Two Tales of the China Shock: Divergence and Convergence of Export Paths Between the United States and Germany in the 21st century

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Abstract:

The rapid expansion of international trade during the 2000s shifted the global composition of industrial production and fractured the historical dominance of large, high-wage countries. These shifts on the global stage had significant and well-documented consequences for local economies of traditional exporters. However, the effects were felt very differently by some industrialized countries than others. Two polar examples were the United States - losing a quarter of its global export share between 1995 and 2007 - and Germany - losing only 6%. Starting with very different level, this changed in the 2010 with Germany experiencing a slightly stronger loss than the United States. In this paper, we study the sources of export growth to understand why these two countries were impacted so differently by the rise of China both in the level and the timing of changes using a new decomposition framework that distinguishes between export growth driven by changes in the product and destination country composition of global trade, and changes in competitiveness. Using international trade data, we apply our framework to study why the export growth of Germany and of the US diverged during the 2000s, and why German exports stagnated while US exports rebounded after the financial crisis. We find that, during the 2000s, differences in competitiveness through increasing quality of Germany exports were the main driver of export growth differences, while changes in trade patterns across products and world regions fueled the resurgence of US exports but accounted for most of the stagnation of German exports after the financial crisis.

JEL Codes: F16, F66, J23, J24, L15

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1 Introduction

The first decade of this century witnessed substantial growth in global trade volumes. In real terms, world exports more than doubled between 1995 and 2007, growing at twice the rate of global GDP (see Figure 1). After the Great Recession, trade growth slowed significantly, with world exports rising by just 8.4% between 2010 and 2019 and thus falling behind the global GDP growth of 13.3%. Finally, during the last half decade from 2019 until 2023 global trade grew by merely 3.1%, on par with GDP growth. This pattern of rapid trade expansion up to 2007, followed by slower growth in the 2010s, led to significant shifts in export market shares. The five largest exporters in 1995—the United States, Germany, Japan, France, and the United Kingdom—historically dominant in global trade – saw their combined export market share decline from 43.5% in 1995 to 27.5% by 2019. The US alone saw a decrease in market share by 3.7 percentage points (30.3% of their baseline market share). These declines were largely offset by the rise of China, whose share increased by 12.3 percentage points, and Eastern Europe, which gained 3.8 percentage points.

This dramatic shift was particularly felt in the United States, resulting in accelerated deindustrialization and higher unemployment in affected regions (Autor, Dorn, and Hanson, 2013).[2] In stark contrast, Germany experienced a much smaller decline in global market share falling from 10.9% in 1995 to 8.9% in 2019 while maintaining a significantly larger manufacturing sector. As a result, the effects of globalization were felt very differently in Germany than in the U.S., with the strong export sector more than compensating for the negative employment impacts of import competition (see Dauth et al., 2014). This raises two key questions: Why did these two countries respond so differently to the rise of China (and Eastern Europe) as global competitors in the 2000s? And why did the responses change after the financial crisis when the U.S. experienced some resurgence while the global share of Germany continued to fall. And a third question we touch upon is how these trends continue in the 2020s post Covid, arguably a period of deglobalization also due to increasing geopolitical tensions.

[2] It also led to political polarization and growing anti-globalization sentiment (Autor et al., 2020; Colantone and Stanig, 2018; Foliano and Riley, 2017; Malgouyres, 2017), as well as adverse health effects (Adda and Fawaz, 2020; Autor et al., 2019).

This paper addresses these very issues. We provide novel evidence explaining why these developments had different consequences for Germany on the one hand and the United States on the other. In the first step, our analysis investigates the sources of trade growth to understand whether the decline in global market shares for traditional exporters was driven by exporter-specific competitiveness factors or by compositional changes in international trade across industries and destination countries. We consider three potential reasons for changes in an exporter's global market share over time. First, some destination countries may grow faster than others, leading to changes in the geographical distribution of import demand. This would affect exporting countries differently, depending on their existing trade relationships. Second, global preferences over products may shift, resulting in changes towards or away from an exporter's initial product portfolio. Third, the attractiveness of an exporter's product variety may decline relative to competing varieties, causing a shift in market shares among exporters of the same product in a given destination. We consider these as changes in *competitiveness*.

To quantify the contribution of each of these three sources to changes in aggregate national trade growth, we propose a novel decomposition framework centered around local product markets. We argue that trade changes between markets are common to all exporters within the same market and therefore only affect individual exporters through their initial exposure to the market.[3] In contrast, changes in trade that occur within a given market are specific to each exporter and therefore directly speak to how their competitiveness changes in that market.

We distinguish between two types of compositional (between market) changes. First, across products, such as those driven by shifting global consumer preferences over products. Second, across destinations, which may result from factors like shifting relative income levels between importing countries. Our central measures of these patterns are market sizes, defined as the total trade volume of a specific product or for a specific market. Changes in market size reflect shifts in trade between products or markets. The central measures of competitiveness are *market shares*, defined as the proportion of trade within each market that is supplied by a specific exporter.

Using bilateral trade data that includes highly disaggregated product categories for the period 2000–2023, we apply our decomposition framework to analyze the decadal aggregate trade growth

[3] We define as a *market* all international trade of the same product to a given importing country, i.e. a product-destination pair.

of the US and Germany as two polar examples of traditionally exporting countries with vastly different experiences during the two and a half decades in our study.

We demonstrate that declining competitiveness was the primary cause of the fall in the United States' global market share in the 2000s. Between 2000 and 2007, reduced competitiveness accounted for 63% (3.86 percentage points) of the decline in the US's global market share. Germany too experienced a decline in competitiveness but to a much lesser degree, lowering its global market share by only 18% during the same period. As a result, diverging competitiveness emerged as the main driver behind the divergence in aggregate trade trends between the two countries, explaining 47.4% of the total difference in trade growth. This suggests that, while Germany's competitiveness declined between 2000 and 2007, the extent of this decline was modest compared to the sharp fall in US competitiveness, and this divergence accounts for nearly half of the disparity in export performance during the 2000s. In contrast, compositional changes played only a smaller role in Germany and the US.

In the second period (2007-2019), we demonstrate a convergence in trade growth between Germany and the US, but the underlying drivers of these patterns diverged fundamentally. Deteriorating competitiveness remains the primary cause of the United States's falling global market share, accounting for 229% of aggregate trade growth between 2007 and 2019, even as the country benefited from favorable changes in the composition of global trade.[4] In stark contrast, the slowdown in German trade growth during this period was driven by a combination of adverse changes in the composition of global trade across products and destinations that jointly explain 46.5% of the decline in Germany's aggregate global market share and declining competitiveness on the other, that explains the remaining 53.5%. An important reason was that between 2007 and 2019, the geographical distribution of demand shifted away from Europe, where German exporters initially had strong trade ties, to East and Southeast Asia, where relative income levels rose rapidly during this period. Consequently, compositional changes between markets alone account for 34.8% of the fall of Germany's global market share between 2007 and 2019.

Next, we examine the underlying mechanisms behind changes in competitiveness, which can arise from three factors: decreasing prices while maintaining quality, improving the relative

[4] These numbers are large because compositional changes and competitiveness factors operate in opposite directions, and the aggregate change is thus relatively small.

quality (compared to other competitors) of the existing product portfolio, or shifting the product portfolio towards initially higher-quality products. Existing methods for measuring quality either cannot be applied to disaggregated trade flow data (Hallak and Schott, 2007), rely on price instruments that are often unavailable (Khandelwal, 2010), or impose overly restrictive assumptions on consumer preferences across industries (Khandelwal, Schott, and Wei, 2013).

To address these limitations, we adopt a demand-side approach that identifies latent product quality according to how it is valued by consumers in the destination countries. We assume a nested CES (constant elasticity of substitution) structure for consumer preferences which allows for different substitution patterns between varieties of the same product category (e.g., substituting between Japanese and US cars) than between varieties of different categories (e.g., substituting between cars and suits). Our method extends the approach of Khandelwal, Schott, and Wei (2013), who used a simpler CES framework with a single elasticity of substitution governing demand across all varieties. By introducing market-level nests into the CES demand structure, we apply a distinct elasticity of substitution for each product using estimates from Soderbery (2015) for product-specific CES elasticities. This enables us to estimate the quality of every variety relative to the average quality within the same market. Conceptually, this quality measure captures the residual demand for a variety that cannot be explained by its relative price, given the product-specific elasticity of substitution between varieties. In CES demand systems, this residual demand can be interpreted as a demand shifter or taste shock. Following the literature on product quality in international trade (Khandelwal (2010); Manova & Zhang (2012); Khandelwal, Schott, and Wei (2013), Amiti and Khandelwal (2013); Fan, Li, and Yeaple (2015); Manova and Yu (2017)), we attribute this residual to (relative) product quality (or product appeal) as valued by the consumers.

Using this measure, we document trends in average product quality over time. To determine whether changes in average quality stem from improvements within the initial product mix or from shifts in the export portfolio composition toward higher-quality products, we decompose changes in average product quality for each exporter into within-product and between-product effects.

Our findings reveal that the superior competitiveness of German exporters (compared with the US) was driven primarily by increases in *relative* product quality rather than price reductions. Between 2000 and 2007, the average relative quality of German export goods increased significantly, by 0.234 log points (+26.4%), while the average *relative* quality of US exports

declined by 0.174 log points (-16%) over the same period. Additionally, we find that the rise in relative average product quality for German exports during this time was primarily due to quality improvements within the initial product portfolio, with changes in the composition of the product portfolio playing a negligible role. In contrast, the US experienced a deterioration in the relative quality of its initial product portfolio. Again, compositional changes contributed minimally to this change.

Regarding prices, we find that German exports became significantly more expensive, with prices rising by 0.058 log points (+6%) relative to average market prices, while relative prices of US exports remained roughly the same and only increased by 0.008 log points (+0.8%). These findings challenge the common narrative that Germany's export success during the 2000s was primarily driven by declining labor costs (Tilford, 2010; Bofinger, 2015; Fadinger, Herkenhoff, and Schymik, 2024). If lower labor costs had been the key driver, we would expect the relative prices of German exports to decrease, while product quality would remain unchanged—or potentially decline if lower wages were associated with reduced skill levels.

Between 2007 and 2019, the aggregate trends in product quality for both countries converged: the relative average quality of US exports increased by 0.25 log points, while the relative average quality of German exports rose by 0.27 log points. Moreover, the driving forces behind these trends became more aligned. In contrast to the earlier period, Germany's average product quality during the 2010s increased mainly due to shifts in export composition toward products that initially had higher quality, with a smaller contribution from improvements in the initial product mix. Similarly, the US moderately improved the quality of its initial product portfolio during this period but was particularly successful in shifting export activity towards higher-quality products.

This paper contributes to several strands of the literature. First, it adds to papers on the determinants of export success. New theories of trade emphasize the role of geography (Eaton & Kortum (2002); Bernard et al. (2003); Anderson (2011); Head & Mayer (2014)) and firm heterogeneity (Melitz (2003); Bernard et al. (2007); Helpman & Melitz (2008); Melitz & Ottaviano (2008); Bernard et al. (2012)), for explaining international trade patterns. In these models, exports grow either because of rising trade partner size, declining trade costs, or increasing firm productivity. Related empirical papers have focused on estimating the relationship of exports to

gravity forces, i.e. destination size and distance (see Head & Meyer (2014) for a review), trade policy, i.e. changes in tariffs, quotas, and non-tariff barriers (Topalova (2010); Autor, Dorn, and Hanson (2013) Pierce & Schott (2016); Dix-Carneiro & Kovak (2017); Utar (2018); Caliendo, Dvorkin and Parro (2019)), and the selection of firms into exporting (Bernard and Jensen (1995); Bernard et al. (2007); Freund & Pierola (2015), Bernard et al. (2018)). Other literature has proposed product quality as an additional important driver of export growth, through within-product specialization (Schott (2004)), quality-upgrading in developing countries to appeal to richer customers (Verhoogen (2008)), profit maximization in the face of non-homothetic demand (Feenstra & Romalis (2003)), increased demand for higher-quality inputs (Kugler & Verhoogen (2009); Kugler & Verhoogen (2012)), and as a strategy to avoid leap-frogging from low-wage countries (Thoenig & Verdier (2003); Khandelwal (2010)). We add to this literature by developing a novel and highly tractable decomposition framework that enables the distinction between compositional determinants and competitiveness in export performance and apply this framework to nationally aggregated bilateral product trade data. While we focus on explaining national export performance, our decomposition framework is, in principle, easily portable to more granular contexts, e.g., firm-specific trade, and can thus help understand the nature of firm heterogeneity and dynamics in export performance.

Second, we make a methodological contribution to the literature on the role of quality in international trade by proposing an extension to measuring product quality from observable trade price and -volume information. Existing methods either require exporter-specific price instruments that are uncorrelated with product quality (Khandelwal (2010)) or impose strong restrictions on consumers' substitution patterns that are usually only applicable when studying a single, narrow industry (Khandelwal, Schott, and Wei (2013), henceforth KSW). Price instruments that vary across exporters, destinations, products, and time are rare and typically only recorded for a handful of importing countries. Imposing symmetric substitution between *all* varieties, irrespective of the product category they belong to, is unlikely to represent consumer preferences well in a context with many industries. Thus, existing methods are not easily applicable to more general contexts. We add to this literature by proposing an extension to the approach introduced by KSW that allows for richer patterns of substitution. Like KSW, our measurement approach builds on a CES-structure of consumer demand where pre-estimated elasticities of substitution parameterize a structural relationship between prices and residual demand of each exporter. Relative to KSW, however, we

allow for much richer substitution patterns by introducing market-level nests with product-specific elasticities of substitution governing the nest-specific demand patterns. Our method is thus well suited to estimate exporter-specific product quality in the context of many industries and the absence of price instruments.

Third, our paper relates to a broader literature on the 'Rise of the East' and its consequences for industrialized economies. An extensive literature documents the effects of global changes in trade patterns on local labor markets (Autor, Dorn, and Hanson (2013); Dauth, Findeisen, and Suedekum (2014); Foliano and Riley (2017); Malgouyres (2017), Branstetter et al. (2019), Caliendo, Dvorkin, and Parro (2019)). This literature widely agrees that the increasing competition from China and Eastern Europe's rapidly growing economies negatively affected labor demand in advanced economies both in the tradable and non-tradable sectors. However, the literature finds substantial heterogeneity in the aggregate effect size of the 'rise of the East' on local labor markets in absolute terms. In some contexts, e.g., Germany (see Dauth, Findeisen, and Suedekum (2014)), it even documents negative competition effects being more than offset by positive export demand effects. We contribute to this literature by providing insights into the origins of this heterogeneity across advanced economics. We find that during the 2000s, the prime period of the 'China shock,' differences in competitiveness were the main reason for differential export performance between the US and Germany, driven, in turn, mainly by different responses to increasing low-wage competition: while the US attempted to become more competitive on price, German exporters even raised prices, but were able to improve the quality of their products and remain highly differentiated from Chinese competitors. Our findings emphasize the importance of product quality for sustainable success in global export markets, even in the face of rising competition from low-wage competitors.

Lastly, our paper also makes important contributions to economic policy. Policymakers in most industrialized countries have been trying to find solutions to protect workers from the detrimental effects globalization has had on them. Under Trump's first presidency, the US started a trade war in 2018, first with China and later with other countries, by raising tariffs on a variety of products to revive the American manufacturing sector. Fueled by a similar anti-globalization sentiment, the exit of the United Kingdom from the European Union has unraveled the deep integration with the world's largest export and import region in 2021. In more recent years, a revival of industrial policy in the United States, China, Europe, and many other parts of the world

has implicitly raised trade costs and thus created incentives to localize production. Given the sustained decline in manufacturing sectors and global export market shares of most rich economies, the success of these attempts has been limited so far.

Understanding the nature of traditional exporters' declining export market shares matters therefore greatly for economic policy. If changes in product or destination country composition are the driving force behind the decline, an industrial policy that facilitates a fast transition from shrinking to expanding industries is most promising to counteract a continued trend of decline. However, *geographical shifts* across destinations call for a re-thinking of trade policy with destinations that grow in importance. *Declining competitiveness,* on the other hand, is likely best tackled by improving business dynamism, reducing labor costs, and attracting investment in public and private infrastructure. Our paper contributes to better understanding the sources of decline, by proposing framework to identify which of these three sources holds back export growth of any given exporter.

The paper is organized as follows. In the next section, we provide a discussion of our data and sample, as well as some background information on the evolution of trade in the 21st century. In Section 3, we specify our main export growth decomposition and outline our methodology of the analysis of mechanisms that may drive each of the sources of export growth we identify. In Section 4 we present our results. Finally, Section 5 concludes.

2 Background and Data

2.1 The Evolution of Trade since the 1990's

Trade volumes grew steadily in the post-war period among a group of established trade partners, most of which were classified as high-wage industrialized market economies. By 1995, exports from the five largest export nations—the United States, Japan, Germany, France, and the United Kingdom—accounted for 43.8% of global manufacturing trade (see Figure 2a). As Eastern European nations and China rapidly transitioned from communist states to market economies, and trade costs declined due to tariff reductions with the establishment of the World Trade Organization (WTO) in 1995, trade expanded significantly both in scale (+68% between 1990 and 1999) and in the diversity of trading countries, with emerging low-wage nations stepping onto the global stage.

This trend persisted and intensified throughout the 2000s. From 1995 to 2007, the "large 5" traditional export nations lost nearly a quarter of their manufacturing export share (from 43.8% to 32.9%). China (+7.4 percentage points) and the former Soviet states in Eastern Europe (+2.7 percentage points) nearly offset this decline (see Figure 2a). For high-wage countries, this marked the beginning of a new phase of globalization where workers in their export sectors had to compete with labor from low-wage countries. Consequently, some industrialized nations experienced a considerable loss of manufacturing jobs (Autor, Dorn, and Hanson, 2013; Foliano and Riley, 2017; Malgouyres, 2017; Citino and Linarello, 2022), which resulted in a slowdown in trade liberalization and trade growth during the 2010s.

Following the financial crisis, international manufacturing trade grew by only 8.4% in real terms from 2010 to 2019 (compared to 76.2% from 2000 to 2007) (see Figure 1). Simultaneously, the economic stagnation in several European Union member countries caused the share of global imports to Europe to fall by 5 percentage points, from 45% in 2007 to 40% in 2010, and this decline persisted throughout the decade. In contrast, import demand in Asia, South America, and Africa increased, leading to a shift in global demand for manufacturing products from Europe and North America toward the East and South. For European exporters, this meant that export opportunities were located further away. The average distance to import demand (a proxy for export opportunities) for German exporters increased by approximately 13 percent between 2007 and 2015, hindering export growth due to higher variable trade costs and increased fixed costs tied to establishing new trading relationships.

The departure from a broadly shared objective of free trade, established in the second half of the 2010s and the beginning of the 2020s, has become evident. With Brexit occurring in 2016, the onset of the China-US trade war in 2018, and a wave of national industrial policies alongside an emerging narrative of decoupling supply chains from China, a deepening of trade agreements across political blocs seems unlikely in the near future.

2.2 Data and Samples

Data sources – We draw on two main sources of data. First, we use the International Trade Database at the Product Level (BACI) (Gaulier and Zignago, 2010) to measure bilateral product level trade volumes. Second, to measure trade unit values (prices), we use the Trade Unit Values

Database (TUV) (Berthou and Emlinger, 2011). Both datasets are at the origin-destination-product-year level and based on the UN Comtrade database. They contain information on the trade volume (in current USD) and the unit value (trade value per kilogram). Products are categorized using the 6-digit codes of the Harmonized System (HS92).

Additionally, we use World Bank data on country GDP, Federal Reserve Economic Data (FRED) data on the US GDP deflator, the Structural Analysis Database of the OECD (STAN) for sectoral employment, value-added, labor productivity and labor costs, Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) gravity data on bilateral geographical distances between countries (Conte et al., 2023), and estimated product level elasticities of substitution from Soderbery (2015).

Samples – From these databases, we construct two main samples, which we refer to as the "full" and "price" samples. We use the full sample for our decomposition analysis of export growth and the price sample to estimate product quality and relative prices and investigate changes in competitiveness that are driven by changes in prices or product quality. Both samples encompass only trade flows in product categories that we categorize as manufacturing goods.[5] Our empirical analysis focuses on the years 2000 to 2023 as our price data is only recorded reliably from 2000 onwards.

The price sample is a subset of the full sample. We use unit values, i.e., the ratio of trade value and trade quantity, as our raw price measure. Because trade quantity information is less reliably recorded than trade value information in our dataset, prices are missing for some trade flows. To account for this, we focus only on the largest 100 destination countries based on total imports from 2000 to 2019 because the share of trade with available price information in these countries is higher than for smaller destination countries. Among this group, we restrict the sample to markets with at least where at least 50% of trade is recorded with unit value information for at least three different exporters. We follow Khandelwal (2010) and exclude trade flows that either are small (with a trade value of less than 20,000 in 2015-USD) or occur in only two years or less.

[5] We classify a product as a manufacturing good if we link it to a manufacturing industry according to the NACE Rev. 1 classification of industries. To do so, we use concordance tables between NACE Rev. 1 and ISIC Rev. 3 as well as between ISIC Rev. 3 and HS92 supplied by Worldbank WITS to assign 6-digit HS codes to 3-digit NACE industry groups. We consider all industry groups that belong to industry divisions (2-digit) between 15 and 36 to be manufacturing industries. When a product code is ambiguously assigned to both manufacturing and non-manufacturing industries, we consider it a manufacturing product and include it in the sample.

To limit the influence of price outliers, we restrict the sample to trade flows between the first and 99th percentiles of the global price distribution for each product-year combination. Despite these sample restrictions, the price sample still covers most manufacturing trade recorded in BACI (ca. 75% in 2000, 79% in 2007 and 75% in 2019).

We deflate trade volumes and prices using the US GDP Deflator to reflect a constant dollar series denominated in 2015 USD for all analyses.

3 Methodology

3.1 Decomposing Export Growth

Figure 3 visualizes the structure of our main framework for the decomposition of export growth. The columns represent the three sources of export growth that we consider: product composition, (destination) country composition, and competitiveness. To understand what portion of export growth can be attributed to each of these three factors, we decompose a country's export growth into changes in the composition of trade volumes *between products*, changes in the composition of trade within the same product category but *between destination countries (markets),* and changes in the composition of trade within markets *between exporters* (competitiveness).[6] In addition to these three components, changes in the aggregate scale of global trade volumes are another factor of export growth. However, since this component is common across exporters, we do not consider it as a *source of export growth* trade but instead consider a specific exporting country's export growth relative to the global trade trend (which we term *detrended export growth*).

To formalize this, consider exporting country c, destination country d, product k, year t and base year t_0. Aggregate export growth between year t and t_0 for exporter c, $\frac{X_t^c - X_{t_0}^c}{X_{t_0}^c}$, relative to the global trend in trade, $\frac{X_t - X_{t_0}}{X_{t_0}}$, can be written as follows:

[6] We define a *market* as all trade of the same product to a given destination country in a given year, e.g. the Italian market for cars in year 2005.

$$\underbrace{\frac{X_t^c - X_{t_0}^c}{X_{t_0}^c} - \frac{X_t - X_{t_0}}{X_{t_0}}}_{\text{Country c's detrended Export Growth}}$$

$$= \underbrace{\sum_k \left(w_{kt_o}^c - w_{kt_0}\right) \frac{\Delta X_{kt}}{X_{kt_0}}}_{\text{Product composition}} + \underbrace{\sum_k \beta_{kt}^c \sum_d m_{dkt_0}^c \left(s_{dkt} - s_{dkt_0}\right)}_{\text{Destination country composition}}$$

$$+ \underbrace{\sum_k \beta_{kt}^c \sum_d \left(m_{dkt}^c - m_{dkt_0}^c\right) s_{dkt}}_{\text{Competitiveness}} \quad (1)$$

where X_t^c are aggregate exports of the exporting country c, X_t are aggregate global trade volumes and X_{kt} are global trade volumes of product k, all in year t. Moreover, $w_{kt_0}^c = \frac{X_{kt_0}^c}{X_{t_0}^c}$ and $w_{kt_0} = \frac{X_{kt_0}}{X_{t_0}}$ are the *baseline portfolio weights* of product k for exporter c and the world, respectively. We refer to the difference between the exporter-specific ($w_{Kt_0}^c$) and the world's (w_{kt_0}) weights as the *residual portfolio weight* of exporter c for product k.[7] The term $s_{dkt} = \frac{\mathrm{X_{dkt}}}{\mathrm{X_{kt}}}$ is the *market size* of market $k \times d$ relative to the global trade volume of product k in year t, and $m_{dkt}^c = \frac{X_{dkt}^c}{\mathrm{X_{dkt}}}$ is the *market share* of exporter c in market $k \times d$ in year t. Finally, the $\beta_{kt}^c = \frac{X_{kt}}{X_{t_0}^c}$ are exporter-product specific *scale normalization coefficients* in year t. We derive equation (1) in Appendix B.1.

Equation (1) decomposes detrended national aggregate export growth into three components: a product composition term, a destination composition term, and a competitiveness term. These three terms add up to the difference between the export growth of the respective country c and the global trend.

The *product composition* term captures the reallocation of trade across products, holding fixed the composition of trade across destination countries (*market sizes*) and exporters (*market shares*). Specifically, this term represents the average trade growth across products weighted by the exporting country's residual portfolio weight at baseline. This term picks up product-specific changes in trade that may occur either due to changes in consumer preferences that are common

[7] Note that this can be interpreted as a measure of revealed comparative advantage (RCA), with a positive value indicating a comparative advantage. Compared to the standard Balassa (1965) measure of RCA, this measure is a difference rather than a ratio of export portfolio weights.

across destination countries or due to changes in supply-side factors that are common to all exporters.

The *destination country composition* term captures the reallocation of trade across markets, holding fixed the composition of trade across exporters in each market (*market shares*). This term picks up destination-specific changes of trade due to changing relative incomes, market access, or destination-specific preference shifts. These adjustments in the relative size of a market are common to all exporters in that market and affect them differently only through differences in their initial trade ties.

The *competitiveness* term captures the reallocation of trade across exporters *within* markets, holding fixed the composition of trade across markets in the final year (market sizes). This term picks up changes in the demand for an exporter's variety relative to that of competitors in the same market. These changes speak directly to the competitiveness of the exporter in a given market and may occur either because of changing relative prices or relative quality across varieties.[8] These adjustments in market shares are specific to a given exporter and, therefore, directly speak to changes in exporter-specific factors.

Together, these three terms provide a decomposition of aggregate export growth that allows for a quantitative assessment of whether the export success (or lack thereof) of an exporting country was due to favorable industrial specialization in products that gained importance (product composition), stronger trade ties with growing destination countries (destination country composition), or improved market positioning in the country's export markets (competitiveness).

3.2 The Determinants of Competitiveness

To understand *why* the competitiveness of a focal exporter may change over time, we further distinguish between two characteristics of exported product varieties that shape consumer demand: relative price and product quality. We derive measures of these two determinants of

[8] We adopt a demand-side interpretation of "perceived quality" that is standard in the literature on product quality in international trade (see, e.g., Khandelwal 2010 and Manova and Yu 2017). Therefore, changes in relative product quality may either reflect alterations in the characteristics of a product variety while keeping fixed how consumers value different characteristics, or they may indicate shifts in consumer valuations of product characteristics.

competitiveness, track their evolution across the periods of our analysis for each exporter, and contrast differences in price- and quality-changes between German and the United States.

As we measure product characteristics (price and quality) *relative* to market averages, different changes over time between exporters may be driven either by differential changes in own characteristics, or by differences in competition. We follow two strategies to isolate these two explanations: first, we contrast differences in price and quality changes in *common markets*; second, we pay tribute to the well documented role of China and Eastern Europe as the two most disruptive competitors in global trade during the period of our analysis and study whether either Germany or the United States was differentially exposed to or affected by their rising presence in global trade.

3.2.1 Prices and Quality

Prices–We measure product prices as the trade value per kilogram (unit values) of each trade flow which are used widely in the trade literature (see, e.g., Feenstra (1994); Broda and Weinstein (2006); Amiti and Khandelwal (2013); Manova and Zhang (2012); Manova and Yu, 2017). [9] Using unit values as a proxy for prices implicitly assumes that the product weight in kilogram is the relevant "unit of consumption". However, while this assumption may be justified for varieties of the same narrow product category, the mapping from consumed kilogram to utility likely differs substantially across product categories. We account for such differences across products by using *relative prices* for each variety ck compared to the average price in the same market kd, estimated as the regression residuals from the following equation:

$$\log p_{ckdt} = \rho_{kdt} + \varepsilon^{p}_{ckdt} \quad (2)$$

where p_{cdkt} are unit values for variety ck in market kd and year t. As we estimate (2) using weighted least squares, weighing each observation by its trade value, the market-year fixed-effects ρ_{kdt} represent trade-weighted average log prices of any given market kd in year t. The ε^{p}_{ckdt} are then our measure of variety ck's relative price in the destination country d in year t as they capture the log price premium of variety ck over the average price in this market.

[9] We calculate trade unit values using trade values and quantities reported by the importing country, which encompass all costs associated with transportation from the exporting country to the importing country (cif). Therefore, these values are more indicative of the prices encountered by consumers in the importing country.

Product Quality–While prices are often used as a proxy for quality, they also contain non-quality-related factors such as production and transportation costs. To overcome this problem, Khandelwal (2010) proposes inferring consumers' perceived quality based on price and quantity information. The basic idea of this approach is that varieties with both a high price and high trade volume must be of high quality, while those with low prices and volume are of low quality. No additional information is required to assess the quality relationship between these two extreme cases. However, whether a variety with a higher price but a lower trade volume is of higher or lower quality than a variety with a lower price and a higher trade volume is ambiguous and depends on how responsive consumer demand is to prices, holding quality constant. If demand is very elastic, a higher quality is required to rationalize a given trade volume than if demand is inelastic. More generally, knowledge of the price elasticity allows us to predict how demand would change in response to price change *if* quality was unchanged. The difference between the observed change in demand and the counterfactual demand change under constant quality identifies the unobserved change in quality. Inferring quality using a demand-side approach, therefore, requires an estimate of the price elasticity of demand. Khandelwal (2010) uses variation in trade costs across varieties to instrument prices, thus recovering the demand response to prices. However, trade costs or other price instruments are not widely available in most contexts.

To address this issue, Khandelwal, Schott, and Wei (2013) (hereafter referred to as KSW) modified Khandelwal's (2010) method by utilizing a CES demand structure with a pre-estimated elasticity of substitution.[10] Rather than estimating the demand-price relationship using price instruments, KSW relies on a structural estimate of the CES elasticity to construct the counterfactual demand changes associated with observed price changes if quality was fixed that is needed to back out unobserved quality. A central assumption of the CES demand system imposed by KSW is that a single elasticity σ governs the demand responses to changes in prices.

While this may be appropriate in the context of a single industry, as in KSW, it is too restrictive in our context of many industries and would require (i) that the price elasticity is the same across all products and (ii) that consumers substitute in the same way between varieties of the same product category as they do between varieties of different product categories, i.e., that a

[10] Several papers on the role of product quality in international trade have since adopted an equivalent measure of quality based on CES preferences (see Khandelwal, Schott, and Wei (2013); Fan, Li, and Yeaple (2015); Manova and Yu (2017)).

consumer's demand for Japanese cars is as responsive to price changes of Italian suits as it is to price changes of German cars.

We, therefore, extend KSW's method by adopting a nested CES-structure with product-specific price elasticities to account for richer substitution patterns. To fix ideas, we first consider a single destination country in a single year and drop subscripts d and t. See Figure 3 for a visual example of the nested structure of consumer demand. We define the lowest utility nest at the product level k. In particular, we assume the preferences of the representative consumer of an importing country d over varieties of a product k are represented by the sub-utility function $U_k = \left(\sum_c \lambda_{ck}^{\frac{1}{\sigma_k}} \, q_{ck}^{\frac{\sigma_k - 1}{\sigma_k}}\right)^{\sigma_k/(\sigma_k - 1)}$, where λ_{ck} is the taste shock and q_{ck} the consumed quantity of a variety ck. The constant elasticity of substitution between varieties of product k is given by σ_k. As we formally derive in Appendix B.2, demand for variety ck (i.e., the supply of product k from exporter c), q_{ck}, is then characterized by the nested CES demand function

$$q_{ck} = \lambda_{ck} p_{ck}^{-\sigma_k} E_k P_k^{\sigma_k - 1} ,$$

where p_{ck} is the price of variety ck; $E_k = \sum_c p_{ck} \cdot q_{ck}$ is the expenditure on varieties of product category k, and P_k is the (quality-adjusted) Dixit-Stiglitz price index of product k.[11] The taste-shock λ_{ck} can be interpreted as the *perceived product quality* of the representative consumer.

Taking logs, we can solve the demand equation for quality λ_{ck}:

$$log\ \lambda_{ck} = \log(p_{ck} \cdot q_{ck}) + (\sigma_k - 1) \log p_{ck} - \log E_k - (1 - \sigma_k) \log P_k \quad (3)$$

Everything on the RHS of equation (3) that varies at the exporter-product level ck is measurable from our trade data, i.e., trade values and prices. We use product-specific structural estimates of the CES-elasticities (on 6-digit product level), σ_k, from Soderbery (2015)[12]. Note that the Dixit-Stiglitz (quality-adjusted) price index P_k is itself a function of unobserved product quality λ_{ck}, and

[11] The Dixit-Stiglitz price index is given by $P_k = \left(\sum_c \lambda_{ck} p_{ck}^{1-\sigma_k}\right)^{1/(1-\sigma_k)}$

[12] Soderbery (2015) refines the structural estimator by Broda and Weinstein (2006) by correcting for small sample biases and constrained search inefficiencies. Both methods go back to an identification strategy to identify demand elasticities from observable volume and price time-series information proposed by Leamer (1981) and applied to the context of international trade by Feenstra (1994).

thus cannot be directly measured. We account for this by including market-year fixed effects when estimating product quality.

Quality Estimation – To measure variety-specific product quality, we regress the elasticity-weighted log of the demand index, $\log X_{ckdt} + (\sigma_k - 1)\, log\, p_{ckdt}$, on market-year fixed effects α_{kdt}:

$$\log X_{ckdt} + (\sigma_k - 1) \cdot p_{ckdt} = \alpha_{kdt} + \varepsilon^{\lambda}_{ckdt} \quad (4)$$

We weigh each observation by its trade value when estimating equation (4). The market-year fixed effects, α_{kdt}, account for time-varying differences in size (E_{kdt}) and price level (P_{kdt}) and quality level ($\overline{\lambda}_{kdt}$) between markets. We show in Appendix B.3 that the regression residual $\varepsilon^{\lambda}_{ckdt}$ identifies the log of *perceived product quality,* λ_{ckdt}, for product k sold by exporter c in destination d in year t relative to the trade-weighted average quality in that market, $\overline{\lambda}_{kdt}$. This measure of quality represents the attractiveness of an exporter's variety ck to consumers of destination d *relative* to the other varieties available in the same local product market. To ease notation, we will denote this measure of relative log quality henceforth as $\tilde{\lambda}_{ckdt}$.

Aggregation – To obtain the average product quality and price of each exporter, we take the log of the geometric mean of product quality of each market (product × destination) weighted by the portfolio share w^{c}_{dkt}. Note that this corresponds to taking the weighted arithmetic mean of log product quality across markets.[13]

Proximity to Frontier – We use the proximity to frontier measure proposed by Amiti & Khandelwal (2014) to infer the quality ladder position of an exporter in a market as the ratio of the exporter's own quality divided by the highest quality available in that market:

$$PF_{ckdt} = \frac{e^{\tilde{\lambda}_{ckdt}}}{\max_{c' \in C(k,d,t)} e^{\tilde{\lambda}_{c'kdt}}}, (5)$$

[13] The weighted arithmetic mean of log product quality across markets is given by $log\left(\prod_k \prod_d \lambda_{ckdt}^{w_{ckdt}}\right) = \sum_k \sum_d w_{ckdt}\, log\, \lambda_{ckdt}$.

where $C(k,d,t)$ is the set of exporting countries from which the destination d imports product k in year t. This proximity to the quality frontier measure ranges from 0 to 1, as $e^{\tilde{\lambda}_{ckdt}} \geq 0$. Higher values indicate a higher position on the quality ladder in the local product market kdt.

Decomposition of aggregate quality changes– An exporter's average quality may increase because of quality improvements in the initial product portfolio, changes in the composition of the product portfolio towards higher-quality products, or product entry and exit. To better understand *why* the aggregate relative product quality of an exporter may change over time, we decompose changes in the average quality into three components that reflect these three channels and quantify how each channel contributes to the changes in average quality.

To do so, we first aggregate over destinations to obtain the log (geometric) average product quality of exporter c in product k as $\ln \bar{\lambda}_{ckt} = \sum_d w_{dkt}^c \ \tilde{\lambda}_{ckdt}$ where $w_{kdt}^c = \frac{X_{ckdt}}{X_{ckt}}$ is the share of product-k-trade of exporter c that is exported to importer d. Next, we aggregate in an analog manner over products, taking the log of the geometric product-average as $\ln \bar{\lambda}_{ct} = \sum_k w_{kt}^c \ln \bar{\lambda}_{ckt}$ where $w_{kt}^c = \frac{X_{ckt}}{X_{ct}}$ is the share of exporter c's exports that is accounted for by product k. We can then decompose log changes in the average aggregate product quality of exporter c between period t and t_0 as follows:

$$\ln \bar{\lambda}_{ct} - \ln \bar{\lambda}_{ct_0} = \underbrace{\sum_k \left(w_{kt}^c - w_{kt_0}^c\right) \ln \overline{\lambda_{ckt}}}_{\text{Compositional changes}} + \underbrace{\sum_k w_{kt_0}^c \left(\ln \overline{\lambda_{ckt}} - \ln \overline{\lambda_{ckt_0}}\right)}_{\text{Quality improvements}}$$

$$+ \underbrace{\sum_{k:w_{kt_0}^c=0} w_{kt}^c \ln \overline{\lambda_{ckt}} \ - \sum_{k:w_{kt}^c=0} w_{kt_0}^c \ln \overline{\lambda_{ckt_0}}}_{\text{Product entry and exit}}, \quad (6)$$

The first term, *compositional changes,* captures changes in aggregate quality by changing the composition of the product portfolio. The second term, *quality improvements,* captures changes in aggregate quality by increasing the quality of the initial product portfolio. The last term, *product entry and exit,* measures changes in aggregate quality by adding or removing products from the overall product mix.

3.2.2 Differences in competition

In section 3.2.1 we proposed changes in relative prices and quality characteristics as mechanisms that may change the competitiveness of an exporter. However, the competitiveness of a focal exporter may also decline simply due to increasing competition in its export markets even if the characteristics of the focal exporter do not change. We now turn to examining whether competitiveness of German and US exporters may have diverged because of differences in competition.

First, we will assess whether different trends in relative price and product quality between Germany and the United States are driven by differences in each exporter's own product characteristics or a result of differences in the *exporter-specific composition* of exports across markets with varying degrees of competition. Intuitively, the relative quality of German car exports to Italy may increase either because of an increase in the (unobserved) *absolute* quality of German cars, or because of a decline in the average quality of cars in the Italian market. If German exports are more concentrated in markets with lower average market quality, than US exports, this may drive differences in the aggregate trends in relative quality between the two exporters. To rule out that differences in market composition are solely responsible for heterogeneity in the aggregate trends, we compare changes in aggregate relative quality and relative prices between the two countries, but equalize the market composition of exports of both exporters by restricting our sample only to *common markets* to which both countries export. We use common weights for both exporters when averaging prices and quality across markets. This allows us to obtain price and quality averages for both exporters over a *common market composition* in which both exporters thus face the same degree of market competition. Our modified measures of aggregate quality and prices for a focal exporter c_1 in period t are then

$$Y_{c_1 t}^{CM(c_1,c_2)} = \sum_{kd \in CM_t(c_1,c_2)} \frac{w_{kdt}^{c_1} + w_{kdt}^{c_2}}{2} \cdot Y_{c_1 kdt}, \quad (7)$$

where $Y \in \{\tilde{p}, \tilde{\lambda}\}$ are the relative log price or log quality we used before, $CM_t(c_1, c_2)$ refers to the set of markets in which both exporter c_1 and c_2 export to in year t, and $w_{kdt}^{c_1} = \frac{X_{c_1 kdt}}{\sum_{kd \in CM_t(c_1,c_2)} X_{c_1 kdt}}$ are the market weights for exporter c condition only on trade to *common markets*.

Second, we quantify the exposure to competition with China and Eastern Europe – the competitors with arguably most substantial gains in competitiveness during this period – of each

exporter. We measure the exposure to *disruptive competition* of each focal exporter c as the average market share of competitor b across the export markets of focal exporter c, weighted by share of the focal exporter's trade to each market:

$$m_{ct}^{b} = \sum_{kd} w_{kdt}^{c} \cdot m_{kdt}^{b}, (8)$$

Where $w_{kdt}^{c} = \frac{X_{ckdt}}{X_{ct}}$ is the share of focal exporter c's trade to market kd and $m_{kdt}^{b} = \frac{X_{bkdt}}{X_{kdt}}$ is the market share of competitor b in market kd.

4 Results

We organize the discussion of our findings along the three periods of globalization we study – 2000-2007, 2007-2019, and 2019-2023.[14]

4.1 Divergence of export growth in the 2000s

Table 1 displays the global trend of trade growth per year, actual and detrended national export growth for Germany (column (1)) and the United States (column (2)), as well as differences in export growth between both exporters (column (3)) separately for each of the three periods of our analysis. The first entry of the upper panel in column (1) shows that during the first period, 2000-2007, global trade volumes grew by 8.43% per year. Exports from the United States increased by 2.33% per year during this period, thus lagging behind the global trend by 6.1 percentage points. Germany's exports, on the other hand, grew by 9.9% per year, thus outpacing the global trend by 1.47 percentage points. This implies that the annual export growth rate of Germany diverged by 7.57 percentage points from that of the United States.

To understand the sources of divergence in export growth patterns between Germany and the United States during the first period, we now turn to the results of our main decomposition analysis reported in Figure 5. Results for the first period, 2000-2007, are reported in the left panel of this figure. The black dot reports the detrended annual export growth rate–defined as the difference between an exporter's actual export growth and the global trend– and the stacked bars

[14] We present the main results for the alternative periods of 1995-2007 for the 2000s and 2007-2018 for the 2010s in appendix Figure A.1.

report the contribution of each of the three components we describe in section 3.1 (equation 1) to detrended export growth.

The contribution of product composition, represented by the blue bar in Figure 5, to detrended export growth is positive for Germany but negative for the United States. It indicates that Germany's annual export growth was 0.69 percentage points higher per year due to its initial product portfolio expanding disproportionately in global trade volumes. In contrast, this source contributed -0.47 percentage points to the United States' detrended export growth. This factor thus benefited German exports by 1.17 percentage points more than the United States, thereby increasing the overall difference in export growth between the two countries. However, this factor is small in absolute terms, and differences in product composition contribute only 15.4% to the overall difference in export growth between Germany and the United States. In other words, German export growth did not diverge from that of the United States due to a favorable shift in global trade toward the products that Germany has historically exported.

Changes in *destination country composition* of international trade, represented by the green bar in Figure 5, too benefitted German export growth, while lowering US export growth. Yearly German export growth was 1.05 percentage points *higher* because the markets it initially served increased in size, holding market shares fixed at the initial level. The United States was adversely affected, with export growth lower by 1.76 percentage points. This indicates that global trade has shifted away from the markets that the United States initially served and towards markets that Germany traded with. Overall, this contributed 37.1% to the total difference in export growth between the two exporters thus widening the export growth gap between Germany and the United States.

Changes in competitiveness, represented by the orange bar in Figure 5, have reduced the export growth of both Germany and the United States. While German export growth relative to the global trend was 0.27 percentage points lower, that of the United States was 3.86 percentage points lower, attributed to decreased market shares while keeping market sizes fixed at the final level. This suggests that both exporters lost competitiveness in the markets they served. Although this source of trade growth negatively impacted both exporters, the effect on the United States was over 14 times larger (3.59 percentage points more) than that on Germany. Thus, changes in competitiveness were the most important driver of the divergence in export growth relative to the global trend between Germany and the United States, accounting for 47.4% of the total difference

in export growth, while differences in compositional changes between products and markets accounted for only 15.4% and 37.1% of the total divergence.

4.1.1 Divergence in competitiveness in the 2000s

In the previous section, we established that the divergence in export growth patterns between Germany and the United States during the first period was primarily due to differences in competitiveness. We now examine the factors driving this divergence in competitiveness. We will first explore whether the competitiveness of each exporter changed due to lower relative prices, improvements in the product quality of the initial export portfolio, or compositional changes in the portfolio towards products with higher initial quality. In a second step, we will investigate the role of differences in exposure to competition, in particular from China and Eastern Europe, on the different trends in competitiveness of Germany and the United States.

4.1.1.1 Relative price and quality

We first present results on changes in the average relative price and quality of German and US exporters. Panel (a) of Figure 6 presents results on the changes in the average (relative) price and quality of Germany and the United States between 2000 and 2007. German prices increased on average by 0.058 log-points (+6%), and US prices remained mostly unchanged, increasing by only 0.008 log-points (+0.8%) relative to market prices, suggesting that German exporters did not become more price-competitive during the 2000s, while US exporters did. Regarding changes in product quality, the figure shows that the quality of German exports rose on average by 0.234 log-points (+26.4%) more than the mean quality in the export markets they traded with. In contrast, the product quality of US exporters fell on average by 0.174 log-points (-16%) compared to market averages during this period.

Next, we document the evolution of each exporter's average quality ladder position, i.e. the average ratio of own quality in a given market to the highest quality in the same market as described in equation (5). Panel (b) of Figure 6 presents the evolution of the export-weighted average proximity to the quality frontier for Germany and the United States between 2000 and 2007. The highest attainable value is 1, which would indicate that all exports of the exporter are at the quality frontier, i.e. have the highest quality in their respective market.

In 2000, US exporters were on average very high *up on the quality ladder*: their average export attained 81% of the highest available quality. By 2004, this number had dropped dramatically to

71% and remained relatively. German exporters, on the other hand, started on a much lower position of the quality ladder, attaining on average 63% of the highest quality in their markets. However, while the US quality ladder position deteriorated by 10% during this period, German exporters rapidly *moved up the quality ladder* and by 2004 achieve 69% of the quality frontier, almost catching up with US exporters. After 2004, the German quality ladder position, however, slightly declined again to 66% by 2007. Overall, however, German exporters reduced the gap on the quality ladder position with US exporters from 18.5% in 2000 to a mere 4.4% by 2007.

These results suggest that different trends in product quality can explain the diverging competitiveness between German and US exporters that we documented in the results of our export growth decomposition, while price trends differ between German and US exporters, too, however, working in the opposite direction with German prices rising more than those of US exports.

We now turn to our analysis of the drivers of the observed aggregate product quality trends. Panel (c) of figure 6 presents the results of our decomposition of aggregate product quality changes from equation (5) for Germany and the United States between 2000-2007. The black dot reports the change in the average log quality between 2000 and 2007, and the stacked bars report the contribution of each decomposition term to this aggregate change for Germany and the United States, respectively. Note that by construction, the three decomposition components sum up to the aggregate change in log quality.

As we have seen in panel (a) of figure 6, product quality increased by 0.234 log-points (+26.4%) for Germany, but declined by 0.174 log-points (-16%) for the United States. For both countries, quality changes of the initial product portfolio, i.e. changes *within products,* reported as the green bars, were the main driver of changes in aggregate quality, explaining 124.9% (or 0.293 log points) of the increase in German quality and 109.2% (-0.19 log points) of the decrease of US quality. Thus, the quality of the initial product portfolio of the United States deteriorated (relative to competitors in the same markets), while in sharp contrast, German exporters substantially improved theirs.

Compositional changes of the product portfolio, i.e. changes *between products* valued at the final quality, reported as the blue bars, played a smaller role and contributed positively to changes in product quality for the United States (+0.016 log points) but negatively to the quality changes for Germany (-0.058 log points). Thus, altering the composition of the product mix

improved average product quality in the United States, showing that they increased exports of higher-quality products, while Germany decreased exports of its high-quality products. For both exporters compositional changes work in the opposite direction of the overall change in average quality and play much smaller role than *within product* changes, lowering aggregate quality by 24.8% of the overall quality increase of German exports and increasing aggregate quality by 9.3% of the overall quality decrease of US exports.

Neither new nor dying products that a country only exported in one of the two periods contributed meaningfully to either Germany or the United States (reported as orange bars).

In summary, we do not find that German exporters became more price-competitive than the United States during the first period; rather, Germany increased prices by more than their direct competitors in the same markets, while prices of US exports remained roughly unchanged. Instead, we find that German exporters significantly improved the average quality of their exports between 2000 and 2007, allowing them to move up the quality ladder and substantially reduce the gap. We further find that Germany achieved this mainly by enhancing the product quality of its initial portfolio rather than altering the portfolio's composition toward higher quality products.

4.1.1.2 Differences in competition

We now investigate whether the differential price and quality trends documented in section 4.1.1.1 were due to differences in each focal exporter's own price and quality or because of differences in market composition. Figure 7 presents the changes in the average relative price and quality for German and US exports between 2000 and 2007 with *exporter-specific market compositions* (left panel), i.e., across all markets and exporter-specific weights, as well as for a *common market composition* (right panel), i.e., only across common markets and using the average portfolio weights between the two exporters as common weights as described in equation (7).

We see the same qualitative patterns in both panels of Figure 7: relative prices of German exports increase on average more than those of US exports, and relative quality of German exports increases while that of US exports decreases. Both the price and quality changes differ substantially more for the common market than for the export-specific compositions: relative prices of German exports increase on average by 0.097 log-points more than prices of US exports

in common markets compared to only 0.05 log points in all markets. Moreover, relative quality of German exports increases on average by 1.084 log points more than US exports in common markets, while 0.408 log points more in all markets.

Differences in price and quality changes between German and US exports are substantially more pronounced for common market composition, i.e., when market trends in prices and quality are identical for both exports, than for exporter-specific market compositions, when market trends in prices and quality may differ across exporters, provide strong evidence, that differential changes in *own prices and product quality* are the reason why *relative prices and product quality* of German and US exports diverged in the 2000s.

Next, we ask whether German and US exporters were differently exposed to competition with the most disruptive competitors during the 2000s. Table 3 presents results on the average market share of China and Eastern Europe (separately and jointly) in the export markets of Germany and the United States respectively. Columns 1-3 report these statistics in the base year while columns 4-6 report changes in market shares of these competitors between the base year and the final year. The upper panel presents results for the period 2000-2007. German and US exporters had very similar initial levels of exposure to Chinese competition with an average market penetration of 1.8% in the case of Germany and 2.2% for the US. By 2007, the peak of the China-shock period, Chinese market penetration increased by 3 percentage points for German exporters and by 3.9 percentage points for US exporters. The slightly higher exposure to Chinese competition in the United States by 1.3 percentage points in 2007 was more than made up by a 4.1 percentage point higher exposure of German exporter to competition from Eastern Europe in the same year. As a result, German exporters faced a larger combined market penetration of Chinese and Eastern European exporters in their export markets during the 2000s. It is therefore unlikely that fiercer competition with these two competitors can explain the differences in competitiveness patterns of these two exporters.

4.1.2 Compositional changes of international trade patterns

While competitiveness was the most important source of export growth divergence in the first period, compositional changes of global trade, particularly between destination countries, significantly contributed to the divergence in trade growth between the United States and Germany. We now turn to documenting how the composition of global trade has changed between product

groups and destination regions in the first period and relate these changes to the exposure of each focal exporter to these changes.

To study changes in the global product composition of trade, we define eight broad product groups: consumption goods, metals and minerals, chemicals (incl. pharmaceuticals), electronics, machinery, medical, optical, or precision instruments, motor vehicles, and other transportation (mainly aircrafts, ships, and trains). Figure 9 presents results on the *residual portfolio shares*[15] of each product group for German and US exports in 2000 (left panel) and *global trade growth* between 2000 and 2007 for each product group (right panel). Recall, that these are the two ingredients of the product composition term of our decomposition framework. Intuitively, a country's aggregate export growth benefits from being more specialized in products with global trade growth above the global trend.

The left panel reveals that in 2000, Germany disproportionally exports motor vehicles (+9.8%), machinery (+6.4%) and chemicals (+2.8%), while the US disproportionally exports other transportation (+4.0%), medical, optical, and precision instruments (+2.9%), electronics (+2.9%) machinery (+2.3%) and chemicals (+1.2%). Both exporters under proportionally export metals and minerals (-1.6% for Germany and -4.4% for the US), consumption goods, and in the case of Germany electronics (-9.4%). This indicates that the comparative advantage of German exports was highly concentrated, while that of the United States was much more diversified.

Looking at the right panel of Figure 9, we see that metals and minerals (+132%), machinery (+99.5%), and chemicals (+98.8%) were the three fastest growing export industries during the 2000s, while electronics (+41%), consumption goods (+52.5%), and other transportation (+61%) experienced the slowest growth. The global trend during this period was 76%. This indicates that German revealed comparative advantage was concentrated in the right industries – namely machinery and chemicals, which belonged to the fast-growing product groups, while the United States, though more diversified, was more specialized in industries with global trade growth below trend – namely electronics and other transportation. Germany was also less negatively affected by the high trade growth in metals and minerals, for which both Germany and the United States had

[15] Residual portfolio shares are defined as the difference between the portfolio share of a product group in a given exporters export portfolio with that of the world portfolio. A positive residual portfolio weight thus indicates that the exporter disproportionately exports this product. This measure can be interpreted as a proxy for revealed comparative advantage or export specialization.

a negative residual portfolio share, however, that of the US was 2.75 larger in absolute values. Thus, global trade shifted towards the few industries in which Germany exporters had a strong comparative advantage in the 2000s, while the US was less specialized in high-growth industries than in low-growth ones.

Next, we turn our focus towards changes in the composition of trade between destination regions. We group all countries into five broad destination regions: Europe, North America, South and Central America, East and South-East Asia, as well as an "Other" region that includes all of Africa, large parts of Asia (excl. East and South-East Asia), and Oceania. Figure 10 displays the destination-region shares of exports for Germany and the United States in 2000 (left panel) as well as destination-region shares of global imports in 2000 and 2007 (right panel). The left panel reveals a similar pattern as in the case of industries emerges: German exports are concentrated while those of the United States are diversified across regions: 69.5% of German exports are going to Europe in 2000, while exports of the US are going in almost equal parts to North America (19.4%) , South and Central America (23.0%), Europe (26.1%), and South and South East Asia (24.5%).

However, the right panel shows that German exports were concentrated in the *right* region for this decade, as Europe's share of global imports increases by almost 3 percentage points from 41% in 2000 to 44%, while that of all regions with which the US has stronger trade ties than Germany decreases. This reallocation of world imports towards Europe and away from North America thus benefits German exports disproportionally while it harms US export growth.

To sum up, German exports benefitted greatly from being specialized in the *right* industries and having trade ties with the *right* destinations at the beginning of the 2000s, while the stronger diversification of US exports across products and regions harmed rather boosted its aggregate trade growth during this period.

4.2 Stagnation and reversal of trade growth in the 2010s

This first decade starkly contrasts with the second period, 2007-2019 (middle panel of table 1), when global real export growth slowed to 0.8% per year. Real exports in Germany shrank by 0.62% annually, while those in the United States grew by 0.25% annually. The deviation from the global trend thus increased in absolute terms for Germany to -1.42 percentage points per year but

decreased for the United States to -0.55 percentage points. The divergence in export growth between Germany and the US thus reversed relative to the first period, with US exports growing 0.87% faster than German exports between 2007-2019.

Global trade growth remained low in the last period, 2019-2023 (lower panel of table 1), when global trade volumes increased by 0.85% annually. Both Germany and the US experienced negative export growth of -0.75% and -0.03%, respectively, during this period. The US's detrended export growth was -0.88 percentage points per year, which is lower than in the previous period but still higher than that of Germany, which slightly decreased from the previous period to -1.6 percentage points.

While trade growth experienced a significant slowdown globally during the second period, the decline is particularly large for Germany, as illustrated in Figure 1. The middle panel of Figure 5 reports our decomposition analysis for the second period. The numbers show that in contrast to the first decade, the initial German product portfolio underperformed relative to the world average, lowering annual German export growth by 0.17 percentage points (*product composition*). The United States, on the other hand, benefited from a disproportionately growing product portfolio, increasing US export growth above the global trend by 0.64 percentage points. Compositional changes across destination countries also hampered German export growth (-0.49percentage points) but slightly boosted that of the United States (0.07 percentage points). This suggests that German exports were adversely affected by shifts in the composition of global trade across destination countries and products during the 2010s. At the same time, the United States benefited from both changes.

Changes in competitiveness continue to negatively impact export growth for Germany (-0.76 percentage points) and the United States (-1.27 percentage points). However, relative to the first period, this term has decreased in absolute terms for the US, while it has more than doubled for Germany. For the United States, competitiveness was the only factor that reduced overall export growth, contributing negatively by 228.2% of the total detrended export growth. Thus, while the aggregate export performance of Germany and the United States shifted in the 2010s with the US experiencing 0.9 percentage points more export growth per year, German exporters continue to outperform US exporters in terms of competitiveness but are disproportionately affected by compositional changes in global trade patterns concerning products and destination countries.

Appendix Table A.1 compares trade growth and contributions of each decomposition term across decades separately for Germany and the United States. Columns (1) and (3) report annual detrended export growth and the contributions of each decomposition term. Columns (2) and (4) report the share of each decomposition term's contribution to the exporters overall detrended export growth. Column (5) presents the difference in export growth (and decomposition term contribution) between the United States and Germany and column (6) presents the share of each decomposition term's contribution to the overall difference in detrended export growth between the two countries. The upper panel presents results from the 2000s (2000-2007), the middle panel for the 2010s (2007-2019) and the lower panel documents differences across decades.

Focusing on the lower panel, changes across decades, German annual detrended export growth was 2.9 percentage point lower during the second period than it was in the first. The decline of the competitiveness term from -0.27% to -0.76% accounts for merely 17% of this aggregate fall in detrended export growth, while product composition accounts for 29.7% and destination country composition for 53.3%. This showcases, that the stagnation of German exports growth in the second period was predominantly driven by a fall in the contributions of compositional changes to Germany's export growth.

4.2.1 Compositional changes in international trade patterns in the 2010s

In section 4.2, we have shown that compositional changes in global trade patterns mainly drove the strong decline of German export growth after the financial crisis. Adverse shifts in global trade across products and destinations account for 14% and 38% of the total deviation of German exports from the global trend during the second period, respectively (see the middle panel of Figure 5) and together account for 86% of the decline in detrended export growth in the second relative to the first period, while these two sources benefited the export growth of the United States. Analogously to section 4.1.2, we now explore *where* demand moved in the second period in terms of destination regions and product categories.

Figure 11 presents results on the *residual portfolio shares* of each product group for German and US exports in 2007 (left panel) and global trade growth between 2007 and 2019 for each product group (right panel). The left panel reveals that compared to the previous period, the concentration of German specialization in its top industry (motor vehicles) has increased further, while the US remains highly diversified, although losing comparative advantage in electronics and

instead becoming more specialized in other transportation and chemicals compared with the previous period.

However, in stark contrast to the 2000s, the concentration of German exports in just three industries no longer boosts the country's export growth: the right panel of Figure 11 shows that of Germany's core industries only chemicals have a trade growth above the global trend (+20.3%), while both machinery trade contracted (-0.9%) and motor vehicles (+2.7%) grew much below the global trend which was 14.9% in this period. The opposite was the case for the United States: it's top three industries had the fastest growing global trade growth during the 2010s (instruments (+27.9%), chemicals (+20.3%) and other transportation (+24.3%).

Thus, the strong and increasing concentration of German exports combined with slow global trade growth in these industries hurt Germany's aggregate export growth in the 2010s, as global trade shifted away from motor vehicles and machinery, while the US was able to benefit from these shifts due to a more diversified and more moderate distribution of comparative advantage.

Looking next at the geographical reallocation of global imports, Figure 12 displays the destination-region shares of exports for Germany and the United States in 2007 (left panel) as well as destination-region shares of global imports in 2007 and 2019 (right panel). The left panel of Figure 12 shows that compared to the first period, German exports became even more concentrated in Europe (72% of trade), while those of the United States remained a similar level of diversification. The right panel, however, reveals, that while Europe's share of trade expanded in the 2000s, in massively decreased by 7 percentage points from 44% to 37.1% between 2007 and 2019. The decrease in Europe's share of imports was mostly compensated by an increase in East and South East Asia's share (+4.0%) and that of the Other category (+2.3%).

Since the United States had stronger trade ties than Germany with all regions except Europe, it benefited from this shift of global imports away from Europe, while German exports suffered greatly.

4.3 Export growth in recent years

The lower panel of Table 1 shows that global trade volumes declined by 0.2% annually between 2019 and 2023. Germany saw a drop in exports of 0.75% each year, while US exports were stagnant (-0.03% p.a.). Consequently, US exports declined 0.72% less annually than German exports during this period and both exporters continued to fall behind the global trend by 0.88 and 1.6 percentage points respectively.

The lower panel of Table 1 presents the results of our decomposition analysis for the last period. Just as in the second period, negative changes in the composition of traded products diminished German export growth, with a decline of -0.89 percentage points, more than three times greater than in the previous period. Conversely, the US continued to benefit from shifts in the composition of global trade, though at only 0.13 percentage points per year, which is significantly less than during the second period.

Unlike the previous period, the destination country composition term positively contributed to German export growth, increasing it by 0.41 percentage points; it had a similar effect on US exports, adding 0.19 percentage points to overall export growth.

Finally, Germany's competitiveness significantly declined, reducing export growth by 1.12% annually and accounting for 70.3% of the overall deviation of German exports from the global trend during this period. German competitiveness finally almost converged to that of the United States (-1.2 percent per year) during this last period.

5 Conclusion

This paper presents a novel decomposition framework for analyzing the sources of national export growth, differentiating between compositional changes in international trade patterns and exporter-specific competitiveness. By applying this framework to global trade data from the United States and Germany over three distinct periods of globalization in the 21st century, we demonstrate compelling evidence that Germany’s export success between 2000 and 2007 was chiefly driven by competitiveness, although changes in trade composition across destination countries also significantly contributed. In the decade following the financial crisis, US exports rebounded and outperformed German exports, a reversal largely influenced by shifts in product and destination country composition that benefited US exporters while putting German ones at a disadvantage.

Examining the factors influencing competitiveness from a demand-side perspective—focusing on relative prices and quality—we find that Germany's export strength stemmed not from lower prices but from enhancements in product quality and a stronger resistance to Chinese competition through quality differentiation. In contrast, US exports experienced a decline in relative quality but remained more price-competitive compared to German exports. These findings remain valid even when considering variations in market competition.

Unlike the 2000s, period after the financial crisis saw U.S. exports grow faster than those of Germany. Our findings suggest that this shift was primarily driven by changes in the composition of global trade that benefited U.S. exporters while placing German exporters at a disadvantage. Nevertheless, German exporters continued to sustain a higher level of competitiveness than their U.S. counterparts following the financial crisis.

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Tables & Figures

March 20, 2025

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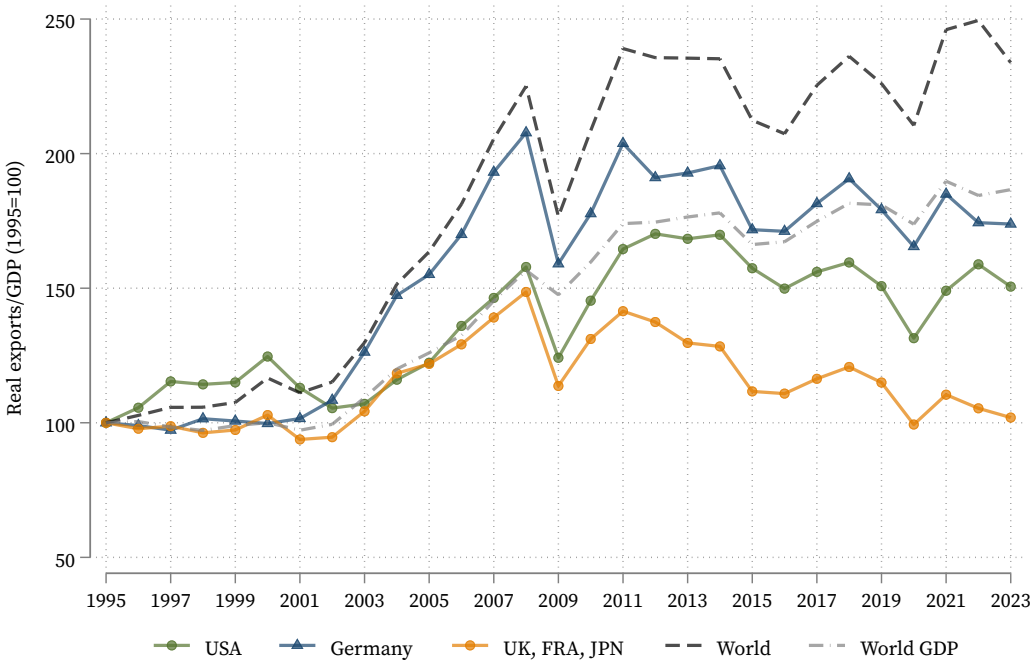
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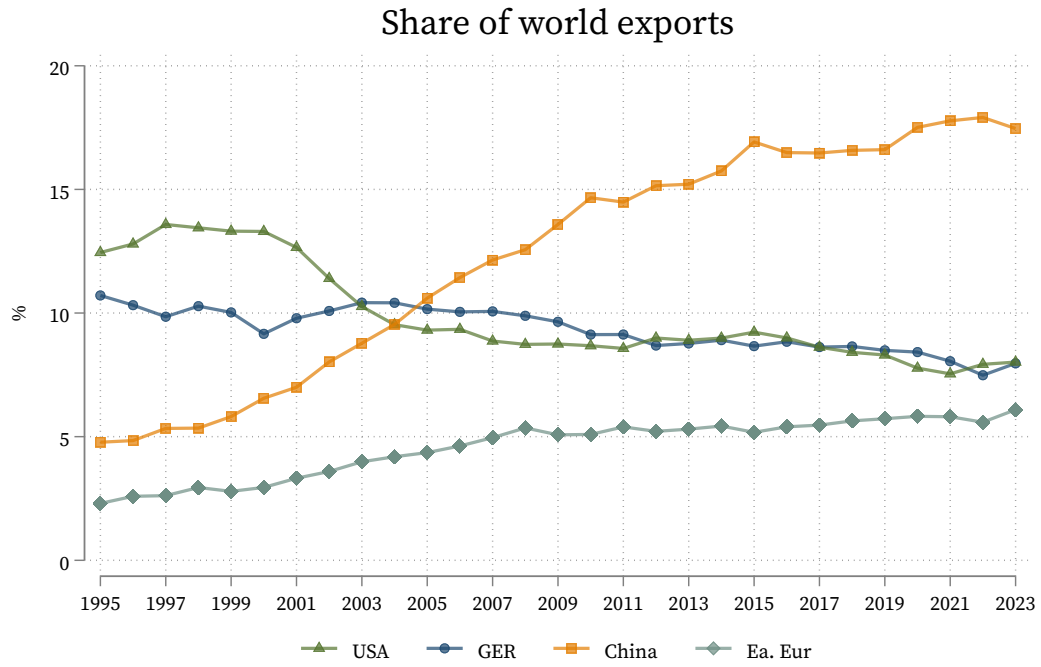
1 Figures

Figure 1: Real Export Growth

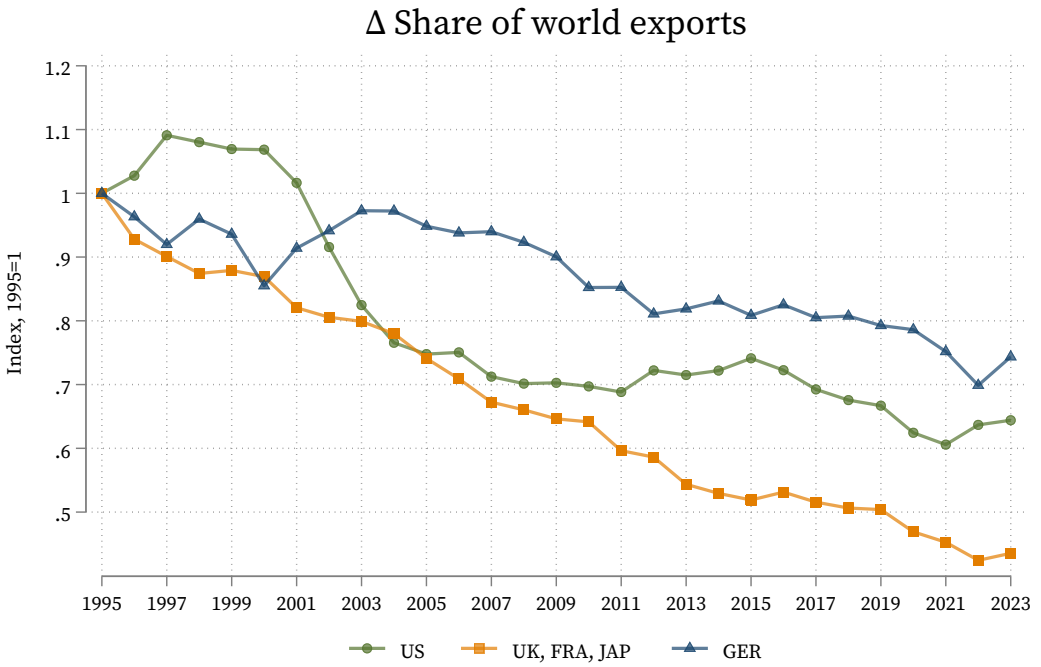


Notes: Figure displays real exports of the United States, Germany, the combination of UK, France, and Japan, and the world as well as real GDP of the world all normalized to 1995 levels.

Figure 2: The decline of the "Large 5" in global export markets



(a) Levels



(b) Changes

Notes: Panel (a) displays the share of global trade exported by the United States, Germany, China, and Eastern European countries in percent. Panel (b) displays the change in export share of global trade relative to each exporter's export share in the baseyear 1995 separately for the United States, Germany, and jointly for the United Kingdom, France, and Japan.

Figure 3: Framework of the decomposition of trade growth

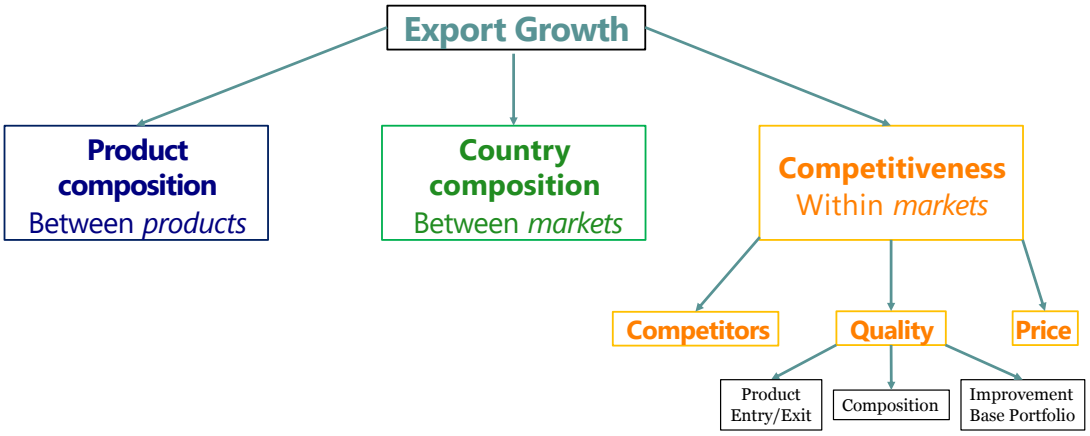


Figure 4: A nested structure of consumer demand

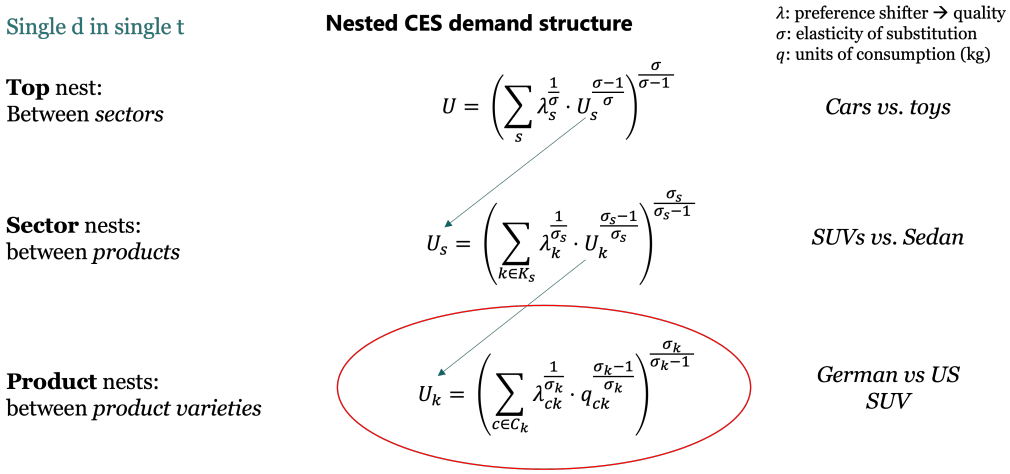
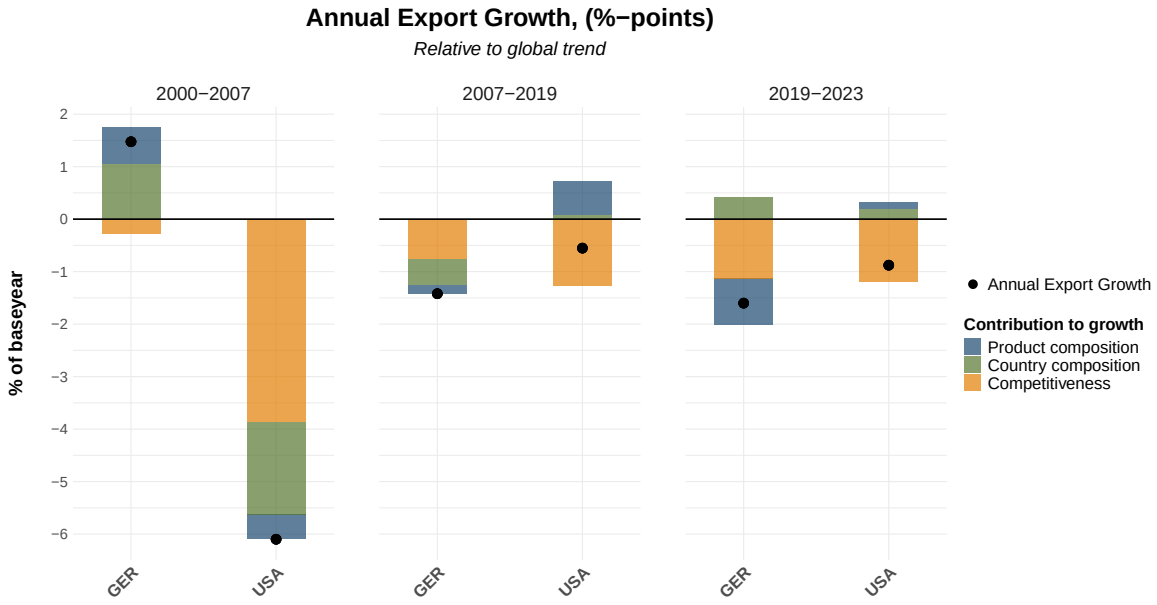
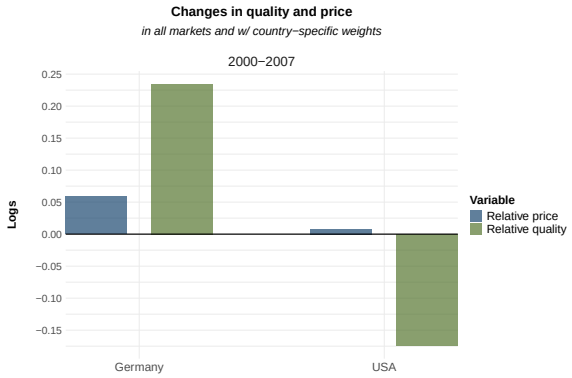


Figure 5: Sources of Export Growth — Germany vs USA

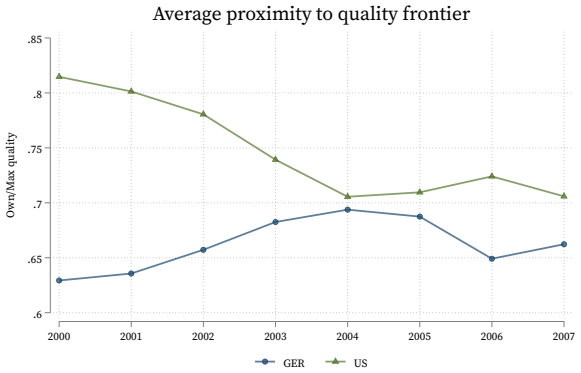


Notes: Figure displays detrended annual export growth rates and the contributions of each decomposition term from equation (1) for 2000-2007 (left panel) and 2007-2019 (middle panel) and 2019-2023 (right panel).

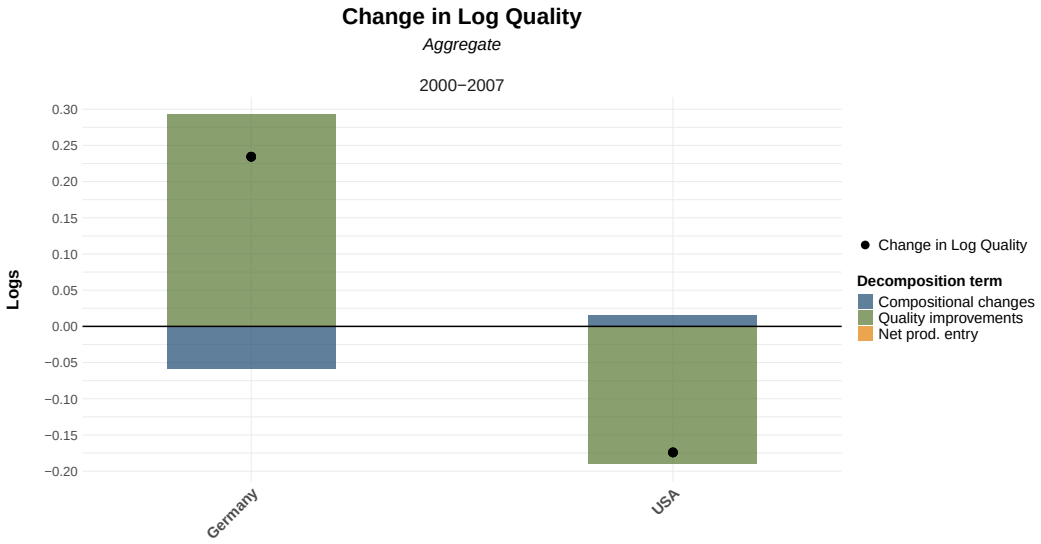
Figure 6: Sources of Competitiveness – 2000-2007



(a) Changes in average relative price and quality



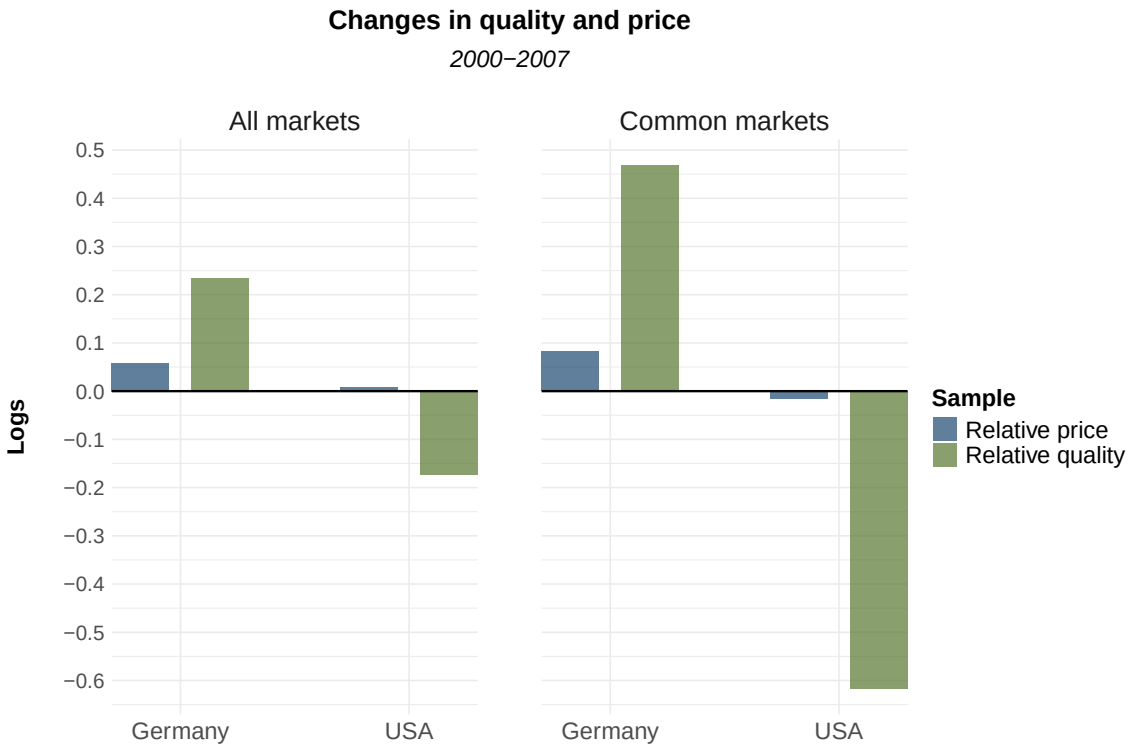
(b) Proximity to the quality frontier



(c) Decomposition of changes in log quality

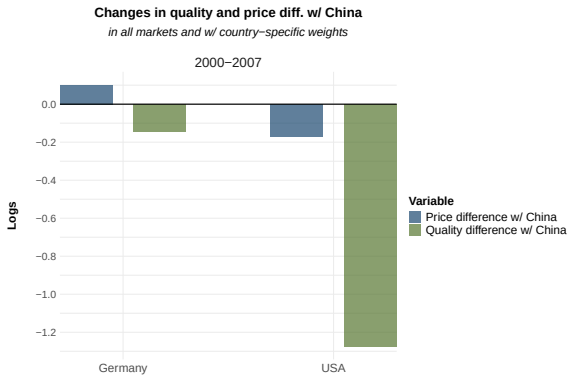
Notes: Panel (a) presents changes in aggregate log quality and prices of Germany and the United States relative to trade-weighted market averages for 2000-2007. Aggregate changes represent averages of market-level changes, weighted by the exporter's share of trade to each market. Panel (b) shows the evolution of the proximity to the frontier of each exporter, i.e. the ratio of own quality relative to the highest quality in the same market as outlined in equation (5). Panel (c) presents the results of the decomposition of changes in aggregate log quality between 2000-2007 as outlined in equation (6).

Figure 7: Changes in relative quality and price in common markets

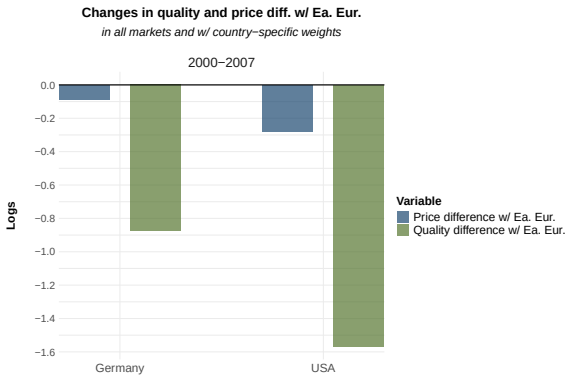


Notes: Figure displays changes in aggregate log quality and prices of Germany and the United States relative to trade-weighted market averages for 2000-2007 in all markets of the respective exporter (left panel) and in common markets (right panel).

Figure 8: Price and quality differentiation from competitors – 2000-2007



(a) Diff. vs China



(b) Diff. vs. Ea. Eur.

Notes: Panel (a) presents the change in the average difference in log price and quality of each exporter with China between 2000-2007. Panel (b) presents the same statistics for the difference with Eastern Europe.

Figure 9: Shifts in global product demand in the 2000s

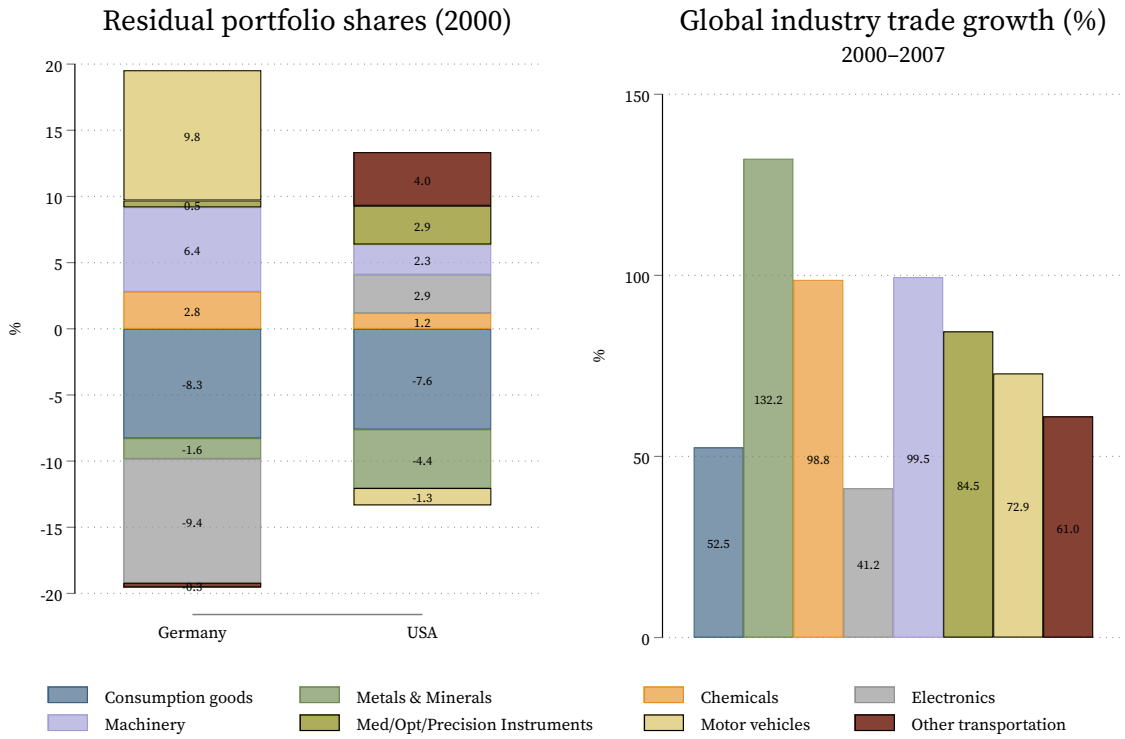


Figure 10: Geographical Shifts in world demand in the 2000s

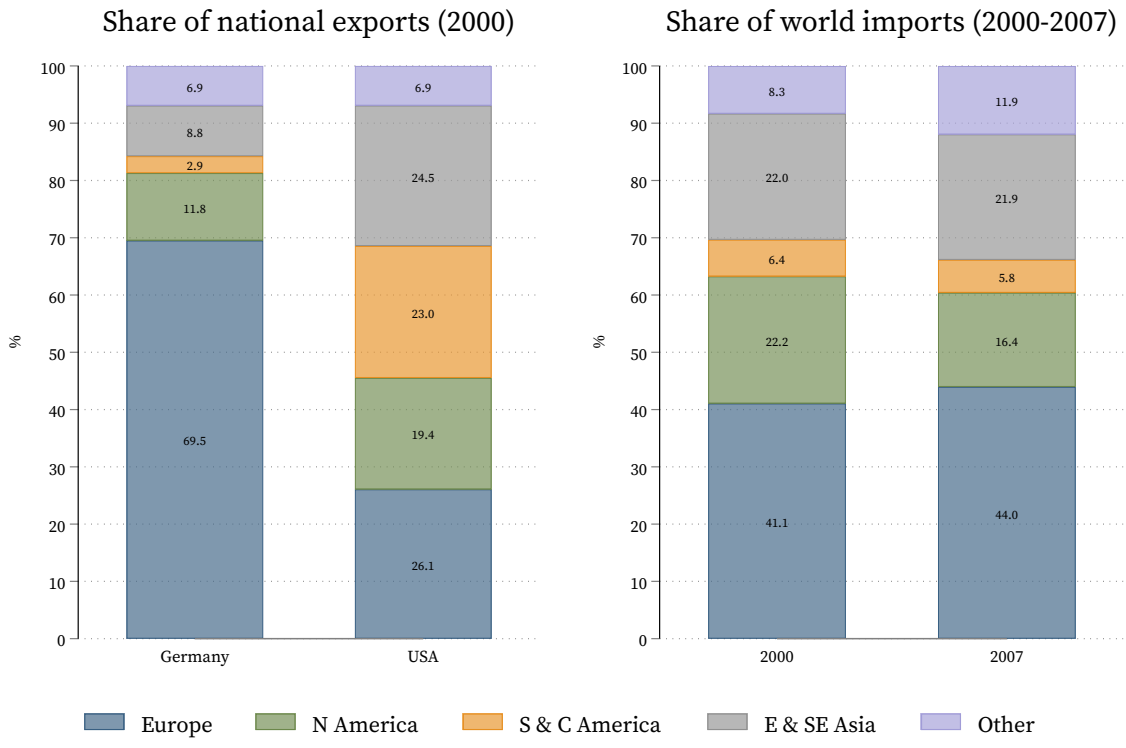


Figure 11: Shifts in global product demand in the 2010s

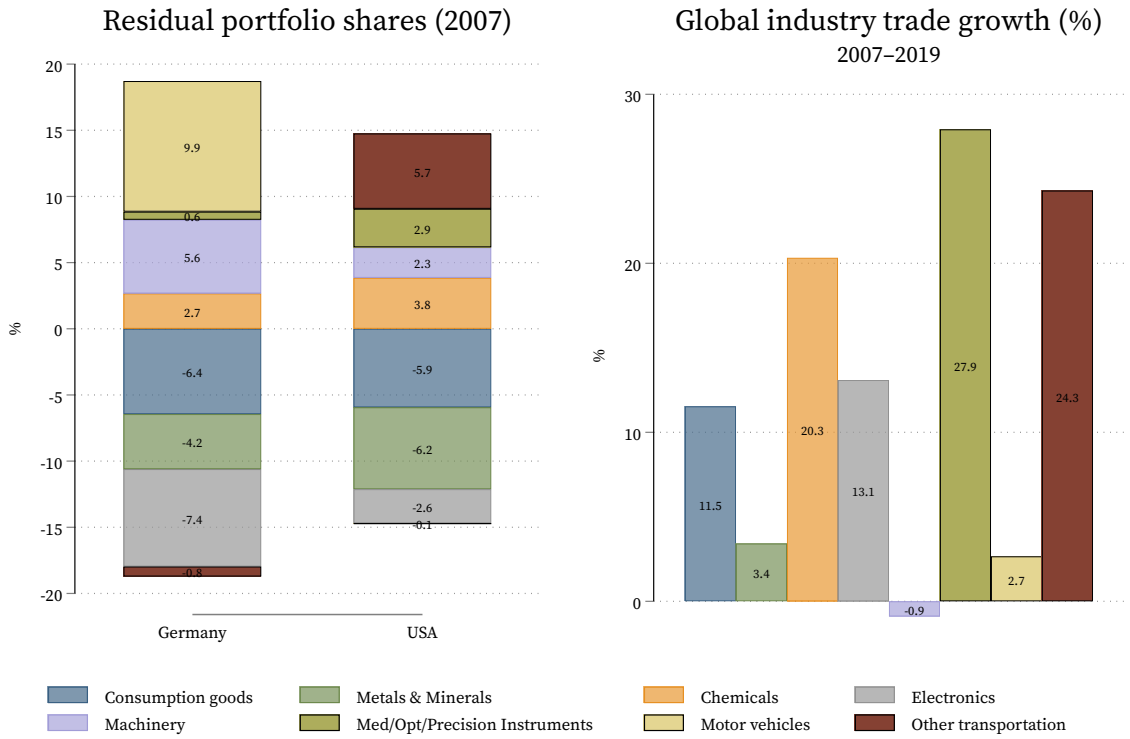
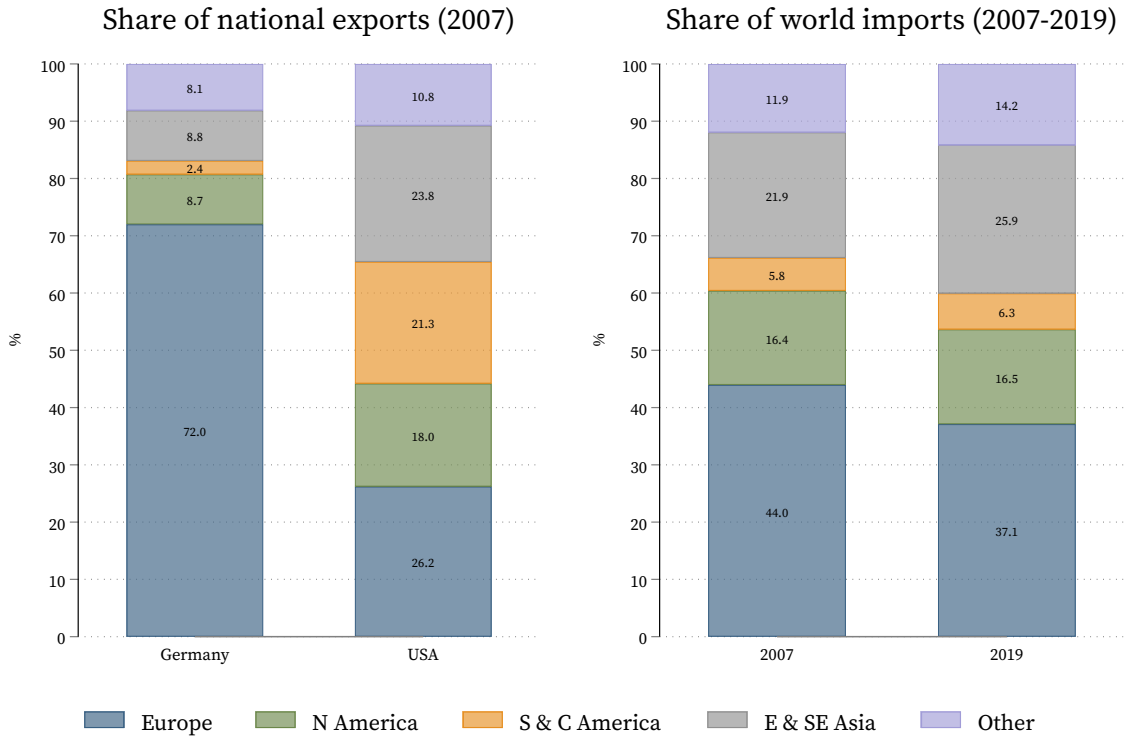


Figure 12: Geographical Shifts in world demand in the 2010s



2 Tables

Table 1: Annual export growth Germany, US, and the world

	GER	US	Diff. US - GER
	growth	growth	Δ growth
	(1)	(2)	(3)
2000-2007:			
Global trend	8.43	8.43	
National export growth	9.90	2.33	
Detrended export growth	1.47	-6.10	-7.57
2007-2019:			
Global trend	0.80	0.80	
National export growth	-0.62	0.25	
Detrended export growth	-1.42	-0.55	0.87
2019-2023:			
Global trend	0.85	0.85	
National export growth	-0.75	-0.03	
Detrended export growth	-1.60	-0.88	0.72

Notes: This table presents global and country specific export growth for the intervals 2000-2007 (upper panel), 2007-2019 (middle panel), and 2019-2023 (lower panel).
Columns 1 and 3 report annualized growth rates in real exports.
Column 3 reports the difference in annual growth rates between the US and Germany in percentage points.

Table 2: Decomposition of changes in log quality

	Germany		USA	
	Change	% of total	Change	% of total
2000-2007:				
Log quality	0.234		-0.174	
Decomposition components:				
– Compositional changes	-0.058	-24.8%	0.016	9.3%
– Quality improvements	0.293	124.9%	-0.190	-109.2%
– Net product entry	-0.000	-0.2%	-0.000	-0.1%
2007-2019:				
Log quality	0.038		0.134	
Decomposition components:				
– Compositional changes	0.114	303.2%	0.144	107.3%
– Quality improvements	-0.078	-207.1%	0.005	3.4%
– Net product entry	0.001	3.8%	-0.014	-10.7%

Notes: This table presents the changes in average log quality (relative to market averages) for the intervals 2000-2007 (upper panel) and 2007-2019 (lower panel) as well as the contributions to aggregate changes of each decomposition term from equation (3). Columns 1 and 3 report log-changes in (or log-contributions to) relative quality for German and US exports respectively.
Columns 2 and report the share of the country's aggregate change in log quality that is accounted for by each decomposition component in percent for German and US exports respectively.

Table 3: Exposure to competition with China and Eastern Europe

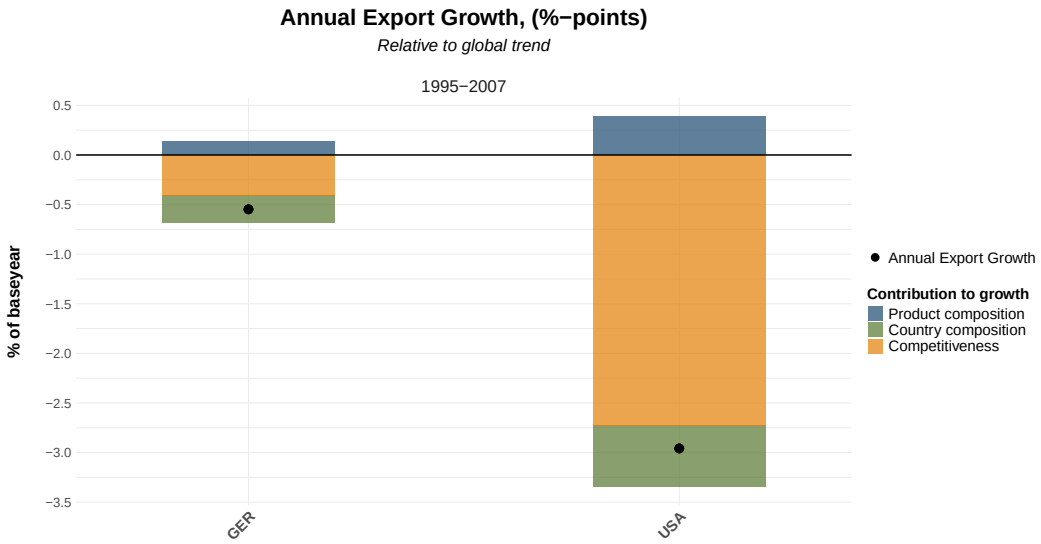
	Avg. market share in exporter's markets					
	Baseyear t_0			Δ_{t_0-t}		
Exporter	China	Ea. Eur.	Joint	China	Ea. Eur.	Joint
2000-2007:						
Germany	0.018	0.030	0.048	0.030	0.028	0.057
USA	0.022	0.008	0.030	0.039	0.009	0.047
2007-2019:						
Germany	0.048	0.058	0.106	0.027	0.022	0.049
USA	0.061	0.016	0.077	0.030	0.007	0.036

Notes: This table presents the average market share of China and Eastern Europe in the US and German export markets in the baseyear as well as its changes over time for the intervals 2000-2007 (upper panel) and 2007-2019 (lower panel) according to equation (8) in the text.

A Additional Tables and Figures

A.1 Figures

Figure A.1: Sources of Export Growth — Alternative time periods



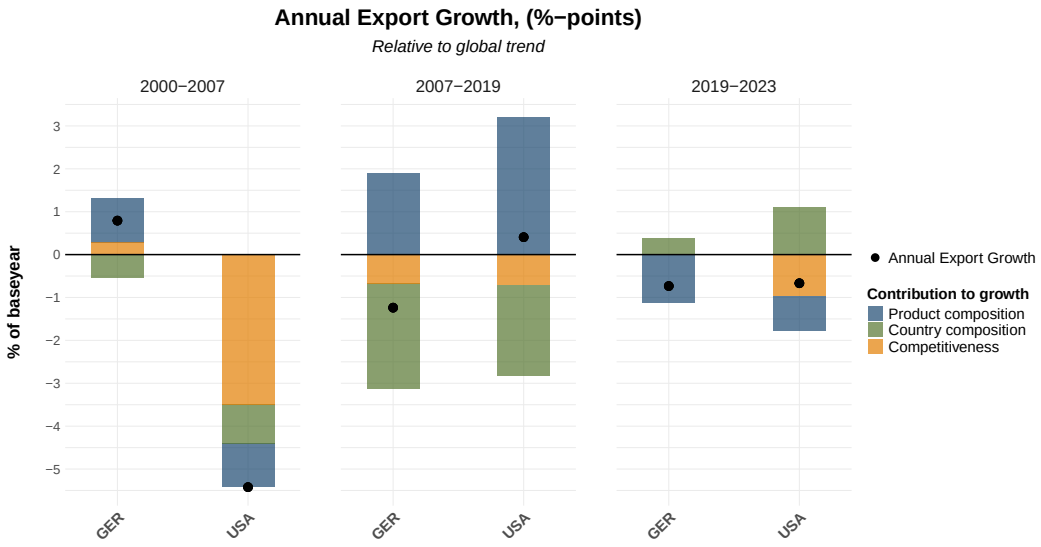
(a) 1995-2007



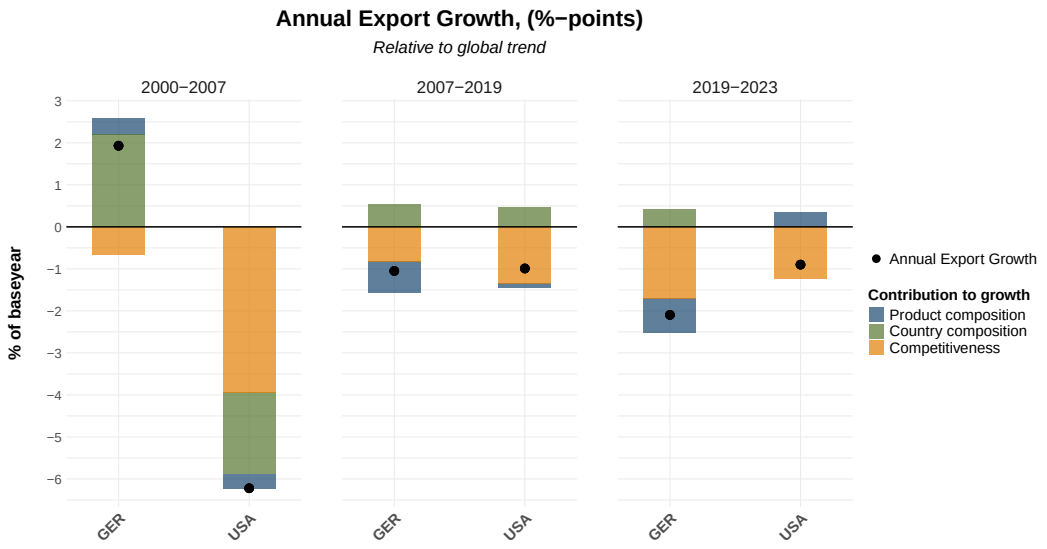
(b) 2007-2018

Notes: Panel (a) displays the export growth decomposition of equation (1) for the period 1995-2007 and panel (b) for the period (2007-2018).

Figure A.2: Sources of Export Growth — Eurozone vs. Non-Eurozone



(a) Exports to Eurozone



(b) Exports to non-Eurozone

Notes: Panel (a) displays the export growth decomposition of equation (1) for exports to Eurozone countries (as of 2007) and panel (b) displays the same export growth decomposition for all exports to non-Eurozone exports.

A.2 Tables

Table A.1: Sources of **Annualized** Export Growth

	GER		US		Diff. US - GER	
	ann. growth (in pp.) (1)	share (in %) (2)	ann. growth (in pp.) (3)	share (in %) (4)	Δ (in pp.) (5)	share of Δ (in %) (6)
2000-2007:						
Detrended export growth	1.47		-6.10		-7.57	
Decomposition terms:						
– Product composition	0.69	(47.1)	-0.47	(-7.8)	-1.17	(-15.4)
– Country composition	1.05	(71.2)	-1.76	(-28.9)	-2.81	(-37.1)
– Competitiveness	-0.27	(-18.2)	-3.86	(-63.3)	-3.59	(-47.4)
2007-2019:						
Detrended export growth	-1.42		-0.55		0.87	
Decomposition terms:						
– Product composition	-0.17	(-11.7)	0.64	(115.6)	0.80	(92.7)
– Country composition	-0.49	(-34.8)	0.07	(13.4)	0.57	(65.5)
– Competitiveness	-0.76	(-53.5)	-1.27	(-229.0)	-0.51	(-58.3)
Diff. 2010s - 2000s						
Detrended export growth	-2.90		5.55		-8.44	
Decomposition terms:						
– Product composition	-0.86	(-29.7)	1.11	(20.1)	1.97	(23.4)
– Country composition	-1.54	(-53.3)	1.84	(33.1)	3.38	(40.1)
– Competitiveness	-0.49	(-17.0)	2.60	(46.8)	3.09	(36.6)

Notes: This table presents detrended national export growth of Germany and the United States for the intervals 2000-2007 (upper panel), 2007-2019 (middle panel), and the difference between the 2010s (2007-2019) and 2000s (2000-2007) (lower panel) as well as the results from the decomposition equation (1).
Columns 1 and 3 report annualized growth rates in real exports and the contributions of each decomposition term to the detrended growth rate (in percentage points).
Columns 2 and 4 report the share of the country's detrended export growth that each decomposition term accounts for in percent.
Column 5 reports the difference in annual growth rates and decomposition term contributions between the US and Germany in percentage points. Column 6 reports the share of the difference in annual export growth rates between the US and Germany that each decomposition term accounts for in percent.

B Theory appendix

B.1 Derivation of export growth decomposition

In this section, we provide a detailed derivation of the export growth decomposition equation (1). We start by defining the four main variables along which we decompose *national aggregate exports* X_{ct}. First, the *global trade volume* X_t is the sum of all trade across products, destinations, and exporters. Second, the *global product trade volume* X_{kt} is the sum of all trade in product k across all destinations and exporters. Third, the *market size* is the share of product-k trade to a given location d: $s_{kdt} = \frac{X_{kdt}}{X_{kt}}$, where $X_{kdt} = \sum_c X_{ckdt}$ is the sum of all trade in product k to destination d and $X_{kt} = \sum_d X_{kdt}$ is the sum of all trade in product k across *all* destinations. Fourth, the *market share* is the share of trade in product k to destination d that is served by exporter c: $m^c_{kdt} = \frac{X_{ckdt}}{X_{kdt}}$.

We refer to X_{ckdt} as exporter c's *market exports* to the market $k \times d$ in period t. Aggregate trade is then the sum of all market exports, $X_{ct} = \sum_k \sum_d X_{ckdt}$. We are interested in the difference in *aggregate exports* between two time periods t and t_0, i.e. $X_{ct} - X_{ct_0}$. Note that, we can rewrite this aggregate difference as the sum of the differences in market exports:

$$\begin{aligned}\underbrace{X_{ct} - X_{ct_0}}_{:=\Delta X_{ct}} &= \sum_k \sum_d X_{ckdt} - \sum_k \sum_d X_{ckdt_0} \\ &= \sum_k \sum_d \underbrace{(X_{ckdt} - X_{ckdt_0})}_{:=\Delta X_{ckdt}}\end{aligned}$$

Next, we rewrite market exports as the product of global product trade, market size, and market share:

$$X_{ckdt} = X_{kt} \cdot \underbrace{\frac{X_{kdt}}{X_{kt}}}_{s_{kdt}} \cdot \underbrace{\frac{X_{ckdt}}{X_{kdt}}}_{m^c_{kdt}}$$

We take differences in market exports using the RHS of the equation above:

$$\begin{aligned}\Delta X_{ckdt} &= X_{kt_1} \cdot s_{kdt_1} \cdot m^c_{kdt_1} - X_{kt_0} \cdot s_{kdt_0} \cdot m^c_{kdt_0} \\ &= (X_{kt_1} - X_{kt_0}) \cdot s_{kdt_0} \cdot m^c_{kdt_0} + X_{kt_1} \cdot (s_{kdt_1} \cdot m^c_{kdt_1} - s_{kdt_0} \cdot m^c_{kdt_0}) \\ &= \underbrace{(X_{kt_1} - X_{kt_0}) \cdot s_{kdt_0} \cdot m^c_{kdt_0}}_{\text{Product composition}} + \underbrace{X_{kt_1} \cdot (s_{kdt_1} - s_{kdt_0}) \cdot m^c_{kdt_0}}_{\text{Country composition}} + \underbrace{X_{kt_1} \cdot s_{kdt_1} \cdot (m^c_{kdt_1} - m^c_{kdt_0})}_{\text{Competitiveness}}\end{aligned}$$

which gives us the market level versions of our three decomposition terms, Product composition, Country composition, and Competitiveness. We can aggregate these market level terms by summing over products and destinations and get:

$$\begin{aligned}\Delta X_{ct} = &\sum_{k,d} (X_{kt_1} - X_{kt_0}) s_{kdt_0} m^c_{kdt_0} + \sum_{k,d} X_{kt_1} (s_{kdt_1} - s_{kdt_0}) m^c_{kdt_0} \\ &+ \sum_{k,d} X_{kt_1} s_{kdt_1} (m^c_{kdt_1} - m^c_{kdt_0}) \end{aligned} \tag{A.1}$$

Equation (A.1) gives us the aggregate *absolute differences* in exports in USD terms for exporter c between period t_1 and t_0. To get the relative change in percentage points $\frac{X_{ct_1} - X_{ct_0}}{X_{ct_0}}$, we need to divide both sides by the baseyear export volume X_{ct_0}:

$$\begin{aligned}\frac{X_{ct_1} - X_{ct_0}}{X_{ct_0}} = &\sum_{k,d} (X_{kt_1} - X_{kt_0}) \frac{s_{kdt_0} m^c_{kdt_0}}{X_{ct_0}} + \sum_{k,d} \frac{X_{kt_1}}{X_{ct_0}} (s_{kdt_1} - s_{kdt_0}) m^c_{kdt_0} \\ &+ \sum_{k,d} \frac{X_{kt_1}}{X_{ct_0}} s_{kdt_1} (m^c_{kdt_1} - m^c_{kdt_0}) \end{aligned} \tag{A.2}$$

Last, we need to split the first term on the RHS of (A.2) up into the global trend in aggregate trade growth and the Product composition term from equation (1). To do this, first note that $s_{kdt_0} \cdot m^c_{kdt_0} = \frac{X_{ckdt_0}}{X_{kt_0}}$. Second, the global trend $\frac{X_{t_1} - X_{t_0}}{X_{t_0}}$ is the average of global product trade growth rates, weighted by the initial product weights $w_{kt_0} = \frac{X_{kt_0}}{X_{t_0}}$, i.e.:

$$\frac{X_{t_1} - X_{t_0}}{X_{t_0}} = \sum_k w_{kt_0} \frac{X_{kt_1} - X_{kt_0}}{X_{kt_0}}$$

These two facts allow us to rewrite the first term in equation (A.2) as:

$$\begin{aligned}\sum_{k,d}(X_{kt_1}-X_{kt_0})\frac{s_{kdt_0}m^c_{kdt_0}}{X_{ct_0}} &= \sum_k \frac{X_{kt_1}-X_{kt_0}}{X_{kt_0}}\frac{1}{X_{ct_0}}\underbrace{\sum_d X_{ckdt_0}}_{=X_{ckt_0}} \\ &= \sum_k \frac{X_{kt_1}-X_{kt_0}}{X_{kt_0}}\underbrace{\frac{X_{ckt_0}}{X_{ct_0}}}_{w^c_{kt_0}} \\ &= \underbrace{\frac{X_{t_1}-X_{t_0}}{X_{t_0}}}_{\text{Global trend}} + \underbrace{\sum_k \frac{X_{kt_1}-X_{kt_0}}{X_{kt_0}}(w^c_{kt_0}-w_{kt_0})}_{\text{Product composition}}\end{aligned}$$

Plugging this in for the first term in equation (A.2) gives us the decomposition equation (1):

$$\begin{aligned}\underbrace{\frac{X_{ct_1}-X_{ct_0}}{X_{ct_0}}}_{\text{Exp. growth}} - \underbrace{\frac{X_{t_1}-X_{t_0}}{X_{t_0}}}_{\text{Global trend}} &= \underbrace{\sum_k \frac{X_{kt_1}-X_{kt_0}}{X_{kt_0}}(w^c_{kt_0}-w_{kt_0})}_{\text{Product composition}} + \underbrace{\sum_{k,d}\frac{X_{kt_1}}{X_{ct_0}}(s_{kdt_1}-s_{kdt_0})m^c_{kdt_0}}_{\text{Country composition}} \\ &\quad + \underbrace{\sum_{k,d}\frac{X_{kt_1}}{X_{ct_0}}s_{kdt_1}(m^c_{kdt_1}-m^c_{kdt_0})}_{\text{Competitiveness}}\end{aligned} \tag{A.3}$$

B.2 Derivation of product quality estimation

B.2.1 Setup

A representative consumer in each destination d chooses imported quantities q_{ck} of each variety to maximize her utility U given income Y and import prices p_{ck}. The utility function U consists of a separate nest for each product k with an associated product-specific elasticity of substitution σ_k that governs the substitution patterns *within* product nests between varieties of product k, while the aggregate elasticity σ governs substitution patterns *between* product nests. The utility function is given by:

Top-level utility (across products k):

$$\max_{\{U_k\}_k} U = \Big(\sum_k \lambda_k^{\frac{1}{\sigma}} U_k^{\frac{\sigma-1}{\sigma}}\Big)^{\frac{\sigma}{\sigma-1}}$$
$$s.t.\ Y \geq \sum_k P_k U_k$$

where $P_k = \big(\sum_{c\in\mathcal{C}_k} \lambda_{ck} p_{ck}^{1-\sigma_k}\big)^{\frac{1}{1-\sigma_k}}$ is the Dixit-Stiglitz price-index of product k, σ is the elasticity of substitution between products, λ_k is the sectoral quality measure and U_k represents the product-k sub-utility.

Product-level sub-utility (across varieties ck within product):

$$\max_{\{q_{ck}\}_{c\in\mathcal{C}_k}} U_k = \Big(\sum_{c\in\mathcal{C}_k} \lambda_{ck}^{\frac{1}{\sigma_k}} q_{ck}^{\frac{\sigma_k-1}{\sigma_k}}\Big)^{\frac{\sigma_k}{\sigma_k-1}}$$
$$s.t.\ E_k \geq \sum_{c\in\mathcal{C}_k} p_{ck} q_{ck}$$

where $\mathcal{C}_k$ is the set of varieties of product k, σ_k is the elasticity of substitution between varieties within product k, λ_{ck} is the variety quality measure, p_{ck} is the price of variety ck in destination d, q_{ck} is the quantity of variety ck in destination d, and E_k is the expenditure on product k.

B.2.2 Solving the consumer problem

We solve the representative consumer's full utility maximization problem in two steps: first we derive the demand for each variety ck that maximizes subutility U_k given product expenditure

E_k, variety prices p_{ck}, variety taste shocks λ_{ck}, and product-k price index P_k. In a second step, we solve for the optimal expenditure allocation $\{E_k\}_k$ across products that maximizes the top-level utility U given the full profile of product price indices $\{P_k\}_k$, product-level taste shocks $\{\lambda_k\}_k$, and aggregate income Y.

1. Demand for variety ck:

The Lagrangian for the variety choice problem of a given product k is given by:

$$\mathcal{L}_k = \Big(\sum_{c\in\mathcal{C}_k} \lambda_{ck}^{\frac{1}{\sigma_k}} q_{ck}^{\frac{\sigma_k-1}{\sigma_k}}\Big)^{\frac{\sigma_k}{\sigma_k-1}} - \mu_k(E_k - \sum_{c\in\mathcal{C}_k} p_{ck}q_{ck})$$

Taking first order conditions with respect to q_{ck} gives us the following:

$$\frac{\partial\mathcal{L}_k}{\partial q_{ck}} = \Big(\sum_{c'\in\mathcal{C}_k} \lambda_{c'k}^{\frac{1}{\sigma_k}} \cdot q_{c'k}^{\frac{\sigma_k-1}{\sigma_k}}\Big)^{\frac{1}{\sigma_k-1}} \lambda_{ck}^{\frac{1}{\sigma_k}} \cdot q_{ck}^{\frac{-1}{\sigma_k}} - \mu_k \cdot p_{ck} = 0 \qquad \forall c \in \mathcal{C}_k$$

Take any two exporters c, c' and divide their first order conditions:

$$\begin{aligned}
&\Big(\frac{\lambda_{ck}}{\lambda_{c'k}}\Big)^{\frac{1}{\sigma_k}} \Big(\frac{q_{ck}}{q_{c'k}}\Big)^{\frac{-1}{\sigma_k}} = \frac{p_{ck}}{p_{c'k}} \\
\Leftrightarrow &q_{c'k}p_{c'k} = \frac{q_{ck}}{\lambda_{ck}} p_{ck}^{\sigma_k} \lambda_{c'k} p_{c'k}^{1-\sigma_k}
\end{aligned}$$

Substituting this expression into the expenditure constraint of product k gives us the conditional demand for variety ck:

$$\begin{aligned}
E_k &= \sum_{c'\in\mathcal{C}_k} p_{c'k}q_{c'k} \\
&= \frac{q_{ck}}{\lambda_{ck}} p_{ck}^{\sigma_k} \underbrace{\sum_{c'\in\mathcal{C}_k} \lambda_{c'k} p_{c'k}^{1-\sigma_k}}_{:=P_k^{1-\sigma_k}} \\
\Leftrightarrow\ q_{ck} &= \lambda_{ck}\ p_{ck}^{-\sigma_k}\ E_k\ P_k^{\sigma_k-1}
\end{aligned} \tag{A.4}$$

where E_k is the optimal expenditure on product k that is determined by solving the utility maximization problem across nests, given the full distribution of price indices $\{P_k\}_k$.

2. Expenditure on product k:

Next, we solve the top-level utility maximization problem to determine the optimal allocation of expenditures for each product category k. The Lagrangian for the expenditure allocation problem is given by:

$$\mathcal{L} = \big(\sum_k \lambda_k^{\frac{1}{\sigma}} U_k^{\frac{\sigma-1}{\sigma}}\big)^{\frac{\sigma}{\sigma-1}} - \mu(Y - \sum_k P_k U_k)$$

Taking first order conditions with respect to U_k gives us the following:

$$\frac{\partial \mathcal{L}}{\partial U_k} = \big(\sum_k \lambda_k^{\frac{1}{\sigma}} U_k^{\frac{\sigma-1}{\sigma}-1}\big)^{\frac{1}{\sigma-1}} \lambda_k^{\frac{1}{\sigma}} U_k^{\frac{-1}{\sigma}} - \mu P_k = 0 \qquad \forall k$$

Take any two products k, k' and divide their first order conditions:

$$\begin{aligned} &\big(\frac{\lambda_k}{\lambda_{k'}}\big)^{\frac{1}{\sigma}} \big(\frac{U_k}{U_{k'}}\big)^{\frac{-1}{\sigma}} = \frac{P_k}{P_{k'}} \\ \Leftrightarrow &U_{k'} P_{k'} = \frac{U_k}{\lambda_k} P_k^{\sigma} \lambda_{k'} P_{k'}^{1-\sigma} \end{aligned}$$

Substituting this expression into the budget constraint gives us the optimal expenditure on product k:

$$\begin{aligned} Y &= \sum_k P_k U_k \\ &= \frac{U_k}{\lambda_k} P_k^{\sigma} \underbrace{\sum_{k'} \lambda_{k'} P_{k'}^{1-\sigma}}_{:=P^{1-\sigma}} \\ \Leftrightarrow E_k = P_k U_k &= \lambda_k \; P_k^{1-\sigma} \; Y \; P^{1-\sigma} \end{aligned} \tag{A.5}$$

It remains to solve for the variety demand as function of variety prices p_{ck}, aggregate income Y, the aggregate Dixit-Stiglitz price index $P = \sum_k \lambda_k^{1\sigma} P_k$, elasticities of substitution σ_k and σ, and quality measures λ_{ck}, λ_k. We can do this, by substituting the expression for optimal sectoral expenditure E_k from (A.5) into the optimal product expenditure E_k from (A.5) and subsequently, the optimal product expenditure E_k into the optimal variety demand q_{ck} from (A.4). This gives us the following expression for variety demand:

$$X_{ck} := p_{ck} \cdot q_{ck} = \lambda_{ck} \; p_{ck}^{1-\sigma_k} \; \lambda_k P^{\sigma-1} \; Y \tag{A.6}$$

B.2.3 Identification and estimation

Note that from (A.6), we observe q_{ck}, p_{ck}, Y for each destination d, and assume parameters σ_k, σ by using estimates from the literature. We do not observe quality measures λ_k, λ_{ck} and therefore cannot directly solve for product-, and aggregate price indices P_k, P. We take logs and get the following expression for variety expenditure in destination d at time t:

$$\log(X_{ckdt}) = \log(\lambda_{ckdt}) + (1-\sigma_k)\log(p_{ckdt}) + \log(\lambda_{kdt}) + (\sigma-1)\log(P_{dt}) + \log(Y_{dt}) \tag{A.7}$$

We do not have sufficient variation to identify λ_{kdt} from the data, however, we can identify the *demeaned* variety-specific quality measure λ_{ckdt} from the following equation:

$$\log(X_{ckdt}) - (1-\sigma_k)\log(p_{ckdt}) = \alpha_{kdt} + \varepsilon_{ckdt} \tag{A.8}$$

where α_{kdt} are product-destination-time fixed effects that capture all variation that is common across varieties of the same product k in a given destination d and year t.

$$\begin{aligned}\alpha_{k'd't'} = {} & E[\log(\lambda_{ck'd't'})|k', d', t'] + \log\lambda_{k'd't'} + (\sigma_{k'} - \sigma_{s'})\log P_{k'd't} \\ & + \log\lambda_{s'd't'} + (\sigma_{s'} - \sigma)\log P_{s'd't'} + (\sigma-1)\log P_{d't'} + \log(Y_{d't'})\end{aligned}$$

It follows that

$$\varepsilon_{c'k'd't'} \equiv \log(X_{c'k'd't'}) - (1-\sigma_{k'})\log(p_{c'k'd't'}) - \alpha_{k'd't'} = \underbrace{\log(\lambda_{c'k'd't'}) - E[\log(\lambda_{ck'd't'})|k', d', t']}_{:=\tilde{\lambda}_{ckdt}\text{ Demeaned variety log quality}}$$

We estimate (A.8) by OLS and obtain the demeaned variety quality measure $\tilde{\lambda}_{ckdt}$ for each variety ck in each destination d and year t as the regression residual.