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"Made in China" – How Does it Affect Measures of Competitiveness?

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Editorial

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"Made in China" - How Does it Affect Measures of Competitiveness?

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Abstract
We propose a comprehensive analysis of a country's price and non-price competitiveness that accounts for changes in the value added content of trade by combining two datasets – highly disaggregated trade data from UN Comtrade with internationally integrated Supply and Use Tables from the WIOD database. When we focus attention to the traditional measure of gross exports of goods, the analysis shows that advanced economies lost non-price competitiveness relative to emerging economies over the period 1995 to 2011. This picture changes when the fragmentation of production is considered. We find that the relative quality of production from the US, Canada, Germany and the UK when tracing value added in exports remained unchanged or even increased over this period. Likewise, the seemingly unchanged or improving relative quality of Brazil's, Russia's and India's export goods largely arose from outsourcing rather than from improvements in the quality of domestic production. However, gains in Chinese non-price competitiveness remain impressive even after accounting for global value chain integration.

Keywords: value added content of trade, fragmentation, non-price competitiveness, China, BRIC, G7
JEL-codes: C43, F12, F15, L15, O47

1 Introduction
Within roughly two decades China has risen from being a relatively unimportant low-cost and low-quality producer to become the world's largest supplier of goods. This enormous gain in world market shares is often ascribed to the fact that China still has relatively lower production costs, thus alluding to its price competitiveness. More recently, there is also evidence for improving quality of Chinese exporters (Pula and Santabarbara, 2011; Fu et al., 2012; Benkovskis and Wörz, 2014b). Another development that is often overlooked in

such analyses is the fact that China has integrated deeper into global production networks (global value chains – GVCs) over the same period. This stylized fact is observed for all exporting countries and implies that outsourcing and specialization, i.e. the positioning of a specific country within GVCs, plays another important role for export success.

As a consequence, the picture has become considerably more complicated: competitiveness can no longer be assessed by simply looking at price and cost factors, it is even not sufficient anymore to control for the changing quality of a country’s export goods or to assess a country’s ability to react to changes in consumer demand (i.e. meeting tastes). In today’s globalized worlds, competitiveness is also affected by a country’s ability to integrate and position itself well in international production chains.

Thus, the correct assessment of competitiveness meets entirely new challenges. Crucial questions like the following have to be answered in order to give a complete picture: How big is a country’s value added share in the products it sells in international markets? How is a country’s competitiveness affected if its value added share changes over time as a result of changes in international fragmentation? Clearly, data on gross trade flows alone fail to answer these questions. Moreover, they may provide misleading conclusions, as the internationalization of production diminishes the domestic component of exports. Some recent case studies suggest that the share of domestic value added could be extremely small for certain countries and certain products (see e.g. the famous iPod example analysed by Linden et al., 2009). Therefore data on gross export flows is no more an adequate representative of a country’s ability to produce goods for the world market and hence does not reflect competitiveness well.

The number of studies on GVCs and their effect on trade and competitiveness still remains small, although such studies have been growing rapidly in recent years. The early approach by Hummels et al. (2001) to explore vertical specialization was expanded and deepened by Koopman et al. (2010; 2014), Daudin et al. (2011), Johnson and Noguera (2012), and Stehrer (2012). They all confirm the importance of cross-border production linkages and stress the misleading nature of gross trade data.

More recent studies go beyond the calculation of value-added content of trade and modify some basic economic indicators in compliance with the new concept. Providing a unifying framework for previously proposed concepts to identify GVC integration, Koopman et al. (2014) compare revealed comparative advantage (RCA) indices based on gross and value-added trade. They report results for two sectors (metal products and real estate activities) and show that conventional calculations tend to overestimate the competitive position of emerging economies (China and India), while underestimating ranking positions for developed countries (United States, Japan). In this context, attention is also paid to alternative calculations of real effective exchange rates (REER) in the presence of GVCs. Both, deflators as well as the relevant weighting of trading partners are affected by the move from gross to value added trade. Bems and Johnson (2012) extend the benchmark framework of Armington (1969) and McGuirk (1987) by allowing for cross-border inputs on the supply side, and define a REER for trade in value added. They propose a value-added REER that uses weights reflecting value-added trade patterns and GDP deflators (prices for value added). This value-added REER (or "REER in Tasks", as named by Bayoumi et al., 2013) is calculated for 42 countries between 1970 and 2009 and yields important differences compared to the conventional approach. According to their results, the depreciation of the US REER and the appreciation of the Chinese REER were both more pronounced since 2000 under the value added perspective than when looking at the traditional CPI-based REERs. Bayoumi et al. (2013) follow the intuition of Thorbecke (2011) and take into account changes of imported intermediate input prices to construct a so-called "REER in Goods". Bayoumi et al. (2013) again report significant differences to the conventional REER and signal an even larger increase in China's real effective exchange rate.

Our paper contributes to the literature by proposing yet another comprehensive measure of a country's competitiveness that accounts for changes in the value added content of trade. Let us first clearly state the concept of competitiveness we have in mind here. We adopt the OECD definition: "Competitiveness is a measure of a country's advantage or disadvantage in selling its products in international markets". This can easily be measured by a country's global market share. Hence, changes in global market shares will serve as our underlining measure of changes in competitiveness. Further, we decompose changes in export market shares in value added terms into various components, whereby the contribution of price and non-price factors is made explicit. Hence, do not confine our analysis to a price index or simply price and costs competitiveness. Our decomposition further reflects the international fragmentation of production in two ways: by using weights calculated from trade in value-added, and by introducing a specific term accounting for shifts in global value chains.

The starting point is the decomposition of changes in gross export market shares recently developed by Benkovskis and Wörz (2014b). In the present analysis, we also take account of global value chains and re-weight market shares to differentiate between domestic and foreign value added content of trade. According to the empirical analysis of Benkovskis and Wörz (2014b), non-price factors (e.g. quality and taste) play the dominant role in explaining the competitive gains of BRIC countries and the concurrent decline in the G7's share of world exports. Although this indicator is a useful tool to measure a country's non-price competitiveness, it can be significantly affected by shifts in international production chains. Imagine the situation when the final assembly of a high-quality product is moved from US to China. The trade data will report a significant increase in China's exports (both in value and volume terms) accompanied by a growing export price. Despite low domestic value added content in China's exports of the high-quality product, this situation will be interpreted as a rise in China's non-price competitiveness and a corresponding decline in US non-price competitiveness. The analysis based solely on gross trade data may lead to wrong policy conclusions. Therefore we augment the decomposition by a term that makes such shifts in national value-added explicit.

We go beyond a simple illustration of differences in market shares based on foreign and domestic value added. To our knowledge, this is the first attempt to merge traditional decompositions of changes in market shares (which basically distinguish between changes in demand and supply structures and pure growth or performance effects, see for example Cheptea et al., 2014) with the new concept of value added in trade. Our decomposition of market share changes makes use of the exact import price index that was introduced by Benkovskis and Wörz (2014a). We apply this import price index to export prices of source countries (as in Benkovskis and Wörz, 2012), which allows to assess the contribution of price and non-price factors. In addition, we also illustrate the role of the extensive margin, changes in global demand structure, the set of competitors, and as an entirely new aspect changes in the degree of integration into global value chains.

Our approach combines data from two sources. Similar to traditional analyses, we make full use of highly disaggregated bilateral trade data in the UN Comtrade database. We extract export data at the most detailed 6-digit HS level, thus our analysis is based on more than 5,000 products for each possible pair of trading partners in the world. However, we make further use of the recently constructed World Input-Output database (WIOD, see Timmer et al., 2012), which covers 27 EU countries and 13 other major countries for the period from 1995 to 2011. By combining these two data sources, we are able to assess the impact of global value chains (GVCs) on price and non-price competitiveness.

Despite some similarities to methodology proposed by Bems and Johnson (2012), our approach differs from the value-added REER in several aspects. First, similar to Benkovskis and Wörz (2014b), we work with disaggregated data. Hence, we can relax the restrictive assumptions of McGuirk (1987) that are still necessary for REER calculations: changes in individual product prices are assumed to be similar to those of an aggregated price index and the elasticity of substitution between any two suppliers is assumed to be the same for each commodity. Second, our decomposition extends beyond price factors as we evaluate the abovementioned factors that can affect changes in observed market shares (price and non-price factors, extensive margin of export growth, shifts in global demand structure and global production chains, changes in the set of competitors). Hence, we obtain a complex view on a country's competitiveness over time.

Limitations of our approach are mostly determined by data availability. While the use of detailed UN Comtrade data (together with WIOD data) allows relaxing assumptions of a one-for-all elasticity of substitution and disentangling price competitiveness from non-price competitiveness, it comes with a high cost. The statistics on trade in services is by far less detailed and does not provide information on prices, thus we have no final use of services in our analysis (but we still assess an indirect value-added of services sectors in the final use of commodities). Further, detailed data is unavailable for consumption of domestic commodities; consequently, we miss value-added embodied in the production of such goods.

The paper proceeds as follows: Section 2 motivates the use of two data sources in analysing competitiveness and discusses virtues and drawbacks of each source. Section 3 describes the methodology in detail, while section 4 reports the results and section 5 concludes.

2 Joining two data sources – why and how?

Joining trade data with input-output data is not new in the literature. For example, various vintages of the Global Trade Analysis Project (GTAP) database contain country-specific input-output tables and bilateral international trade data by industry for several benchmark years, with the latest database offering data for 129 regions, 57 commodities and two reference years, 2004 and 2007 (Narayanan et al., 2012). Koopman et al. (2010; 2014), Daudin et al. (2011), and Johnson and Noguera (2012) use this data to measure value-added trade. The more recently established World Input-Output Database (WIOD) combines information from national supply and use tables, National Accounts time series on industry output and final use, and bilateral trade in goods and services for 40 countries, 59 commodities and over a time-series from 1995 to 2011 (see Timmer et al., 2012 for more details on the database and Stehrer, 2012, for empirical calculations based on WIOD). We will make use of this dataset, although our paper differs substantially from both approaches. In short, we combine WIOD data with highly disaggregated bilateral commodity trade data. This is similar to Koopman et al. (2014) who also use the most detailed level of disaggregation to identify intermediate goods; however, we do it for an additional reason – disaggregated trade data is needed to interpret unit values as prices of cross-border transactions.

There is another distinction between our paper and the vast literature on vertical specialisation: disaggregated trade data remains our main source of information, while input-output data serves as a useful extension. We want to retain the numerous virtues of very detailed commodity trade data – high degree of harmonization across countries, timeliness, world-wide coverage, availability of price information (unit values) – as these features make disaggregated trade data a natural choice for the assessment of a country's competitiveness. The dataset of UN Comtrade contains annual data on imports of 191 countries from 238 countries between 1996 and 2012.[1] We use trade data from this data set at the six-digit level of the Harmonized System (HS) introduced in 1996 (5,132 products).

The use of highly detailed trade data allows to disentangle price and non-price drivers of export market share changes; however, the use of trade data also implies several limitations. One of those is the disregard of international production fragmentation, which may alter the assessment of a country's performance on external markets dramatically. The WIOD data, although available for a considerably smaller set of countries (40 countries, including all EU-27 members), at a lower level of disaggregation (59 products according to CPA classification), and with a time lag (offering annual data between 1995 and 2011), can fill this gap. The data from WIOD gives an opportunity to calculate the share of country k in the production of good g exported by country c using the inverse Leontieff transformation, which allows to switch from gross export market share changes (decomposed in Benkovskis and Wörz, 2014b) to value-added export market share changes. In other words, we trace a country's value added globally. Thus, we will be able to infer something about the

[1] Since our theoretical framework is developed from consumer's utility maximization problem we analyse changes in export market shares using information on import data of partner countries. This has the further advantage that import data is often better reported, especially since the majority of world imports is still flowing into advanced economies with better reporting systems.

performance of domestic producers (not exporters) on external markets, which should improve our understanding of strong and weak sides of a country.

The lower level of disaggregation in WIOD imposes some difficulties, and we need to assume an equal structure of value added for all HS 6-digit level products within a broad CPA category. This is a very strong assumption, but we have no alternative for a broad analysis at the macro level. Another limitations is the lower country coverage (now calculations can be done for 40 exporter and producer countries instead of 191), but this is an acceptable limitation for us as we are primarily interested in the competitiveness of the world's major exporters, and especially in the performance of EU members which are fully covered in WIOD. A final limitation is given by the time dimension as WIOD data ends at 2011.

3 A comprehensive, GVC-compatible index of competitiveness

This section describes the methodology we propose to evaluate the performance of a country's producers on external markets. It largely builds on the recently developed decomposition of changes in gross export market shares (see Benkovskis and Wörz, 2014b). We extend this approach to include also the effects of international fragmentation of production in the decomposition. Hence, changes in a country's world market share measured in value added terms serve as a comprehensive indicator of competitiveness. However, developments in value added market shares are split into several determinants in order to allow a detailed assessment of underlying determinants of competitiveness. We proceed like this: In the first step, we refine the measurement of market share by tracing each exporter's value added through the entire global value chain (see section 3.1). Second, we distinguish between changes in market shares along the extensive versus the intensive margin of export growth. Market shares may be gained from venturing into new products or destination markets (extensive margin) or from intensifying existing trade relationships (intensive margin, see section 3.2). Third, we scrutinize the intensive margin: market shares arising from the intensive margin are affected by shifts in global demand structure (changes in the composition of global trade) and by growth in bilateral trade relationships. The last effect (i.e. the intensive margin of changes in market share of a specific exporter in a specific importing countries) is then split into four components: price effects, non-price effects, changes in the set of competitors and a term which captures shifts in a country's integration in global production chains (i.e. changes in the amount of the respective producer's value added in global production chains, see section 3.3).

3.1. Value-added export market share

The international fragmentation of production changed the nature of the international economy dramatically and gross exports are no longer a valid indicator of a country's competitiveness. In the majority of cases, goods exported by a specific country are only partly produced domestically, in some cases the fraction of domestic value added is very small (see e.g. Linden et al., 2009). This calls for a refined indicator which is able to capture competitiveness-relevant features of the ongoing fragmentation process. In this paper, we propose to focus on market shares of value-added exports, i.e. gross exports corrected for the source of value added.

Hummels et al. (2001) provide one of the first systematic evidences on vertical specialisation and measure the value of imported inputs embodied in exported goods. This approach captures forward linkages but also misses an important part of vertical specialisation as exports of one country may be used as inputs into another country's production of export goods (backward linkages). Recently, Koopman et al. (2010; 2014), Daudin et al. (2011), and Johnson and Noguera (2012) proposed new approaches to assess value-added trade.

Two important measures are worth being mentioned here. The first one is called "value added in gross exports" (*VAS*, as denoted in Koopman et al., 2010; closely related to value added in trade, as named by Stehrer, 2012) and decomposes gross exports by producer countries:

$$VAS = V \cdot B \cdot X = V \cdot (\mathrm{I} - A)^{-1} \cdot X, \tag{1}$$

$$V \equiv \begin{bmatrix} V_1 & 0 & \cdots & 0 \\ 0 & V_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & V_K \end{bmatrix}, \quad V_r \equiv u\left(\mathrm{I} - \sum_s A_{sr}\right), \quad X \equiv \begin{bmatrix} diag(X_1) & 0 & \cdots & 0 \\ 0 & diag(X_2) & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & diag(X_K) \end{bmatrix},$$

where *VAS* is a $K \times KN$ matrix that provides disaggregated value added by producer country in gross exports for each exporting country and sector, K is the number of countries and N is number of sectors. V is $K \times KN$ block-diagonal matrix, V_r is $1 \times N$ direct value-added coefficient vector and each element gives the share of direct domestic value added in total output of country r in each sector ($r = 1,..., K$). Input-output coefficients are comprised in the $KN \times KN$ matrix A, which is constructed from the $N \times N$ blocks A_{rs}. Those blocks contain information on intermediate use by country s of the goods produced in country r. X is a $KN \times KN$ diagonal matrix of gross exports, and X_r is a $N \times 1$ vector of country r's exports by sector. Finally, B is the Leontieff inverse matrix $B = (\mathrm{I} - A)^{-1}$, and u is a 1×N unity vector. So, the *VAS* measure captures all upstream sectors' contributions to value added in gross exports.

The second measure, introduced by Johnson and Noguera (2012), is termed "value-added exports" or "value-added trade" (*VAX*). It is closely related to value added in gross exports (*VAS*), but differs insofar as it reflects how a country's exports are used by importers. As defined by Koopman et al. (2014, p.462), value-added exports "... is value added produced in source country *s* and absorbed in destination country *r*". This is given by:

$$VAX = \hat{V} \cdot B \cdot Y = \hat{V} \cdot (\mathrm{I} - A)^{-1} \cdot Y, \qquad (2)$$

$$\hat{V} \equiv \begin{bmatrix} \hat{V}_1 & 0 & \cdots & 0 \\ 0 & \hat{V}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{V}_K \end{bmatrix}, \quad \hat{V}_r \equiv diag(V_r),$$

where *VAX* is $K \times KN$ matrix that provides disaggregated value added by producer country in final consumption for each country and each sector. Y is the $KN \times K$ final demand matrix. It contains blocks Y_{sr}, which is the $N \times 1$ final demand vector that gives demand in country r for final goods shipped from country s.

Although seemingly similar, the two indicators (*VAS* and *VAX*) give different results, as *VAS* focuses on gross exports – thus including exports and intermediate goods and therefore double-counting some value-added activities – while *VAX* focuses on final use, including the a country's demand for its own production (which is given by the diagonal element of *VAX;* Koopman et al., 2014, p.480, suggest that these elements should be excluded from the analysis).

Despite these clear conceptual underpinnings, we face a difficult choice in the empirical implementation: should we use highly detailed trade data (i.e. rely on *VAS*) or more aggregated, but double-accounting-free final demand data (basing our indicator on *VAX*)? The main advantage when using data on gross export flows available from commodity trade statistics is that we can work with prices (unit values) and volumes on a very detailed level. This information allows us to identify the contribution of price and non-price factors for the overall performance of value-added exports (see Benkovskis and Wörz, 2014b). Obvious drawbacks of this choice are the complete lack of data on trade in services on the one hand and double-counting due to exports of intermediate products on the other hand.[2] In contrast, with final demand data we avoid the double-counting problem and we can include

[2] The WIOD data shows that the problem of double-counting is rather serious, as value-added exports exceeded exports in value-added approximately 2.5 times for almost all countries in 2011.

information on services. However, we will not be able to study price and non-price contributions due to the lack of detailed price and volume data.

In this paper we propose to use the *VAS* indicator from equation (1), although we modify it such that we avoid double-counting of value-added. Double-counting occurs when a country provides value added in exports of intermediate goods that are further used in the exports of final goods. Clearly, this problem can be eliminated by analysing only gross exports of final use products. Since we obtain trade data at a very fine level of disaggregation, we can exclude exports of intermediate products (according to the BEC[3]) and focus on products for final use. This seems justified, as the Loentieff transformation traces value added through all importing and exporting countries. The production of one final product may include value added from multiple countries whereby the value added from a specific country can cross the same national border more than once (i.e. if an intermediate good is exported for processing and re-imported to be further processed at home before being exported to final assembly).

While avoiding double-counting, confining ourselves to trade in final goods only has two drawbacks. First, trade data allows to analyse final products of foreign origin, but provides no information on domestic products. Therefore, we miss the value added embodied in exports of intermediate products that are further processed and consumed in the same country. This is a significant loss of information and it is impossible to fill this gap with disaggregated data. This drawback should be kept in mind while interpreting the results. Second, final use of domestic goods and of services is missing, but this does not imply that we totally exclude service sectors from the analysis. We still assess the indirect value-added of services sectors in final use of commodities.

Summarizing the discussion above, in building our comprehensive index we propose to solve the problem of international fragmentation by relying on a country *k*'s market share in terms of value added in gross exports of final use products (VASF) rather than gross exports. Thus, we make use of the advantage of the *VAS* index insofar as we use highly disaggregated trade data for both, values and quantities to distinguish between price and non-price factors. At the same time we avoid double counting by ignoring intermediate goods. Our measure of value added market share is defined as follows:

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[3] 1,920 HS 6-digit level products out of 5,132 are classified as final use products, of which 682 are consumption products and 1,238 are capital goods.

$$MS_{k,t}^{VASF}=\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}V(k)_{gc,t}}{\sum_{v\in C}\sum_{i\in I}\sum_{g\in G}\sum_{c\in C}P(i)_{gc,t}M(i)_{gc,t}V(v)_{gc,t}}=\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}V(k)_{gc,t}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}}, \tag{3}$$

where $MS_{k,t}^{VASF}$ is VASF market share of a country k, i is a running index for importing countries, g denotes the final use product, c the exporting country and v stands for value-added contributing countries. Note the differentiation between producing country k (the contributor of value added) and exporting country c. $M(i)_{gc,t}$ represents the quantity of country i's final goods imports from exporting country c (or country c's final goods exports to country i), while $P(i)_{gc,t}$ is the price of the respective trade flow. $V(k)_{gc,t}$ stands for the share of country k in the production of a specific good g exported by country c. Note, that $V(k)_{gc,t}$ includes both direct and indirect contributions of country k and is evaluated as an element of $V\cdot(\mathrm{I}-A)^{-1}$ from equation (1), assuming that the value-added structure of country c's final exports does not depend on the respective destination.[4] Finally, I, G and C are the sets of importing countries, final use HS 6-digit products, and exporting countries respectively whereby the latter set coincides with the set of producing countries. Therefore, the numerator of (3) shows the value-added of country k in total world's exports of final products, while the denominator represents total world exports of final goods.

3.2. Intensive and extensive margins

Having derived a country k's world market share in value added terms, we then follow the framework of Benkovskis and Wörz (2014b) and expand equation (3) in order to split changes in these market shares into the contributions arising from the extensive and the intensive margin:

$$dMS_{k,t}^{VASF}=\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}V(k)_{gc,t}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}}\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t-1}M(i)_{gc,t-1}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t-1}M(i)_{gc,t-1}V(k)_{gc,t-1}}=dEM_{k,t}^{VASF}\times dIM_{k,t}^{VASF}, \tag{4}$$

$$dEM_{k,t}^{VASF}=\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}V(k)_{gc,t}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}}P(i)_{gc,t}M(i)_{gc,t}V(k)_{gc,t}}\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}}P(i)_{gc,t-1}M(i)_{gc,t-1}V(k)_{gc,t-1}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t-1}M(i)_{gc,t-1}V(k)_{gc,t-1}},$$

$$dIM_{k,t}^{VASF}=\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}}P(i)_{gc,t}M(i)_{gc,t}V(k)_{gc,t}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t}M(i)_{gc,t}}\frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G}P(i)_{gc,t-1}M(i)_{gc,t-1}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}}P(i)_{gc,t-1}M(i)_{gc,t-1}V(k)_{gc,t-1}},$$

[4] As mentioned in section 2, $V(k)_{gc,t}$ is calculated from the WIOD database by assuming identical value added structure of all final use products g in the HS 6-digit classification falling within the same CPA category.

where $dEM_{k,t}^{VASF}$ denotes extensive margin of the value added in gross exports of final goods market share changes, $dIM_{k,t}^{VASF}$ the intensive margin, $G(i)_{c,t,t-1}$ is the subset of final use products shipped from country *c* to country *i* in both periods, *t* and *t*–1.

The extensive margin equation is similar to Feenstra's (1994) index accounting for changes import variety, but redefined for the value-added case. The extensive margin is defined in our case as the change in the ratio of country *k*'s value added in total exports to value-added in traditional exports. Value added in traditional products is the value added in final use products exported by any country to any destination market in both periods *t* and *t*–1. The ratio increases (decreases) over time if the share of value added in disappeared products is smaller (greater) than the share of value added in newly exported products. In this case, the contribution of the extensive margin to changes in VASF market share is positive (negative). The intensive margin is obtained as the residual and simply represents the growth of country *k*'s value added in traditional final use products compared to growth of total world trade in final use goods.

While extensive margin cannot be decomposed any further in our framework (ideally, one would need to relate market entries and exits with firm-level characteristics), more can be done with intensive margin.

3.3. Further decomposition of the intensive margin

A country's exports along the intensive margin may grow or diminish because of changes in exports of country *k* to recipient country *i*. This refers to the intensive margin in any bilateral trade relationship $dIM(i)_{k,t}^{VASF}$ (i.e. the contribution of intensive margin growth to changes in VASF market share in a single destination country *i*). However, the aggregation of bilateral trade relationships to obtain an exporter's world market share is further complicated by the fact that the structure of world trade changes over time. In other words, changes in trade value between third countries affect an individual exporter's global market share. Thus, as a first step in the decomposition of the intensive margin, we distinguish between the bilateral intensive margin and changes in the global weight of each exporter's bilateral trading partner. To account for the latter effect, we explicitly allow for different growth rates of various destination markets (importing countries). The term $dDS(i)_t$ captures changes in the intensive margin due to shifts in the recipient country's share in world imports:

$$dIM_{k,t}^{VASF} = \sum_{i \in I} s(i)_{k,t-1}^{X} dDS(i)_t \, dIM(i)_{k,t}^{VASF}, \quad (5)$$

$$dDS(m)_t = \frac{\sum_{c\in C}\sum_{g\in G} P(m)_{gc,t} M(m)_{gc,t}}{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t}} \frac{\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t-1} M(i)_{gc,t-1}}{\sum_{c\in C}\sum_{g\in G} P(m)_{gc,t-1} M(m)_{gc,t-1}}, \quad s(i)_{k,t}^{X} = \frac{\sum_{g\in G} P(i)_{gk,t} M(i)_{gk,t}}{\sum_{i\in I}\sum_{g\in G} P(i)_{gk,t} M(i)_{gk,t}}.$$

$$dIM(i)_{k,t}^{VASF} = \frac{\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}}{\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t}} \frac{\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t-1} M(i)_{gc,t-1}}{\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} P(i)_{gc,t-1} M(i)_{gc,t-1} V(k)_{gc,t-1}}$$

where $s(i)_{k,t}{}^{X}$ is the share of partner country *i* in exporter *k*'s exports.

We then proceed by decomposing the bilateral intensive margin ($dIM(i)_{k,t}{}^{VASF}$) into four factors: price-, and non-price-factors, changes in the set of competitors for the same product at the same destination market and shifts in the integration into global value chains. This decomposition is done by solving the consumer utility maximization problem of the importing country *i* as in Benkovskis and Wörz (2014a).

We depart from a nested, three-level, CES utility function. Consumers gain utility from consuming domestic and imported goods. For simplicity we assume one homogenous domestic good and a composite import good with a constant elasticity of substitution among the two at the outer nest. At the second level, consumers can choose between different import goods $g\in G$ with a constant elasticity of substitution between goods ($\gamma(i)$). At the inner nest, each product can be sourced from a different exporter whereby source countries represent individual varieties of a good denoted by $c\in C$. The elasticity of substitution between varieties is given by $\sigma(i)_g$. Further, a valuation parameter $Q(i)_{gc,t}$ is added at the inner nest such that imports of a certain variety are weighted by non-price factors that reflect product quality, consumers' tastes, labelling, etc.[5]

The solution to the utility maximisation problem in the importing country subject to the consumer's budget constraint gives a minimum unit-cost function, which corresponds to the price of utility obtained from imported good *g*. The important point to note is that minimum unit cost depends not only on prices, but also on non-price factors as a better quality or higher valuation by the consumer offsets for a higher price in terms of derived utility.

We apply this import price index to export prices of source countries, which allows to decompose the bilateral intensive margin into various components, including price and non-

[5] As our theoretical framework is based on consumer utility maximization only, we cannot differentiate between product quality and consumer taste for certain products. This could be done in a framework where firms' behaviour is modelled explicitly like in Feenstra and Romalis (2012), or by obtaining information on products' characteristics like in Sheu (2011). However, both approaches would limit the empirical application of our decomposition as such a more complicated theoretical framework requires additional information typically obtained from micro data on firms or products. Such information is in general not available for a global analysis of trade flows.

price factors. Equation (6) summarizes the decomposition of bilateral intensive margin (technical details of the derivation are outlined in appendix sections A.1 and A.2 as they follow in essence Benkovskis and Wörz, 2014b):

$$dIM(i)_{k,t}^{VASF} = \underbrace{PP(i)_{k,t}^{VASF}}_{1}\underbrace{CC(i)_{k,t}^{VASF}}_{2}\underbrace{QQ(i)_{k,t}^{VASF}}_{3}\underbrace{VV(i)_{k,t}^{VASF}}_{4} = \tag{6}$$

$$= \underbrace{\sum_{g\in G(i)_{c,t,t-1}}\sum_{c\in C}\left(w(k,i)_{gc,t}^{VASF}\left(\frac{\pi(i)_{gc,t}}{\prod_{m\in C(i)_g}\pi(i)_{gm,t}^{w(i)_{gm,t}}}\right)^{1-\sigma(i)_g}\left(\frac{\prod_{m\in C(i)_g}\pi(i)_{gm,t}^{w(i)_{gm,t}}}{\prod_{j\in G}\prod_{m\in C(i)_g}\pi(i)_{jm,t}^{w(i)_{jm,t}w(i)_{j,t}}}\right)^{1-\gamma(i)}\right)}_{1}\times$$

$$\times\underbrace{\sum_{g\in G(i)_{c,t,t-1}}\sum_{c\in C}\left(w(k,i)_{gc,t}^{VASF}\left(\frac{\lambda(i)_{g,t}}{\lambda(i)_{g,t-1}}\right)^{\frac{\gamma(i)-\sigma(i)_g}{1-\sigma(i)_g}}\prod_{j\in G}\left(\frac{\lambda(i)_{j,t}}{\lambda(i)_{j,t-1}}\right)^{\frac{(1-\gamma(i))w(i)_{j,t}}{1-\sigma(i)_j}}\right)}_{2}\times$$

$$\times\underbrace{\sum_{g\in G(i)_{c,t,t-1}}\sum_{c\in C}\left(w(k,i)_{gc,t}^{VASF}\frac{q(i)_{gc,t}}{\prod_{m\in C(i)_g}q(i)_{gm,t}^{w(i)_{gm,t}}}\left(\frac{\prod_{m\in C(i)_g}q(i)_{gm,t}^{\frac{w(i)_{gm,t}}{1-\sigma(i)_g}}}{\prod_{j\in G}\prod_{m\in C(i)_g}q(i)_{jm,t}^{\frac{w(i)_{jm,t}w(i)_{j,t}}{1-\sigma(i)_j}}}\right)^{1-\gamma(i)}\right)}_{3}\times\underbrace{\sum_{g\in G(i)_{c,t,t-1}}\sum_{c\in C}\left(w(k,i)_{gc,t}^{VASF}\frac{V(k)_{gc,t}}{V(k)_{gc,t-1}}\right)}_{4},$$

$$w(k,i)_{gc,t}^{VASF} = \frac{P(i)_{gc,t-1}M(i)_{gc,t-1}V(k)_{gc,t-1}}{\sum_{g\in G(i)_{c,t,t-1}}\sum_{c\in C}P(i)_{gc,t-1}M(i)_{gc,t-1}V(k)_{gc,t-1}},\quad \pi(i)_{gc,t} = \frac{P(i)_{gc,t}}{P(i)_{gc,t-1}},\quad q(i)_{gc,t} = \frac{Q(i)_{gc,t}}{Q(i)_{gc,t-1}}.$$

where $PP(i)_{k,t}^{VASF}$ is the contribution of price factors, $CC(i)_{k,t}^{VASF}$ the contribution of changes in the set of exporters (i.e. changes in the set of competitors from the exporting countries point of view), $QQ(i)_{k,t}^{VASF}$ the contribution of non-price factors (changes in taste or quality), and $VV(i)_{k,t}^{VASF}$ is the contribution of geographical shifts in international production chains. Finally, $w(i)_{gc,t}$ and $w(i)_{g,t}$ are Sato-Vartia weights representing the structure of country *i*'s imports, $\lambda(i)_{j,t}$ is Feenstra's (1994) seminal term that takes into account utility gains arising from changes in varieties available to consumers in country *i*'s.[6]

Let us illustrate the interpretation of the decomposition in equation (6): The first term represents the contribution of price factors to country *k*'s competitiveness and is similar to the term derived by Armington (1969). This term is analogous to a real effective exchange rate based on unit values and accounting for market characteristics – relative price changes have larger consequences in markets with a higher elasticity of substitution. Note that we refer to

[6] This decomposition is similar to the one proposed in Benkovskis and Wörz (2014b), but it offers two important innovations: First, due to the different weighting scheme (accounting for value added in exports), the interpretation of all components changes. Second, we obtain a separate term that identifies shifts in global value chains.

relative price changes for VASF of country *k*, not about gross exports (in contrast to Benkovskis and Wörz, 2014b).[7] Therefore, we use value-added weights that are calculated as the ratio of value added in the particular trade link relative to total value added exported to country *i*.

The second term captures the contribution of changes in the set of competitors to gains or losses in country *k*'s VASF market shares. This term accounts for changes in the set of competitors in all final product markets, which is tantamount to increasing or decreasing variety from the consumer's point of view. Hence, it influences consumers' choice among various final use products and thus affects an exporter's ability to sell.

The third term represents the contribution of non-price factors (such as taste, labelling, quality and the like) to a country's competitiveness. Again, value-added weights are used to calculate the aggregate contribution. We would like to stress that we take into account relative changes in non-price factors for any final use product exported by any country and aggregate these results using the VASF structure of country *k*.[8] Despite the fact that the valuation parameter capturing non-price factors is unobservable, the third term can be calculated as a residual (note, that all other components are observable):

$$QQ(i)_{k,t}^{VASF} = \frac{dIM(i)_{k,t}^{VASF}}{PP(i)_{k,t}^{VASF} CC(i)_{k,t}^{VASF} VV(i)_{k,t}^{VASF}} = \tag{7}$$

$$= \sum_{g\in G(i)_{c,t,t-1}} \sum_{c\in C} \left(w(k,i)_{gc,t}^{VASF} \frac{\mu(i)_{gc,t}}{\prod_{g\in G}\prod_{c\in C(i)_g} \mu(i)_{gc,t}^{w(i)_{gc,t} w(i)_{g,t}}} \left(\frac{\pi(i)_{gc,t}}{\prod_{m\in C(i)_g} \pi(i)_{gm,t}^{w(i)_{gm,t}}} \right)^{\sigma(i)_j} \left(\frac{\prod_{m\in C(i)_g} \pi(i)_{gm,t}^{w(i)_{gm,t}}}{\prod_{j\in G}\prod_{m\in C(i)_g} \pi(i)_{jm,t}^{w(i)_{jm,t} w(i)_{j,t}}} \right)^{\gamma(i)} \times \right.$$

$$\left. \times \left(\frac{\lambda(i)_{g,t}}{\lambda(i)_{g,t-1}} \right)^{\frac{\sigma(i)_g - \gamma(i)}{1-\sigma(i)_g}} \prod_{j\in G} \left(\frac{\lambda(i)_{j,t}}{\lambda(i)_{j,t-1}} \right)^{\frac{(\gamma(i)-\sigma(i)_j) w(i)_{j,t}}{1-\sigma(i)_j}} \right),$$

$$\mu(i)_{gc,t} = M(i)_{gc,t} / M(i)_{gc,t-1}.$$

Equation (7) reflects the fact that observed variables contain useful information for the derivation of a proxy that captures the impact of non-price factors in shaping a country's position. We can see that price dynamics is an important proxy (but not the determinant) of changes in relative quality or taste. If the price of a good imported from one country rises faster than the price of the same good imported from another country, this indicates either

[7] In the empirical implementation we are forced to assume that price changes of the final product are equally distributed at all stages in the international production chain due to data limitations.

[8] One restrictive assumption we make here is that quality changes are identical on all stages of production. This is analogous to the assumption above concerning the distribution of price changes along the production chain.

improving quality of or increasing preference for the first country's good. Moreover, when different varieties are close substitutes, the role of relative prices as a proxy for relative quality increases. It should be noted, however, that relative price is not the sole indicator of relative taste and quality. Changes in relative quantity of a single variety in total consumption also reflect the perception of changes in relative taste and quality. Increasing consumption of a certain variety is a clear sign of improving taste or quality, and relative quantity gains importance when the elasticity of substitution is small. Equation (7) shows how unobservable changes in non-price factors are proxied for by changes in relative prices and real market shares. The last two terms of equation (7) are less intuitive. They are driven by the interaction between taste/quality and variety. Our calculations show that the role of the last two terms is negligible in empirical estimations.

Although the first three terms in equation (6) above represent the same determinants of competitiveness as those resulting from the decomposition proposed in Benkovskis and Wörz (2014b), the different weighting scheme implies an important change in interpretation: Equation (6) analyses competitiveness of all final use products exported by all countries, taking into account country *k*'s value added in each exported product when aggregating the measure to the country level. Hence, the focus shifts from country *k*'s direct exports to a broader perspective, as – at least theoretically – virtually all exported final use products in the world may contain some (indirect) input from country *k*.

Finally, an additional term appears in equation (6) as a consequence of shifting the focus from gross to value added exports. The last term $VV(i)_{k,t}^{VASF}$ measures shifts in global value chains. It implies that an increase in country *k*'s value-added in the production of exports positively affects VASF market share. Such an increase can be achieved either by a higher domestic content in country *k*'s gross exports or by more active involvement in GVCs leading to a higher value-added share in other countries' exports of final use products. We calculate growth in VASF market share for each exported final use product and then aggregate to the country level using Laspeyres-weights of country *k*'s value added exports in final goods ($w(k,i)_{gc,t}^{VASF}$).

To sum up, from the exporter's point of view, the intensive margin of changes in export market share is decomposed into five parts: global demand shifts, price factors, changes in the set of competitors, non-price factors, and shifts in global production chains.

Let us make a final technical remark on the elasticities of substitution (σ's and γ's). We estimate elasticities of substitution between varieties (σ's) following the approach proposed by Feenstra (19994) and developed by Broda and Weinstein (2006) and Soderbery (2010, 2012). Technical details on the methodology and obtained estimates for 20 largest destination countries are provided in Appendix A.4. The elasticity of substitution between goods (γ's) are calibrated to 2 for all destination markets, which is below the median substitutability among varieties (see Appendix, Table A.1). This also corresponds to the elasticity used by Romer (1994). Benkovskis and Wörz (2014b) showed that the conclusions about the decomposition of gross exports market share changes are robust for alternative (and reasonable) values of γ's.

4 Results

We apply the proposed decomposition to global trade over the period 1996 to 2011. We present cumulative changes in world market shares for the G7 and four largest emerging economies for both, gross export markets shares and market shares based on value added in exports. The evolution of market shares and the decomposition of changes therein are illustrated by charts 1–3. The first column in each chart reports the decomposition of gross export market share dynamics, the second column shows the decomposition of VASF market share changes, and the difference between VASF and gross export market share changes and its decomposition is exhibited in the third column. Chart 1 shows the results for European G7 countries (France, Germany, Italy and the UK), Chart 2 is devoted to the non-European G7 (Canada, Japan and the US), and Chart 3 describes the decomposition for largest emerging economies (Brazil, China, India and Russia).[9]

4.1. Cumulative changes in gross versus value added export market shares

Let us first compare total cumulative changes in VASF markets shares over the period 1996-2011 to total cumulative changes in gross export market shares (solid lines in all charts). These lines represent summary measures of a country's competitiveness whereby an increase marks rising competitiveness (i.e. gains in global market shares). As a first important observation, G7 countries lose market shares, while BRIC countries gain. This holds true for both, gross and value added market shares. As a second observation, the difference between

[9] The log-linear approximation of the VASF market share decomposition is described in Appendix, section A.3. Note that for computational reasons the sum of these contributions does not exactly correspond to changes in VASF market shares (as it should theoretically) due to the log-linear approximation and missing information on unit values.

changes in cumulative VASF and gross export market shares in final goods is surprisingly small.[10]

However, we can still observe several interesting regularities. In some G7 countries (Canada, the UK and to a lesser extent the US) the difference between the two lines is more pronounced and VASF market share dynamics report smaller losses in competitiveness than suggested by conventional gross export market shares (see the third column in Charts 1 and 2). These countries show the strongest degree of outsourcing[11] among the G7-countries in our data in 2011; also Canada and the UK show a pronounced decrease in the share of directly exported goods over the observation period.[12] Thus, the better performance in value added terms can be attributed to the outsourcing of final production stages to other countries and is in line with evidence that these countries move upstream along the value chain, away from the final consumer (see De Backer and Miroudot, 2013). In line with their lower degree of outsourcing, the difference between VASF market shares and export market shares is marginal for other European G7 countries (France, Germany, Italy) and for Japan. It is further interesting to note that Germany performs slightly better in gross exports as compared to VASF market shares.

[Chart 1 approximately here]

[Chart 2 approximately here]

As for the BRIC countries, VASF market shares suggest smaller competitiveness gains for China and Brazil in the middle of the sample period as compared to gains in gross export market shares, whereas in 2011 cumulative gains in VASF terms matched or even outperformed cumulative gains in gross export terms. China is clearly the most downstream country in the entire sample in the sense that it shows the lowest degree of outsourcing –

[10] Note that this does not imply that gross export and VASF market shares are similar – in fact the level of gross export and VASF market shares differs significantly. Our results only suggest that both market shares exhibit similar dynamics.

[11] We calculate the degree of outsourcing as the ratio between value added embodied in domestic exports of final use products and total value added embodied in world exports of final use products. The decrease of this ratio implies that a country moves upstream in the global value chain and thus increases its indirect participation in the production (and export) of final use products.

[12] In 2011, the share of value added embodied in domestic exports of final use products was 67.2% of total value added of world exports of final use products for the UK, 70.9% for the US, 72.0% for Canada, 76.1% for Germany, 77.0% for France, 78.1% for Italy, and 79.3% for Japan. The largest decline between 1996 and 2011 was observed for Canada (12.7pp) and the UK (12.4pp).

almost 90% of Chinese VASF exports arise from final assembly in China[13] and China has gained enormous importance as a destination for final assembly by other exporters. Likewise, Germany appears to have gained importance as final assembly exporter – China and Germany are the only two partners featuring among the top-five destinations for indirect exports via foreign final assembly for all countries in our sample. Potentially this downstream movement in the production chain explains the worse performance of value added market shares compared to gross export market shares for Germany. For Brazil and even more so for Russia, VASF market share growth indicated considerably larger gains in competitiveness than gross export market share growth. Russia has by far the highest degree of outsourcing, only less than 30% of all exports are due to final assembly in the country in 2011, which is obvious given its export structure. Hence, the case of Russia is hard to analyse, as the main positive (indirect) contribution to this rise in competitiveness stems from exports of mineral products. Apart from the dominance of the oil price in driving this result, it also potentially reflects restructuring in Russia's oil industry which has moved away from selling (lower value added) crude oil towards exporting refined (and hence higher value added) oil products. According to Russian customs statistics, the share of oil products in Russian exports of oil and oil products has risen from 25% to 40% between 2003 and 2013 at the expense of the share of crude oil. However, the positive picture drawn here for the Russian economy may still be elusive, as there has been little restructuring in the rest of the economy (see also Robinson, 2011). The fact that the Russian economy remains highly concentrated on energy products is also reflected in falling world market shares in final products in our results.

[Chart 3 approximately here]

4.2. Contributions to changes in value added export market shares

Our discussion so far suggests that the increasing international fragmentation of production matters strongly for a country's competitiveness. Let us now take a closer look at individual factors shaping VASF market share gains or losses in our sample. In general, price and non-price factors contribute most strongly to changes in both, gross export and VASF market shares. However, shifts in global production chains give a non-negligible positive contribution to the competitiveness of BRIC countries (see Chart 3, column 2), while their

[13] In 2011, the share of value added embodied in domestic exports of final use products was 27.9% of total value added of world exports of final use products for Russia, 60.7% for Brazil, 73.7% for India, and 87.6% for China.

contribution is often negative for the G7 countries (France, Germany, Italy, Japan and the US since 2003, see Charts 1–2, column 2). In the case of developed countries, GVC-shifts show a positive contribution to competitiveness only for Canada as well as the UK during the pre-crisis period. By analysing the geographical location of the final assembly, we observe significant shifts from developed countries to China, especially in the following industries: radio, television and communication equipment, office machinery and computers, other machinery and equipment.[14] The same process is observed for Brazil and India, although the magnitude is much smaller. It is interesting to note a shift in the final assembly of motor vehicles from large European countries to the Czech Republic and Slovakia, as well as an increasing integration of motor vehicles production between European G7 countries. We also see the increasing role of Mexico as a final assembly for US value added; similarly, the data show an increasing role of Korea for value added from Japan. However, one should not get an impression that emerging countries increase their presence only at the final stage of the production chain – the process of integration has many dimensions, although with different intensity. For example, China gains greater importance as a provider of intermediate inputs for radio, television and communication equipment assembled in Mexico and Korea, while India increases its value added by participating in television and communication equipment, as well as office machinery and computers made in China.

4.3. Determinants of competitiveness for BRICs

The analysis of other factors also gives useful insights into the implications of fragmentation in production for measuring competitiveness. If we focus on gross export market shares for BRIC countries (see Chart 3, column 1), the main common feature is an increase in non-price factors relative to their competitors. China enjoys the most pronounced increase in non-price competitiveness, which is in line with conclusions from other researchers (see e.g. Pula and Santabárbara, 2011, Fu et al., 2012). Price-competitiveness also has a positive, although secondary role in skyrocketing China's gross export market share. We also observe smaller, but still positive non-price competitiveness gains for India. Results for Brazil show a dominant contribution of price and cost factors before 2003, while non-price competitiveness improves afterwards. Growing oil prices negatively affect Russia's price competitiveness,

[14] Detailed results for product groups are available upon request

while this is the only BRIC country for which we do not observe strong gains in non-price competitiveness with respect to final goods gross exports.[15]

The story changes significantly when GVCs enter the analysis (see Chart 3, columns 2 and 3). The huge VASF markets share gains of China are still positively affected by non-price factors, but the size of the contribution reduces dramatically and two thirds of gains are driven by price and costs factors. As regards other BRIC countries, the non-price competitiveness does not play any positive role now (with the exception of India, where we see a positive trend since 2004). The third column of Chart 3 shows that analyses based on conventional gross trade flows overestimate non-price competitiveness gains of BRICs. Thus, the improvement in quality or consumer valuation of export products from in emerging economies arose mainly from the outsourcing of higher-quality production stages rather than from improvements in domestic production. At the same time we observe that the contribution of price and cost factors to market share gains is underestimated when the international fragmentation of production is ignored.

These findings conflict with Bems and Johnson (2012) and Bayoumi et al. (2013), who report a higher appreciation for China when using REER in Tasks and REER in Goods.[16] This outcome, however, is mostly driven by the fact they compare their modified REER indices (based on GDP deflators) with traditional CPI-based REERs (as mentioned above). As noted by Bems and Johnson (2012), the difference between CPI and GDP deflators can be decomposed into the difference between value added versus gross output prices on the one hand (reflecting the change in the concept from gross to value added trade) and difference between gross output prices and consumer prices on the other hand (simply reflecting an approximation error, as the CPI is usually chosen for pragmatic rather than economic reasons). While this decomposition cannot be done for China, we observe from their results that the second component dominates in the case of Germany, the UK, as well as Japan and the US before 2005 (see Bems and Johnson, 2012, Figure 3). Moreover, the "REER in Tasks" for China appreciates more strongly again because of the difference between CPI and GDP deflators, while the change in weighting structure by itself implies a lower appreciation (see Bems and Johnson, 2012, Figure 3). Thus, our results do not contradict the findings of Bems and Johnson (2012) and Bayoumi et al. (2013), but rather emphasize the importance of an

[15] Ahrend (2006) concludes that competitiveness gains of Russia are concentrated in narrowed sectors of raw commodities. This may explain the bad performance in exports of final use products which we observe here.

[16] More specifically, Bems and Johnson (2012) report that China's value-added REER appreciated by 20pp more than the traditional REER between 2000 and 2009. Bayoumi et al. (2013) also claim higher appreciation, although the difference with conventional REER is smaller.

appropriate benchmark for comparisons. Unteroberdoerster et al. (2011) follow Thorbecke (2011) and calculate a so-called "integrated effective exchange rate (IEER)" to take account of vertical linkages. They use same price indices for REER and IEER, which makes their outcome more transparent and comparable to ours. Unteroberdoerster et al. (2011) find that the IEER for China appreciated more slowly in recent years than the traditional REER, confirming our results in Chart 3.

4.4. Determinants of competitiveness for G7

Results for the G7 countries broadly mirror those for the BRIC economies (see Charts 1 and 2). Gross trade data suggest losses in market shares for final use products. Most of these losses in gross export market shares arise from non-price factors (except for Canada), while prices and costs are of secondary importance (although the negative contribution appears sizeable for Italy, Canada and the US). In other words, developed countries are confronted by a decline in the relative quality of or consumers' valuation for their exports.[17] These losses become much smaller when market shares are calculated in value added terms. The reason is that developed countries indirectly contribute to the production of high-quality products in developing countries. The most striking cases are Canada, the UK and the US that show no changes or even a moderate increase in relative quality of their domestic production. We found only two exceptions among G7 members – France and Italy – that experienced worse non-price competitiveness performance in value added terms. As to price competitiveness, we reveal more pronounced market share losses due to price and cost factors for G7 countries when the value added concept is used. Again, these results seemingly contradict Bems and Johnson (2012) and Bayoumi et al. (2013), who report better price competitiveness dynamics for the US and Germany. But again these adjustments in assessment are mostly due to the switch from CPI to GDP deflator, while the isolated effect of changes from gross to value-added weights gives the opposite outcome for the US and suggests almost no changes for Germany (see Bems and Johnson, 2012, Figure 3).

5 Conclusions

We condense various aspects of competitiveness, including the influence of international fragmentation, into one comprehensive measure. Our analysis accounts on the one hand for

[17] Please note that we only capture dynamics here and cannot make any statement about the ordering of absolute quality of goods produced by G7 versus BRICs. Thus, in absolute terms we still expect a sizeable "quality gap" to prevail between G7 and BRIC exports on average.

non-price factors (such as changes in the quality of exported products or consumer tastes) and on the other hand corrects for differences and changes in the value added content of trade. We combine two datasets – highly disaggregated trade data from UN Comtrade with internationally integrated Supply and Use Tables from the WIOD – in order to depart from the narrow definition of competitiveness (that limits to a country's ability to maximise gross exports).

Changing the focus from traditional gross to value added export market shares does not alter the general picture much – developing countries are still gaining market shares at the expense of advanced economies. But the inclusion of international fragmentation alters the underlying story to quite some extent which carries important policy implications. Our results show that the global production process is gradually shifting toward developing countries, thus outsourcing as such is contributing positively to market share changes (in value added terms) in the BRIC countries and is thus eroding G7 countries' competitiveness.

However, the underlying story changes. In the traditional view (based on gross exports), G7 appear to be loosing non-price competitiveness while BRICs show large gains in non-price factors. When we assess export strength in value added terms, these gains in non-price competitiveness by emerging market producers turn out to be smaller while their increased overall competitiveness relies to a larger extent on price factors and a positive impact from shifts in global value chains. In other words, the higher degree of outsourcing of production by advanced economies to emerging markets improves competitiveness of the latter. Apart from the BRIC countries, also Canada shows a clear competitiveness gain from increased integration into GVCs which is likely related to its position in the NAFTA supply chain.

With respect to price and non-price factors – the two main determinants of competitiveness gains and losses – we find that all BRICs have increased their price competitiveness but so have France, Germany and Italy. More importantly, our GVC-adjusted measure of price competitiveness indicate higher price competitiveness gains for the BRIC countries, France and Italy compared to the conventional approach, while we find a more negative impact from price and cost factors for Canada, the UK and the US. The findings by Bems and Johnson (2012) and Bayoumi et al. (2013) seemingly contradict our conclusions, but the gap between their REER in Tasks/Goods and the conventional REER is mostly due to shift from CPI to GDP deflator. The sole adjustment of weights according to value added concept changes the assessment of price competitiveness for China and the US in line with our results. Also Unteroberdoerster et al. (2011) confirms a lower real appreciation for China when adjusting for the effect of vertical linkages.

Accordingly, we also observe that the catching-up process of emerging countries in terms of the quality of their goods (including consumers' valuation, i.e. the effect of non-price factors in general) proceeds more slowly after accounting for GVCs than gross exports would suggest. Hence, an analysis based on gross exports overemphasizes the role of non-price factors in competitiveness gains of the BRIC countries. Our results also show that non-price competitiveness losses of developed countries are in fact lower than claimed before, as they remain important suppliers of high quality intermediates in fragmented production lines. In particular, Canada, Germany, the UK and the US are well able to the keep relative quality of their produced goods unchanged. Only Italy poses an exception to this trend, as its non-price competitiveness shows an even stronger decline in value added than in gross terms. Thus, we are now able to answer our initial question: to what extent has the growing importance of global value chains changed our view on China's competitiveness? Surprisingly, not much, but China seems to be an exception in this respect. For most countries, GVC integration alters the picture. It makes the traditional "loosers" (advanced exporters such as Germany, US, the UK or Canada) look better off in terms of non-price factors, while competitiveness gains of emerging economies such as Brazil, India and Russia are far less pronounced. After controlling for shifts in production chains one can observe that a stable or improving "quality" of Brazil's, Russia's and India's exports arises to a non-negligible extent from the outsourcing of higher-quality products rather than from improvements in the quality of their domestic production.

However, China's increase in competitiveness is striking regardless which view is chosen. Especially non-price competitiveness gains of China remain impressive even after accounting for the role of global value chains. Still, the phenomenon of "Made in China" plays an important role. Ignoring it also leads to a bias in our assessment of the factors underlying China's competitiveness. While we overestimate gains in Chinese non-price competitiveness when we restrict attention to gross exports, we also underestimate China's price competitiveness as well as the effect of foreign value added which is imported mostly from developed countries such as Germany.

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Appendix

A.1 Consumers utility function and import price index

We use a constant elasticity of substitution (CES) utility function for a representative household from importing country i consisting of three nests (similar to Broda and Weinstein, 2006):

$$U(i)_t = \left(D(i)_t^{\frac{\kappa(i)-1}{\kappa(i)}} + M(i)_t^{\frac{\kappa(i)-1}{\kappa(i)}} \right)^{\frac{\kappa(i)}{\kappa(i)-1}}, \quad \kappa(i) > 1, \tag{A1}$$

$$M(i)_t = \left(\sum_{g \in G} M(i)_{g,t}^{\frac{\gamma(i)-1}{\gamma(i)}} \right)^{\frac{\gamma(i)}{\gamma(i)-1}}, \quad \gamma(i) > 1, \tag{A2}$$

$$M(i)_{g,t} = \left(\sum_{c \in C} Q(i)_{gc,t}^{\frac{1}{\sigma(i)_g}} M(i)_{gc,t}^{\frac{\sigma(i)_g - 1}{\sigma(i)_g}} \right)^{\frac{\sigma(i)_g}{\sigma(i)_g - 1}}, \quad \sigma(i)_g > 1 \quad \forall \quad g \in G, \tag{A3}$$

where $D(i)_t$ is the domestic good, $M(i)_t$ is composite imports and $\kappa(i)$ is the elasticity of substitution between domestic and foreign goods, $M(i)_{g,t}$ is the subutility from consumption of imported good g, $\gamma(i)$ is elasticity of substitution among import goods, $Q(i)_{gc,t}$ is the taste and quality parameter, and $\sigma(i)_g$ is elasticity of substitution among varieties of good g.

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

$$P(i)_{g,t} = \left(\sum_{c \in C(i)_{g,t}} Q(i)_{gc,t} P(i)_{gc,t}^{1-\sigma(i)_g} \right)^{\frac{1}{1-\sigma(i)_g}}, \; P(i)_t = \left(\sum_{g \in G} P(i)_{g,t}^{1-\gamma(i)} \right)^{\frac{1}{1-\gamma(i)}} \tag{A4}$$

where $P(i)_{g,t}$ denotes minimum unit-cost of import good g, $P(i)_t$ is minimum unit-cost of total imports, and $C(i)_{g,t}$ is the subset of all varieties of goods consumed in period t. The import price index for a good g is defined as $\pi(i)_{g,t} = P(i)_{g,t}/P(i)_{g,t-1}$, while total import price index – as $\pi(i)_t = P(i)_t/P(i)_{t-1}$.

Benkovskis and Wörz (2014a) extend the work by Feenstra (1994) and Broda and Weinstein (2006) by relaxing the assumption of unchanged taste or quality. They introduce an import price index that adds a term to capture changes in taste and quality:

$$\pi(i)_{g,t} = \prod_{c \in C(i)_g} \pi(i)_{gc,t}^{w(i)_{gc,t}} \left(\frac{\lambda(i)_{g,t}}{\lambda(i)_{g,t-1}} \right)^{\frac{1}{\sigma(i)_g - 1}} \prod_{c \in C(i)_g} \left(\frac{Q(i)_{gc,t}}{Q(i)_{gc,t-1}} \right)^{\frac{w(i)_{gc,t}}{1-\sigma(i)_g}}, \quad \pi(i)_t = \prod_{g \in G} \pi(i)_{g,t}^{w(i)_{g,t}}, \tag{A5}$$

where $\pi(i)_{gc,t} = P(i)_{gc,t}/P(i)_{gc,t-1}$ and Sato-Vartia weights $w(i)_{gc,t}$ and $w(i)_{g,t}$ are computed using cost shares $s(i)^M{}_{gc,t}$ and $s(i)^M{}_{g,t}$ in the two periods as follows:

$$w(i)_{gc,t} = \frac{\left(s(i)^M_{gc,t} - s(i)^M_{gc,t-1}\right)/\left(\ln s(i)^M_{gc,t} - \ln s(i)^M_{gc,t-1}\right)}{\sum_{c\in C(i)_g}\left(\left(s(i)^M_{gc,t} - s(i)^M_{gc,t-1}\right)/\left(\ln s(i)^M_{gc,t} - \ln s(i)^M_{gc,t-1}\right)\right)}, \quad s(i)^M_{gc,t} = \frac{P(i)_{gc,t} M(i)_{gc,t}}{\sum_{c\in C(i)_g} P(i)_{gc,t} M(i)_{gc,t}},$$

$$w(i)_{g,t} = \frac{\left(s(i)^M_{g,t} - s(i)^M_{g,t-1}\right)/\left(\ln s(i)^M_{g,t} - \ln s(i)^M_{g,t-1}\right)}{\sum_{g\in G}\left(\left(s(i)^M_{g,t} - s(i)^M_{g,t-1}\right)/\left(\ln s(i)^M_{g,t} - \ln s(i)^M_{g,t-1}\right)\right)}, \quad s(i)^M_{g,t} = \frac{\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t}}{\sum_{g\in G}\sum_{c\in C(i)_g} P(i)_{gc,t} M(i)_{gc,t}},$$

while $\lambda(i)_{g,t}$ and $\lambda(i)_{g,t-1}$ are Feenstra's (1994) index accounting for changes in variety:

$$\lambda(i)_{g,t} = \frac{\sum_{c\in C(i)_g} P(i)_{gc,t} M(i)_{gc,t}}{\sum_{c\in C(i)_{g,t}} P(i)_{gc,t} M(i)_{gc,t}}, \quad \lambda(i)_{g,t-1} = \frac{\sum_{c\in C(i)_g} P(i)_{gc,t-1} M(i)_{gc,t-1}}{\sum_{c\in C(i)_{g,t-1}} P(i)_{gc,t-1} M(i)_{gc,t-1}}.$$

The important point to note is that the import price index (defined as a change in minimum unit costs) depends not only on prices (unit values), but also on non-price factors as a better quality or higher valuation by the consumer offsets for a higher price in terms of derived utility.

A.2. Decomposition of the intensive margin of value-added export market share changes

The share of country k's VASF exports in total imports of a country i, $IM(i)_{k,t}^{VASF}$, can be rearranged in the following way:

$$IM(i)^{VASF}_{k,t} = \frac{\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}}{\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t}} = \frac{\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}}{P(i)_t M(i)_t} = \tag{A6}$$

$$= \sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} \frac{P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}}{P(i)_{g,t} M(i)_{g,t}} \frac{P(i)_{g,t} M(i)_{g,t}}{P(i)_t M(i)_t}.$$

The first order conditions of the consumer utility maximization problem (A1)-(A3) s.t. budget constraints are the following:

$$M(i)_{gc,t} = Q(i)_{gc,t} P(i)_{gc,t}^{-\sigma(i)_g} M(i)_{g,t}^{1-\frac{\sigma(i)_g}{\gamma(i)}} U(i)_t^{\frac{\sigma(i)_g}{\kappa(i)}} M(i)_t^{\frac{\sigma(i)_g}{\gamma(i)} - \frac{\sigma(i)_g}{\kappa(i)}} \lambda(i)_t^{-\sigma(i)_g}, \tag{A7}$$

where $\lambda(i)_t$ is Lagrange multiplier. By rearranging and summing over c one can obtain the following expression:

$$M(i)_{g,t} = P(i)_{g,t}^{-\gamma(i)} U(i)_t^{-\frac{\gamma(i)}{\kappa(i)}} M(i)_t^{1-\frac{\gamma(i)}{\kappa(i)}} \lambda(i)_t^{\gamma(i)}. \tag{A8}$$

From (A6), (A7) and (A8) follows that country k's VASF exports share in total imports of a country i is driven by minimum unit-costs, taste and quality parameters and value-added share of country k in the production of various goods exported to destination market i:

$$IM(i)_{k,t}^{VASF} = \sum_{c\in C} \sum_{g\in G(i)_{c,t,t-1}} \frac{P(i)_{gc,t}^{1-\sigma(i)_g} Q(i)_{gc,t} V(k)_{gc,t}}{P(i)_{g,t}^{1-\sigma(i)_g}} \frac{P(i)_{g,t}^{1-\gamma(i)}}{P(i)_t^{1-\gamma(i)}}. \quad \text{(A9)}$$

Using the fact that $dIM(i)_{k,t}^{VASF} = IM(i)_{k,t}^{VASF} / IM(i)_{k,t-1}^{VASF}$:

$$dIM(i)_{k,t}^{VASF} = \sum_{c\in C} \sum_{g\in G(i)_{c,t,t-1}} w(k,i)_{gc,t}^{VASF} \frac{P(i)_{gc,t}^{1-\sigma(i)_g} Q(i)_{gc,t} V(k)_{gc,t}}{P(i)_{gc,t-1}^{1-\sigma(i)_g} Q(i)_{gc,t-1} V(k)_{gc,t-1}} \frac{\pi(i)_{g,t}^{1-\gamma(i)}}{\pi(i)_{g,t}^{1-\sigma(i)_g} \pi(i)_t^{1-\gamma(i)}}, \quad \text{(A10)}$$

$$w(k,i)_{gc,t}^{VASF} = \frac{P(i)_{gc,t-1} M(i)_{gc,t-1} V(k)_{gc,t-1}}{\sum_{g\in G(i)_{c,t,t-1}} \sum_{c\in C} P(i)_{gc,t-1} M(i)_{gc,t-1} V(k)_{gc,t-1}}.$$

Combining (A10) with import price index in (A5), one can obtain VASF market share decomposition described in (6).

A.3. Log-linear approximation of VASF market share decomposition

The system of equations (4)-(7) has an unpleasant property as it is a combination of sums and multiplications. For empirical applications it is more convenient to work with a log-linear approximation of the VASF market share decomposition:[18]

$$dms_{k,t}^{VASF} \approx dem_{k,t}^{VASF} + pp_{k,t}^{VASF} + cc_{k,t}^{VASF} + qq_{k,t}^{VASF} + vv_{k,t}^{VASF} + ds_{k,t}, \quad \text{(A11)}$$

where log changes of country k's market shares changes ($dms_{k,t}^{VASF}$) are defined as

$$dms_{k,t}^{VASF} = \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}\right) - \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t-1} M(i)_{gc,t-1} V(k)_{gc,t-1}\right) - \quad \text{(A12)}$$
$$- \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t}\right) + \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t-1} M(i)_{gc,t-1}\right).$$

These are decomposed into six parts. The extensive margin of log changes of country k's market share changes, $dem_{k,t}^{VASF}$, is defined as:

$$dem_{k,t}^{VASF} = \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}\right) - \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t-1} M(i)_{gc,t-1} V(k)_{gc,t-1}\right) - \quad \text{(A13)}$$
$$- \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} P(i)_{gc,t} M(i)_{gc,t} V(k)_{gc,t}\right) + \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G(i)_{c,t,t-1}} P(i)_{gc,t-1} M(i)_{gc,t-1} V(k)_{gc,t-1}\right).$$

The intensive margin is decomposed into the remaining five components: First, the contribution of shifts in global demand structure to market shares' log changes, $ds_{k,t}$:

[18] We log-linearize around the constant steady state (no changes in volumes or prices between periods t and t–1). Although the log-linear approximation works well only for small changes, it is still valid in this application. First, we apply log-linear approximation for year-to-year changes in volumes or prices, which are much smaller than cumulated changes over a longer time period. Second, the results reported in Charts 1-3 show the adequacy of log-linear approximation for G7 and BRIC countries as the sum of all components closely follows the log-changes in total market shares (it should be noted that missing unit values data induce large part of the discrepancy).

$$ds_{k,t} = \sum_{i \in I} \tilde{s}(i)^X_{k,t}\, ds(i)_t, \quad \text{(A24)}$$

$$ds(m)_t = \ln\left(\sum_{c \in C}\sum_{g \in G} P(m)_{gc,t} M(m)_{gc,t}\right) - \ln\left(\sum_{i \in I}\sum_{c \in C}\sum_{g \in G} P(i)_{gc,t} M(i)_{gc,t}\right) -$$

$$-\ln\left(\sum_{c \in C}\sum_{g \in G} P(m)_{gc,t-1} M(m)_{gc,t-1}\right) + \ln\left(\sum_{i \in I}\sum_{c \in C}\sum_{g \in G} P(i)_{gc,t-1} M(i)_{gc,t-1}\right).$$

Second, the price component of market shares' log changes, $pp_{k,t}^{VASF}$:

$$pp^{VASF}_{k,t} = \sum_{i \in I} \tilde{s}(i)^X_{k,t}\, pp(i)^{VASF}_{k,t}, \quad \text{(A15)}$$

$$pp(i)^{VASF}_{k,t} = \sum_{g \in G(i)_{c,y,y-1}} \sum_{c \in C} w(k,i)^{VASF}_{gc,t} \left((1-\sigma(i)_g)\ln\pi(i)_{gc,t} - (\gamma(i)-\sigma(i)_g) \sum_{m \in C(i)_j} w(i)_{gm,t} \ln\pi(i)_{gm,t} \right) -$$

$$-(1-\gamma(i)) \sum_{j \in G} \sum_{m \in C(i)_g} w(i)_{jm,t}\, w(i)_{j,t} \ln\pi(i)_{jm,t},$$

where weights $\tilde{s}(i)^X_{k,t}$ are defined as Tornquist shares of country k's export structure:

$\tilde{s}(i)^X_{k,t} = 0.5 s(i)^X_{k,t} + 0.5 s(i)^X_{k,t-1}$.

Third, the effect of a changing set of competitors for market shares' log changes, $cc_{k,t}^{VASF}$:

$$cc^{VASF}_{k,t} = \sum_{i \in I} \sum_{g \in G(i)_{c,y,y-1}} \sum_{c \in C} \tilde{s}(i)^X_{k,t}\, w(k,i)^{VASF}_{gc,t} \frac{\gamma(i)-\sigma(i)_g}{1-\sigma(i)_g} \left(\ln\lambda(i)_{g,t} - \ln\lambda(i)_{g,t-1}\right) + \quad \text{(A16)}$$

$$+ \sum_{i \in I} \tilde{s}(i)^X_{k,t}\, w(k,i)^{VASF}_{gc,t} \frac{(1-\gamma(i)) w(i)_{g,t}}{1-\sigma(i)_g} \sum_{j \in G} \left(\ln\lambda(i)_{j,t} - \ln\lambda(i)_{j,t-1}\right).$$

Fourth, the contribution of non-price factors for market shares' log changes, $qq_{k,t}^{VASF}$:

$$qq^{VASF}_{k,t} = \sum_{i \in I} \tilde{s}(i)^X_{k,t}\, qq(i)^{VASF}_{k,t}, \quad \text{(A17)}$$

$$qq(i)^{VASF}_{k,t} = \sum_{g \in G(i)_{c,y,y-1}} \sum_{c \in C} w(k,i)^{VASF}_{gc,t} \left(\ln\mu(i)_{gc,t} + \sigma(i)_g \ln\pi(i)_{gc,t} + (\gamma(i)-\sigma(i)_g) \sum_{m \in C(i)_j} w(i)_{gm,t} \ln\pi(i)_{gm,t} \right) -$$

$$- \sum_{j \in G} \sum_{m \in C(i)_g} w(i)_{jm,t}\, w(i)_{j,t} \ln\mu(i)_{jm,t} - \gamma(i) \sum_{j \in G} \sum_{m \in C(i)_g} w(i)_{jm,t}\, w(i)_{j,t} \ln\pi(i)_{jm,t} +$$

$$\left(\sum_{g \in G(i)_{c,y,y-1}} \sum_{c \in C} w(k,i)^{VASF}_{gc,t} \frac{\sigma(i)_g - \gamma(i)}{1-\sigma(i)_g} \left(\ln\lambda(i)_{g,t} - \ln\lambda(i)_{g,t-1}\right) + \frac{(\gamma(i)-\sigma(i)_g) w(i)_{g,t}}{1-\sigma(i)_g} \sum_{j \in G} \left(\ln\lambda(i)_{j,t} - \ln\lambda(i)_{j,t-1}\right) \right).$$

Fifth, shifts in global value chains and their implication for log changes in market shares, $vv_{k,t}^{VASF}$:

$$vv^{VASF}_{k,t} = \sum_{i \in I} \sum_{g \in G(i)_{c,y,y-1}} \sum_{c \in C} \tilde{s}(i)^X_{k,t}\, w(k,i)^{VASF}_{gc,t} \left(\ln V(k)_{gc,t} - \ln V(k)_{gc,t-1}\right). \quad \text{(A18)}$$

A.4. Elasticities of substitution between varieties

We estimate elasticities of substitution between varieties according to the methodology proposed by Feenstra (1994) and later applied by Broda and Weinstein (2006). To derive the elasticity of substitution, one needs to specify both demand and supply equations. The demand equation is defined by re-arranging the minimum unit-cost function in terms of market share, taking first differences and ratios to a reference country l:

$$\Delta \ln \frac{s(i)^M_{gc,t}}{s(i)^M_{gl,t}} = -\left(\sigma(i)_g - 1\right)\Delta \ln \frac{P(i)_{gc,t}}{P(i)_{gl,t}} + \varepsilon(i)_{gc,t}, \tag{A19}$$

where $\varepsilon(i)_{gc,t} = \Delta\ln Q(i)_{gc,t} + \xi(i)_{gc,t}$, and $\xi(i)_{gc,t}$ is an error term (due to e.g. measurement error) in the demand equation. Following Feenstra (1994) and Broda and Weinstein (2006) we treat $\varepsilon(i)_{gc,t}$ as an unobserved random variable, reflecting changes in the quality of product variables. Note, that $Q(i)_{gc,t}$ reflects fundamental characteristics of a particular variety and should be treated as exogenous.

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

$$\Delta \ln \frac{P(i)_{gc,t}}{P(i)_{gl,t}} = \frac{\omega(i)_g}{1+\omega(i)_g}\Delta \ln \frac{s(i)^M_{gc,t}}{s(i)^M_{gl,t}} + \delta(i)_{gc,t}, \tag{A20}$$

where $\omega(i)_g \geq 0$ is the inverse supply elasticity assumed to be the same across partner countries, and $\delta(i)_{gc,t}$ is an error term of supply equation which is assumed to be independent of $\varepsilon(i)_{gc,t}$.

A nasty feature of the system of (A19) and (A20) is the absence of exogenous variables to identify and estimate elasticities. To get the estimates, we transform the system of two equations into a single equation by exploiting the insight of Leamer (1981) and the independence of errors $\varepsilon(i)_{gc,t}$ and $\delta(i)_{gc,t}$.[19] This is done by multiplying both sides of the equations. After transformation, the following equation is obtained:

$$\left(\Delta \ln \frac{P(i)_{gc,t}}{P(i)_{gl,t}}\right)^2 = \theta_1\left(\Delta \ln \frac{s(i)^M_{gc,t}}{s(i)^M_{gl,t}}\right)^2 + \theta_2\left(\Delta \ln \frac{P(i)_{gc,t}}{P(i)_{gl,t}}\right)\left(\Delta \ln \frac{s(i)^M_{gc,t}}{s(i)^M_{gl,t}}\right) + u(i)_{gc,t}, \tag{A21}$$

$$\theta_1 = \frac{\omega(i)_g}{\left(1+\omega(i)_g\right)\left(\sigma(i)_g - 1\right)},\quad \theta_2 = \frac{1-\omega(i)_g\left(\sigma(i)_g - 2\right)}{\left(1+\omega(i)_g\right)\left(\sigma(i)_g - 1\right)},\quad u(i)_{gc,t} = \varepsilon(i)_{gc,t}\,\delta(i)_{gc,t}.$$

Note 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 $u(i)_{gc,t}$. Broda and Weinstein (2006) argue

[19] The independence assumption relies on the assumption that taste and quality does not enter the residual of the relative supply equation ($\delta(i)_{gc,t}$). If this does not hold, then errors are not independent, since changes in taste and quality enter $\varepsilon(i)_{gc,t}$. The assumption of the irrelevance for the supply function seems realistic for taste (if we ignore the possibility that taste is manipulated by advertisement; however, advertisement costs can be viewed as fixed, which should reduce the correlation with the error term). But it is difficult to argue that changes in physical quality of a product should not affect the $\delta(i)_{gc,t}$. The empirical literature did not address this issue until now and the size of induced bias is unclear.

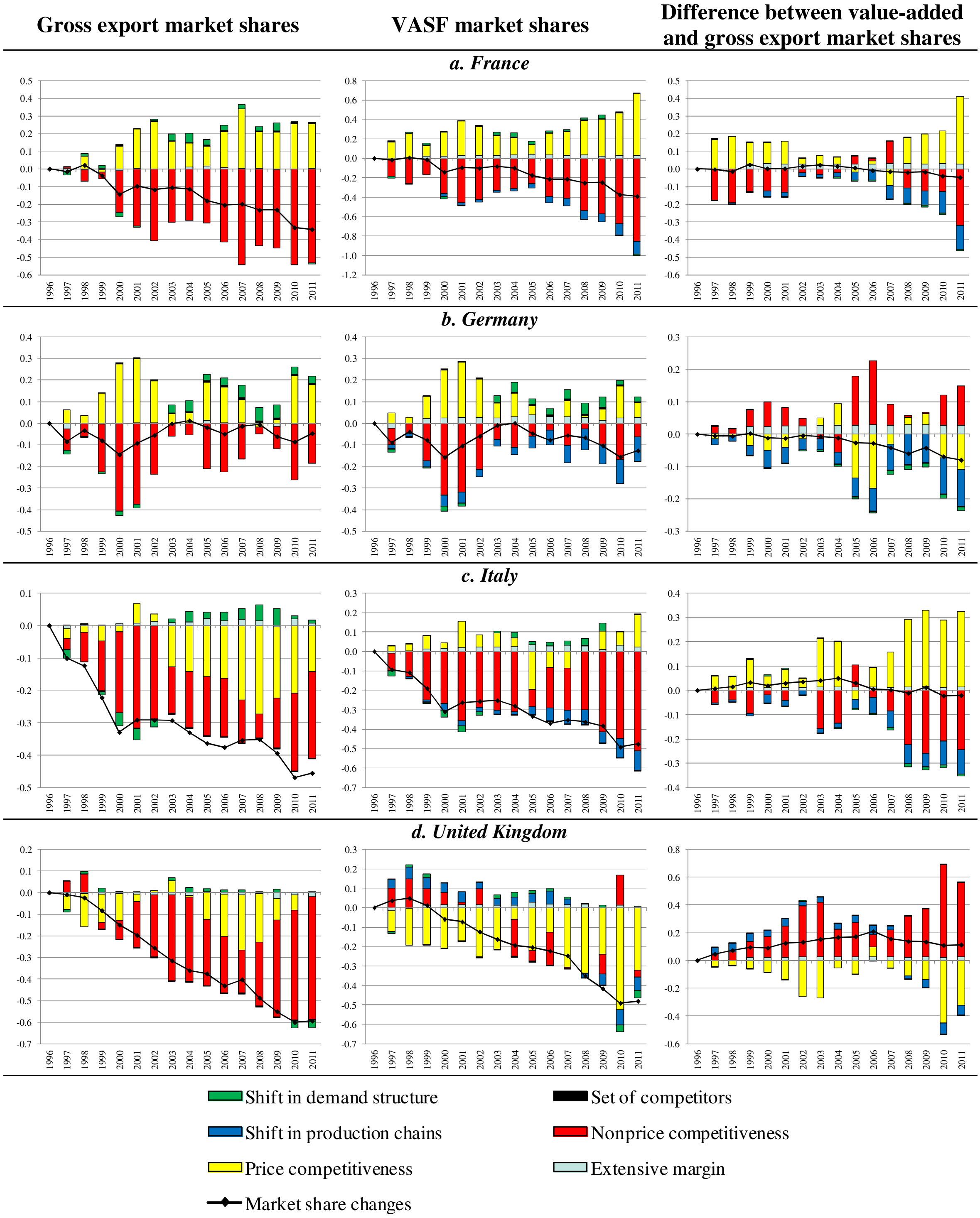
that it is possible to obtain consistent estimates by exploiting the panel nature of data and define a set of moment conditions for each good *g*. If estimates of elasticities are imaginary or of the wrong sign the grid search procedure is implemented. Broda and Weinsten (2006) also address the problem of measurement error and heteroskedasticity by adding a term inversely related to the quantity and weighting the data according to the amount of trading flows. A recent papers by Soderbery (2010, 2012), however, reports that this methodology generates severely biased elasticity estimates (median elasticity of substitution is overestimated by over 35%). Soderbery (2010, 2012) proposes the use of a Limited Information Maximum Likelihood (LIML) estimator instead. Where estimates of elasticities are not feasible ($\hat{\theta}_1$<0), nonlinear constrained LIML is implemented. Monte Carlo analysis performed by Soderbery (2010, 2012) demonstrates that this hybrid estimator corrects small sample biases and constrained search inefficiencies. It further shows that Feenstra's (1994) original method of controlling measurement error with a constant and correcting for heteroskedasticity by the inverse of the estimated residuals performs well. We thus follow Soderbery (2010, 2012) and use hybrid estimator combining LIML with a constrained nonlinear LIML to estimate elasticities of substitution between varieties using the Feenstra's (1994) method.

Table A.1. Elasticities of substitution between varieties for final use products (top 20 importers)

	No. of estimated elasticities	Mean	Minimum	Maximum	25th percentile	**Median**	75th percentile
United States	1526	53.5	1.0213	50285	1.68	**2.38**	4.04
China	1434	159.1	1.0148	88817	2.14	**3.06**	5.35
Germany	1740	9.7	1.0297	1129	2.29	**3.45**	6.06
Japan	1621	32.4	1.0150	38064	1.90	**2.88**	5.17
United Kingdom	1827	4.8	1.0119	283	1.79	**2.55**	4.47
France	1786	149.2	1.0279	99102	1.98	**2.97**	5.16
Hong Kong (China)	1430	86.3	1.0039	75700	1.93	**3.02**	5.56
Korea	1574	92.5	1.0531	64247	2.20	**3.31**	5.90
Netherlands	1658	7.1	1.0012	835	1.88	**2.67**	4.57
Italy	1810	25.9	1.0151	17338	1.92	**2.88**	4.95
India	1254	108.9	1.0421	83948	2.14	**3.10**	5.44
Canada	1322	70.7	1.0013	55515	2.26	**3.50**	6.53
Belgium	1045	84.9	1.0943	79794	2.32	**3.35**	5.99
Singapore	1243	68.9	1.0630	26099	1.95	**2.91**	4.99
Mexico	1343	55.7	1.0582	22629	1.77	**2.66**	4.74
Spain	1796	44.0	1.0273	64044	2.04	**2.95**	5.02
Russia	1611	119.7	1.0600	88274	2.31	**3.58**	6.85
Australia	1127	127.9	1.0747	51655	1.74	**2.56**	4.80
Thailand	1049	7.8	1.0583	1231	2.05	**2.98**	5.12
Turkey	1507	14.9	1.0911	8350	2.18	**3.12**	4.99

Note: Calculated using UN Comtrade data for disaggregated imports of 191 countries using equation (A26). The estimates are based on data between 1996 and 2012 for 238 exporters.

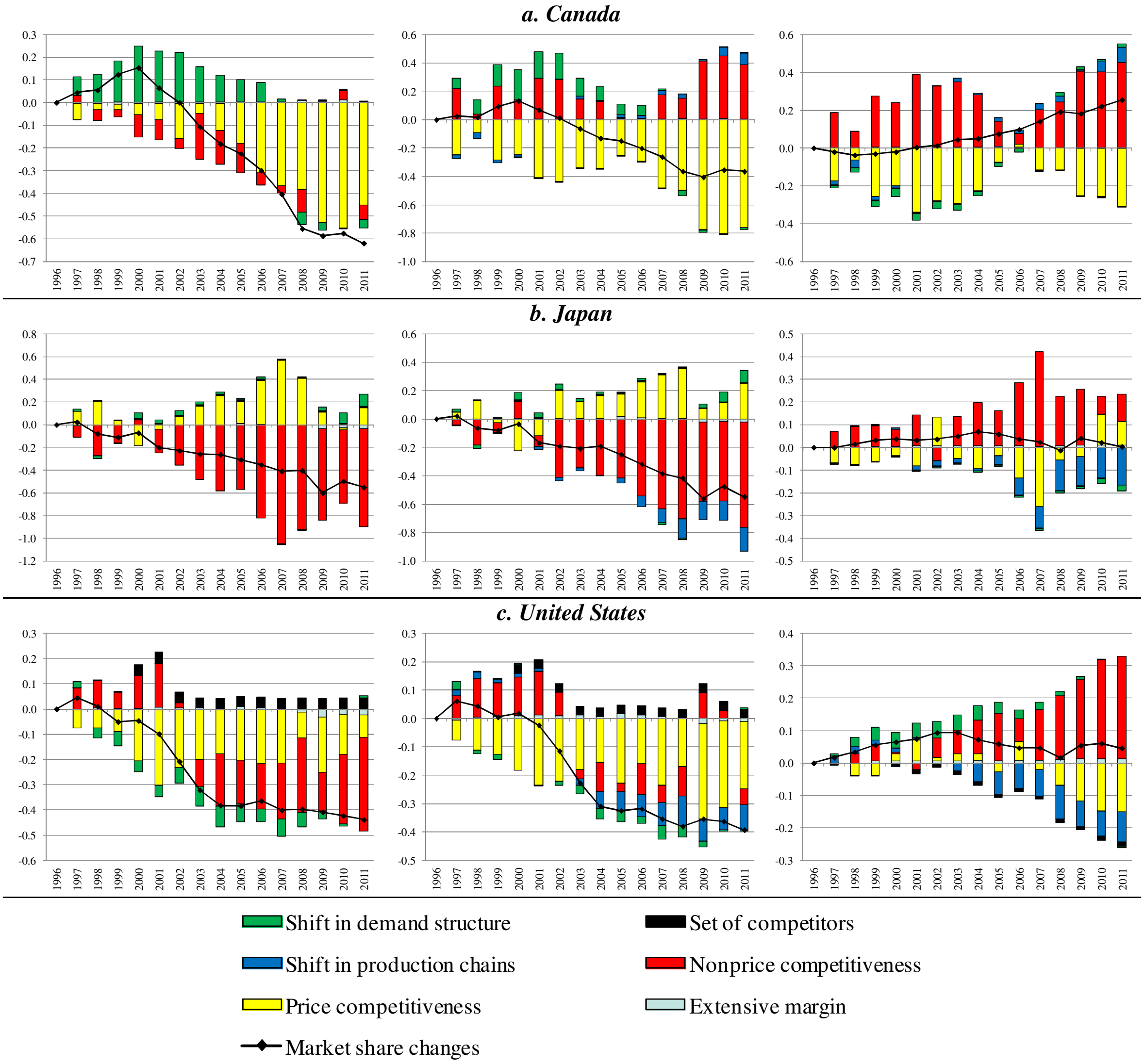
Chart 1. Decomposition of gross exports and value-added in gross exports market share changes of final use products for European G7 countries



Source: WIOD, UN Comtrade, authors' calculations

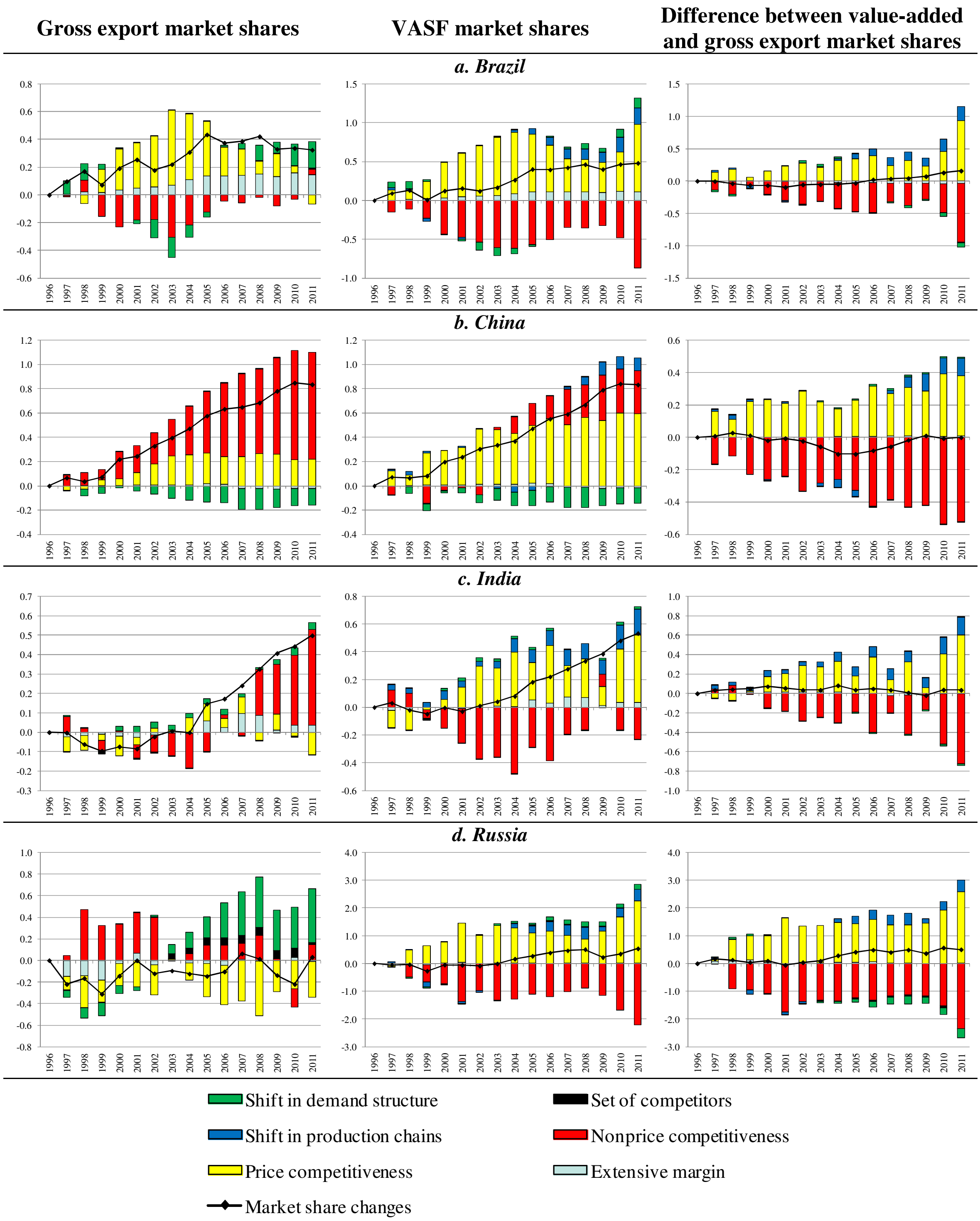
Chart 2. Decomposition of gross exports and value-added in gross exports market share changes of final use products for non-European G7 countries

Gross export market shares	VASF market shares	Difference between value-added and gross export market shares



Source: WIOD, UN Comtrade, authors' calculations

Chart 3. Decomposition of gross exports and value-added in gross exports market share changes of final use products for BRIC countries



Source: WIOD, UN Comtrade, authors' calculations

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The OeNB offers a stimulating and professional research environment in close proximity to the policymaking process. Visiting researchers are expected to collaborate with the OeNB's research staff on a prespecified topic and to participate actively in the department's internal seminars and other research activities. They will be provided with accommodation on demand and will, as a rule, have access to the department's computer resources. Their research output may be published in one of the department's publication outlets or as an OeNB Working Paper. Research visits should ideally last between 3 and 6 months, but timing is flexible.

Applications (in English) should include

- a curriculum vitae,
- a research proposal that motivates and clearly describes the envisaged research project,
- an indication of the period envisaged for the research visit, and
- information on previous scientific work.

Applications for 2014 should be e-mailed to *eva.gehringer-wasserbauer@oenb.at* by November 1, 2014.

Applicants will be notified of the jury's decision by mid-December. The following round of applications will close on May 1, 2015.