 1995-2010. Our first result relates to changes in variety. Ignoring changes in variety leads to an overestimation of price increases, however in contrast to the results by Broda and Weinstein (2006) for the US and for an earlier period, this bias appears to be rather small. Our result is however in line with other findings for the EU27 by Mohler and Seitz (2010). Changes in product differentiation between 1995 and 2010 created an additional upward bias in the conventional import price index for all four countries. This can be mapped into welfare gains in the magnitude of approximately 1.7 percent of GDP in Italy and approximately 0.2 percent of GDP in Germany.

However, the largest contribution to the price index is given by changes in underlying import quality, always relative to the benchmark with unchanged quality. We find that ignoring changes in relative quality introduces a substantial upward bias in the price index, thus suggesting lower welfare gains than actually enjoyed by European consumers. Assuming that the benchmark group of products with unchanged quality is vegetables (HS 07), we can divide European G7 countries into two groups: Germany and the UK with increasing quality of imports during almost all of the sample period (the gains from quality are 14.3 percent and 9.9 percent of GDP accordingly), and France and Italy, where quality of imports was increasing before 2000 and decreasing afterwards (the overall gains from quality over the entire period are smaller – 3.5 and 4.6 percent of GDP accordingly). An interesting observation concerns changes in quality during the financial crisis. In all four European countries the quality of imports went down in 2009 and recovered in 2010. We can interpret this fact as a temporary shift to lower quality (and lower price) production during the time of a sharp drop in income. In other words, during the crisis the decrease of prices was actually lower, but losses in welfare actually higher than estimated without taking quality issue into account.

These results, however, should be taken with a pinch of salt. The estimates of import prices and related welfare effects are conditional on the form of the utility function. The nested CES function, although having obvious advantages in terms of mathematical elegance, implies severe limitations. For instance, the estimation procedure is limited to a common elasticity of substitution between all products, which is still too simplistic. It is likely that the substitution elasticity for several inelastic product groups was overestimated which in turn leads to an excessive volatility on quality. Another limitation is mostly data driven – due to lack of detailed data on domestically produced goods, composite domestic and imported goods are separated already in the upper level of the utility function. This significantly understates the replacement of domestic and imported varieties and, as a result, underestimates the effect of increasing quality and variety of imported products on the welfare of domestic consumers.

In addition, our results crucially rely on the assumption of constant quality in the benchmark HS 07 product group (vegetables). As such the results are to be seen as relative and not absolute. Two problems are related to the definition of the benchmark. On the one hand, quality may not have been constant in this group. Especially in 1998-2000 there is some evidence that consumers' preferences for vegetables may have changed due to an increased concern about organically grown and fair traded products or the safety of genetically modified food.

While robustness checks show that the estimated quality-adjusted index is not robust to the choice of a benchmark group, the fact that omitting quality changes from the estimation altogether introduces a serious bias in the results remains undisputed. Therefore, we still insist on the usefulness of the described methodology. The results, although non-robust in terms of magnitude, have some underlying regularity. For example, in all four countries there is a clear evidence of decreasing quality or taste of meat imports relative to fruits and fish imports. Our results can thus considered to be robust in relative, even if not in absolute terms. We certainly miss a proper choice of a benchmark which could ideally be defined on the basis of scrupulous expert judgement based on firm-level information.

In this paper, we have clearly demonstrated the importance of addressing the issue of changes in quality. Even if we lack information on an ideal benchmark for absolute quality, our results corroborate the view that ignoring the quality issue in the empirical literature can give highly misleading estimates of import prices and consumers' welfare. This paper has shown a potential way out of this problem, although further research will be necessary in this respect.

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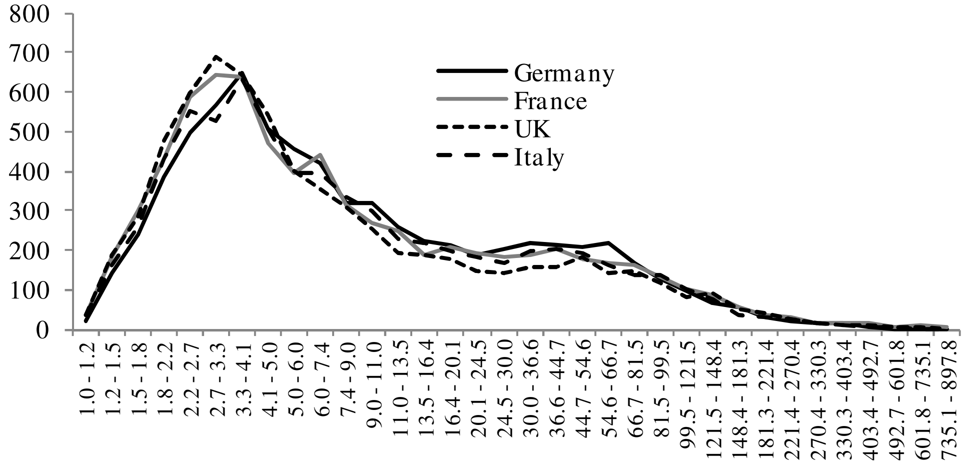
Appendix

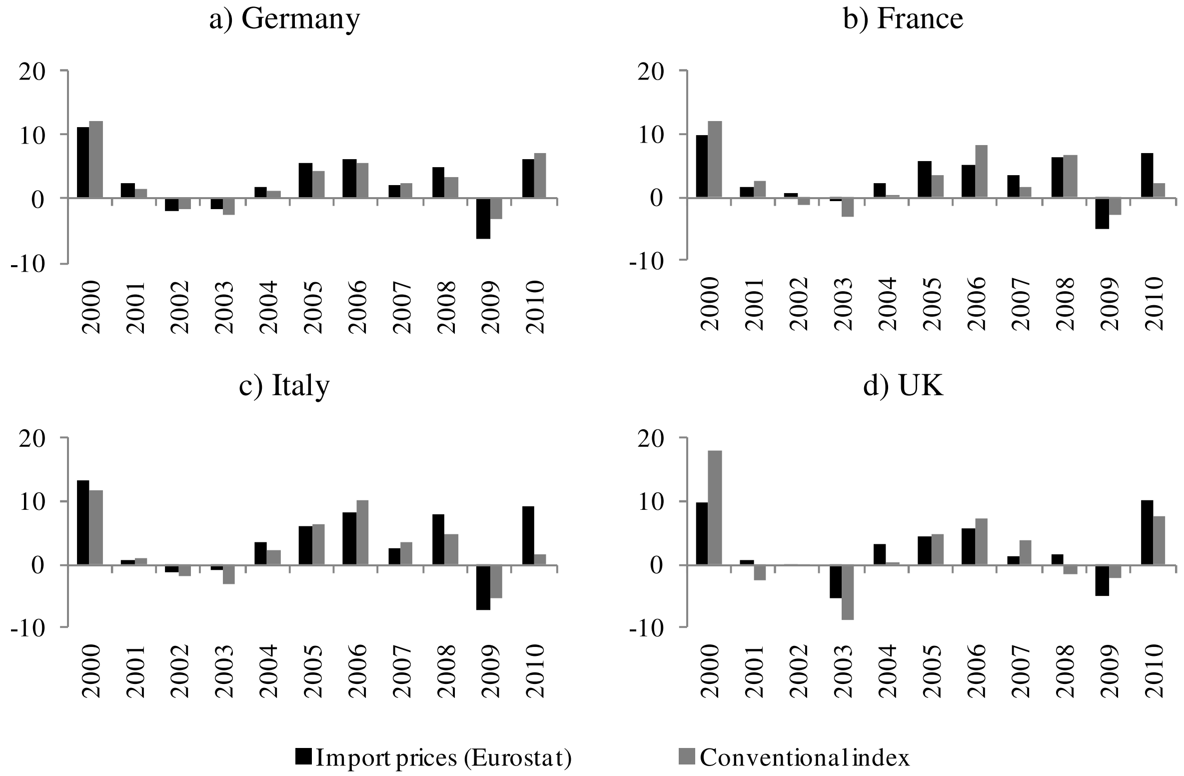
Figure A1. Distribution of elasticities of substitution



Source: Authors' calculations based on *Eurostat Comext*.

Notes: Elasticities of substitutions estimated using equation (18) for all products where data on at least 3 countries of origin were available. The number of observations is 7068 for Germany, 7131 for France, 6863 for Italy and 6838 for the UK.

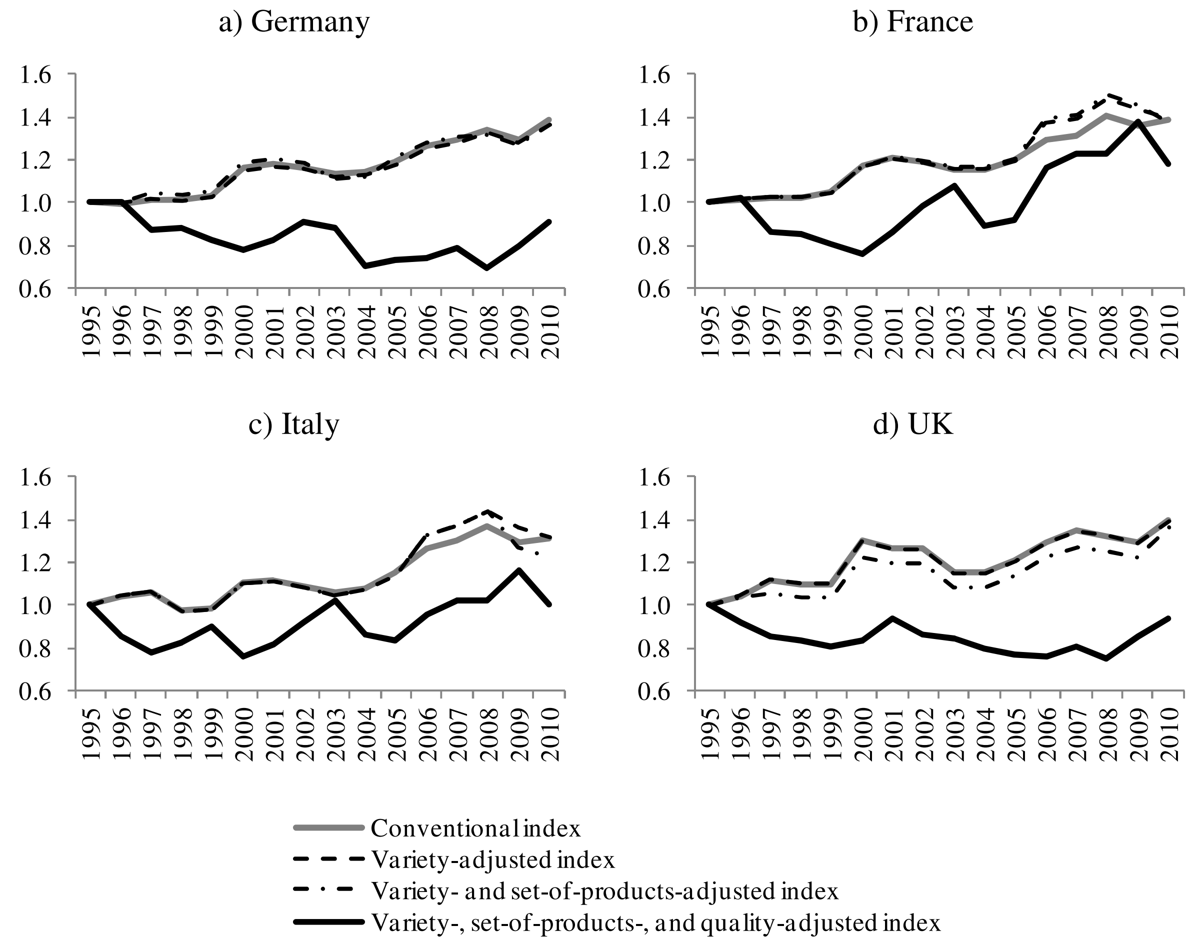
Figure A2. Comparison of officially published import prices and calculations from disaggregated data (annual changes, percent)



Source: Authors' calculations based on *Eurostat Comext*.

Notes: Conventional import price index is calculated from disaggregated import data (eight-digit CN classification level, 50 partner countries) using equations (7) and (8).

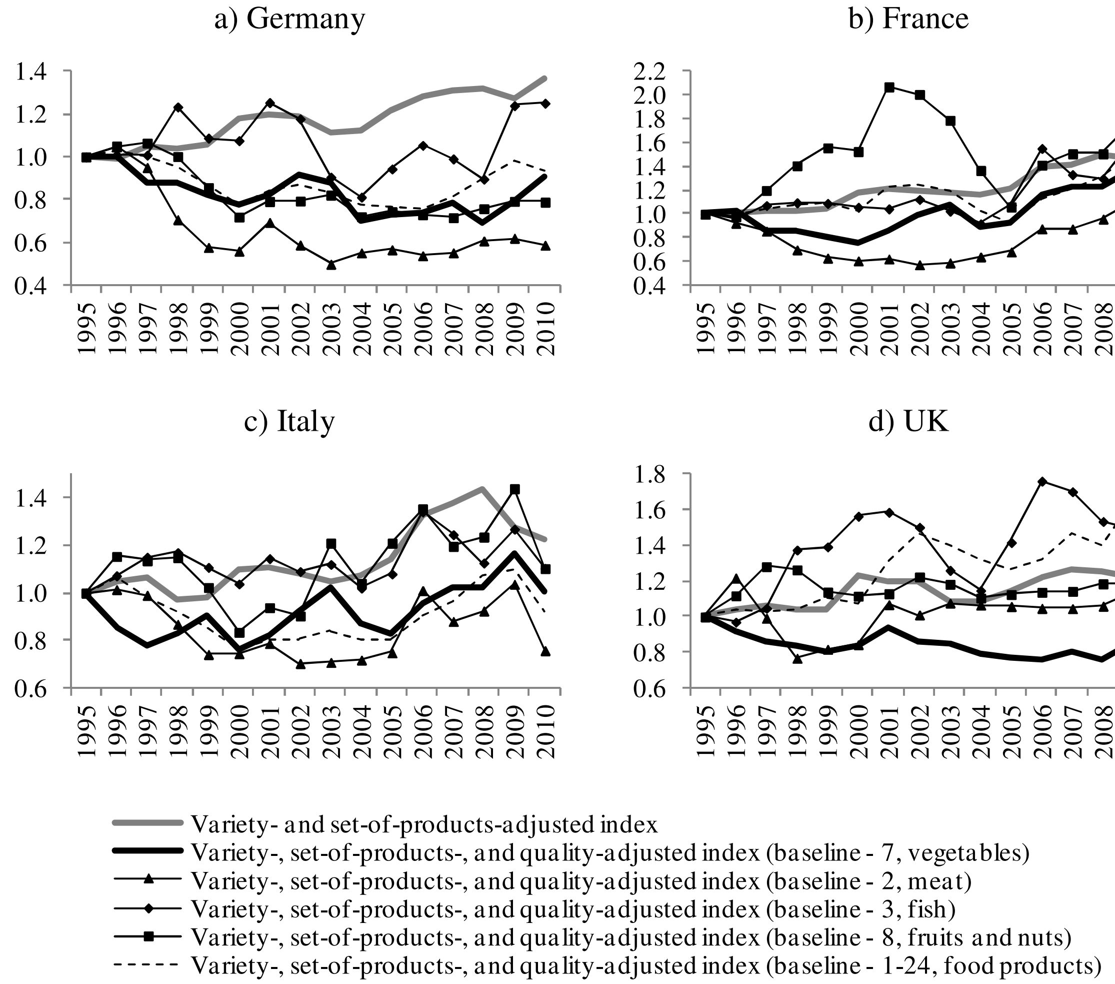
Figure 1. Various price indices for total imports (1995 = 1)



Source: Authors' calculations based on *Eurostat Comext*.

Notes: Conventional import price index is calculated using equations (7) and (8), variety-adjusted import price index – (9) and (8), variety- and set-of-products-adjusted import price index – (9) and (14), variety-, set-of-products-, and quality-adjusted import price index – (13) and (14) assuming constant quality in HS 07 (Edible vegetables and certain roots and tubers).

Figure 2. Quality-adjusted import price indices for different benchmark groups with constant quality (1995 = 1)



Source: Authors' calculations based on *Eurostat Comext*.

Notes: Variety- and set-of-products-adjusted import price index is calculated using (9) and (14); variety-, set-of-products-, and quality-adjusted import price index – (13) and (14).

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- an indication of the period envisaged for the research stay, and
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[1] Other than those eligible for the External Work Experience program established within the ESCB.