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Abstract

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Keywords: quality, products, unit value, trade, diversification, motor vehicles, Asia.
JEL: F14, F10, L62, L15.

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Measuring product-level export quality: Evidence from Asian motor vehicles sector

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We provide the combination of the Asian automotive trade case study and the analysis of indicators that may potentially reflect product quality. We try to assess the relevance of different indicators (particularly, weighted unit value, number of export lines, market share, Grubel-Lloyd index and relative net exports) for constructing an unbiased quality measure. We conclude that one should simultaneously use most indicators from the list to eliminate the impact of possible shocks on quality estimations.

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Introduction

Measuring quality of exported (or imported) products has always been a challenging problem. A common proxy for a product's quality is its export unit value, or export value divided by quantity (expressed in USD per ton or unit). This measure is quite popular due to high data availability at the finest levels of disaggregation.[2] Moreover, some studies show that export unit values at least correlate with relative capital abundance and per capita GNP at the country level (*Schott*, 2004, p. 647-648; *Aiginger*, 1997, p. 581).[3]

However, it has been also pointed out that unit values reflect both prices and quality. *Deaton* (1988) clearly emphasized this for household consumption. Yet, in trade studies unit values were simplistically used as proxies either for quality or for prices long after this statement. For example, *Greenaway et al.* (1994), *Fontagne and Freudenberg* (1997), *Azhar and Elliott* (2006), following *Abd-el-Rahman* (1991), all apply unit values to dissect intra-industry trade by product quality, making an assumption that unit values reflect quality. *Gaulier et al.* (2008), on the contrary, calculate international trade price indices relying on unit values. They state:

> *"Using unit values as proxies for prices is well-known to generate measurement bias, even at a fine level of aggregation. In particular, it is difficult to distinguish price from quality changes in such series. As this is the only source of information available on a worldwide basis, we nevertheless use unit values."* (p. 10)

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[2] The merchandise trade data is available up to the HS 6-digit level (more than 5000 products) worldwide.

[3] High-income and capital abundant countries are usually treated as producing higher-quality products.

This controversy in measuring product quality clearly needs clarification. One strategy is developing a theoretically founded model that accounts for different factors that may bias a simple (unit value) estimation of product quality and bringing it to data. Another strategy applied in this paper is calculating different indicators that (at least partially) should reflect quality in a context of a sector- and country-specific case study. Such a strategy applied to a well-documented case of product quality change may be fruitful in determining relevance of different indicators (unit values, market shares, number of export lines, etc.) for constructing a potentially unbiased quality measure.

The paper is organized as follows. In Section 1, we briefly review the literature related to measuring product quality of exported (or imported) products. In Section 2, we explain the strategy in detail and justify the choice of Asian motor vehicles trade for the case study. In Section 3, we present the results.

1. Literature

The issue of measuring export quality at the product level is addressed by a number of studies. *Khandelwal* (2010) assigns higher quality to products with higher market shares conditional on unit values (he relies on the nested logit framework and estimates quality as the sum of several fixed effects). *Hallak and Schott* (2011) propose a way to estimate export quality at the industry level under the assumption that a countries' export quality is constant across products within industries (they construct the Impure Price Index and decompose it into quality and quality-adjusted-price components assuming that the quality variation corresponds to variation in sectoral net trade). As a result, they assign different quality levels to countries with similar export prices but different international trade balances (positive net trade indicates higher quality).

However, *Feenstra and Romalis* (2014) demonstrate that Khandelwal's quality estimates are very strongly correlated with population (proxy for variety), and estimates by *Hallak and Schott* (2011) correlate with net trade in manufacturing products.[4] They propose an alternative measure of quality-adjusted prices that is estimated from gravity model and depends on c.i.f. and f.o.b. prices, fixed-cost variables (the ad valorem tariffs) and total import expenditure. Their export quality index obtained as the ratio of prices to quality-adjusted prices is not correlated with population or net trade but still weakly correlates with per capita income that should be the case (see *Hallak*, 2006).

[4] "The key lesson we take from these comparisons is that estimates for quality are very sensitive to proxies chosen for important model variables, whether it be population as the proxy for the number of firms or the manufacturing trade balance as a measure of demand." (*Feenstra and Romalis*, 2014, p. 522)

Earlier, *Hallak* (2006) proposed the two-step procedure to determine quality. At the first step, it is supposed that prices are formed by unobservable quality, exporter per capita income and distance. At the second step, unobservable quality (expressed through other variables from the previous step) is put into reduced-form gravity equation with importer and exporter fixed effects, distance and a set of standard trade determinants from the gravity literature. This helps to obtain bilateral quality estimates. Originally, the method was used to estimate the impact of product quality on the direction of trade: *Hallak* (2006) showed that rich countries tend to import relatively more from countries that produce high-quality goods. *Henn et al.* (2017) modify the approach to get quality estimates for more than 20 million product-exporter-importer-year combinations. But the results they report for selected sectors and countries (especially car sector for Japan and South Korea) seem a bit counterintuitive (see discussion in Section 2).

Khandelwal et al. (2013) and *Fan et al.* (2013) estimate quality via an empirical demand equation, given a certain value of elasticity of substitution in CES utility function (it may equal 4 or about that). Accounting for prices, country-year fixed effects and product fixed effects, they obtain estimation of quality as a residual. The intuition is quite simple: conditional on price, a higher quality variety is the one with a higher quantity. *Manova and Yu* (2017) use the same approach.

Byrne et al. (2017) argue that the share-based approach systematically understates the relative quality for entrants:

> *"In a setting where market frictions slow the rate of arbitrage across suppliers, new entrants may have low market shares even when offering the same price and quality as an incumbent supplier."* (p. 331)[5]

To account for this fact, they use long-run ratios of observed prices for each supplier to a baseline supplier (country), thus calculating quality adjustment factors. This is possible because, in the long run, frictions are eliminated. However, this method heavily relies on a restrictive assumption of constant relative quality, and there is also a need to define the long run (ideally that should be done for each product separately). So, this method is more precise than the share-based approach but potentially more time-consuming if one wants to analyze a wide set of products.

Di Comite et al. (2014) develop a model of verti-zontal differentiation in export markets that allows distinguishing tastes from quality (horizontal differentiation from vertical one).

[5] Costs of switching between suppliers are a good example of market frictions (*Byrne et al.*, 2017, p. 332).

This model relies on firm-level trade data but, under certain assumptions, may be also used at the product level as *Vandenbussche* (2014) does. She states:

> *"Company accounts data typically do not report how many products a firm sells or where it sells to. In order to assess quality of products in export markets on an EU wide scale, one needs to turn to country-product level data. In doing so we lose the firm-heterogeneity dimension, but in return we get a much wider coverage. Fortunately, the verti-zontal model, used here to construct the competitiveness indicators, is sufficiently flexible to allow for an interpretation at country-product level (where the "country" is the one of origin of the exports)."* (p. 22)

To determine quality rankings, this method applies information about prices (unit values) and markups (calculated by multiplying the Lerner index[6] by destination specific export unit values). *Vandenbussche* (2014) emphasizes that a clean separation of quality from taste effects in international trade is not possible under a standard CES approach due to a common elasticity of substitution between all products. In the described method, quality varies along products, while taste varies along countries and products.[7]

A number of papers study the links between product quality and other variables (such as export destination, wages, transport costs) at the firm level (*Bastos and Silva*, 2010; *Manova and Zhang*, 2012; *Martin*, 2012; *Brambilla and Porto*, 2016; *Flach*, 2016). These papers do not discuss the measurement of product quality in detail but provide some interesting facts that may be useful for a researcher.

2. Strategy and data

We apply a strategy of calculating indicators that should more or less reflect quality in a context of a sector- and country-specific case study. We focus on Asian motor vehicles international trade as a well-documented case of product quality upgrading.

We concentrate our attention on Asian motor vehicles trade for at least three reasons. First, there are several countries in the region that follow diverse paths of development in the automotive industry. Japan is the recognized leader from the very beginning of the period investigated (we have the data for 1988-2016). South Korea is a country that managed to increase its competitiveness substantially during the 2000s, relying on both quantitative expansion and qualitative upgrading. In China, more and more firms that

[6] Originally the Lerner index is calculated at the firm level for exporter countries. At the product level, the index is calculated relying on average variable cost per unit of sales for firms related to a product. So, even at the product level, the firm-level data is still necessary to use the method.

[7] The constant in the linear demand function represents the willingness to pay for the first unit of variety (or quality of the variety), while the slope is interpreted as the "taste-mismatch" between a consumer's ideal variety and the variety on offer (*Vandenbussche*, 2014, p. 19).

produce motor vehicles are established in recent years, and it also plays an important role in regional global value chains by importing intermediate products and exporting final products. And finally, Thailand is a country that is heavily engaged in car assembly under foreign brands. Second, global trade in motor vehicles has suffered particularly much from the 2008-2009 crisis (*Alessandria et al.*, 2010; *Bems et al.*, 2013). At the same time, a good quality measure should be relatively stable in time. That's why looking at the different indicators related with quality for automotive industry in time is a simple natural test of their potential suitability for a better quality measure. Third, it is relatively easy to get motor vehicles' quality assessments, at least compared with most of other products. J.D. Power annually publishes the Initial Quality Study that measures quality of the cars sold in the US (the study accounts for problems reported by the owners in the first 90 days of ownership).[8] The data is suitable to assess the track of relative quality for Japanese and Korean cars for the period 2012-2017. Of course, it is not enough for an extensive analysis, though it may be partially helpful for verification of the results.

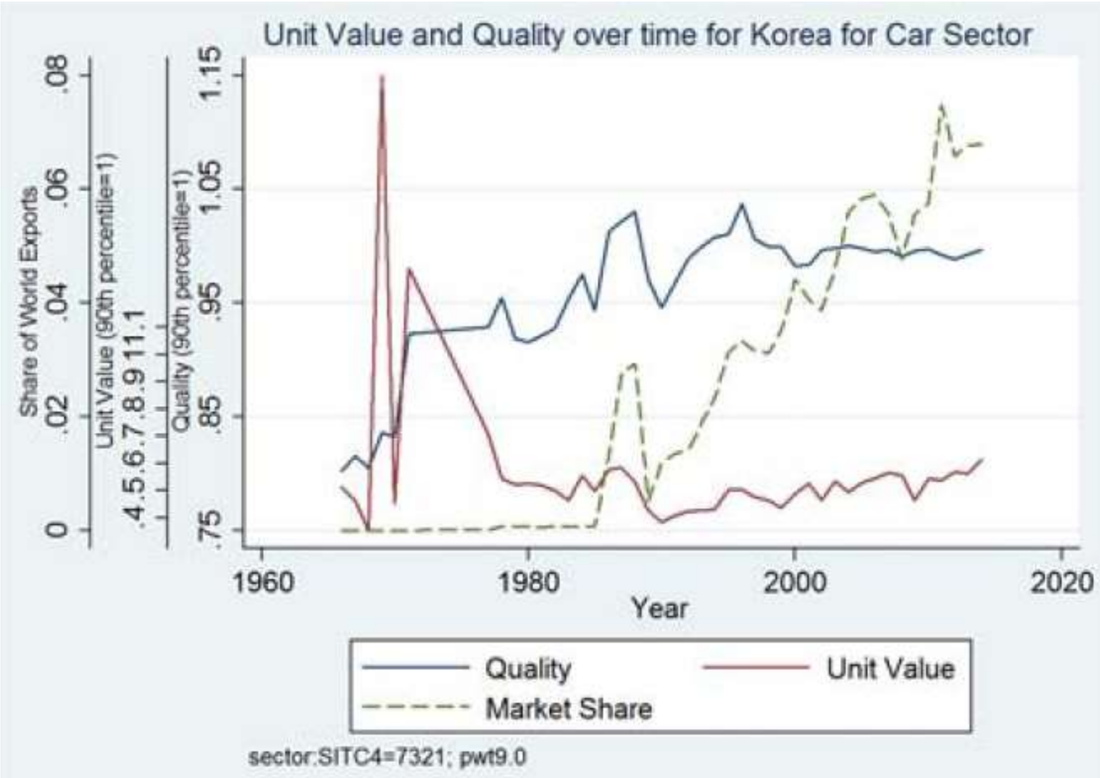
Importantly, quality estimates should go in line with the well-known facts. The milestones for Korean motor vehicles should be around 1998 and 2006:

> *"Hyundai – which controls the two affiliated South Korean brands – recognized that quality was poor and that without vast improvement the automakers had no chance of succeeding in the U.S. In 1998, Hyundai enacted a consistent and dedicated corporate directive to place quality before all else.*
>
> *[…] In 2006, amid criticism from U.S. reviewers that their vehicles looked "weird" and worse, Hyundai poached Peter Schreyer, an Audi designer who had gained renown for his role in the Audi TT sports coupe. Almost immediately, the reviews improved. Under his guidance, the award-winning Kia Soul and others were created."* [9]

Now look at the estimations provided by *Henn et al.* (2017). It is hard to explain why quality of Korean cars peaked at the end of 1990s (**Fig. 1**), while the corporate directive concerning quality was enacted only in 1998. According to J.D. Power Special Power Report on Kia (July 2016), the brand's quality was gradually improving during 2002-2007 and 2011-2016, from below industry average to leading the industry.[10] Starting in 2014, Korean motor vehicles experienced a spectacular rise in quality (**Fig. 2**). Interestingly, the share of Hyundai Motor Company's employees involved in R&D surged from 6.0% in 2000 to 14.1% in 2012, while there were no employees in R&D job category in 1996 (*Jo et al.*, 2016, p. 60). All these facts may not be reflected in the advanced, well-grounded

[8] http://www.jdpower.com/press-releases/2017-us-initial-quality-study-iqs.
[9] http://fortune.com/2015/06/29/korean-japanese-cars-quality/.
[10] http://www.jdpower.com/sites/default/files/kia_2016iqs_spr-2pg_medium.pdf.

estimations of the type provided by *Henn et al.* (2017). This justifies our choice to look at the indicators potentially relevant for estimating quality in a context of a case study.



Source: *Henn et al.* (2017, p. 27, figure 3)

Fig. 1 – Quality and unit values for Korean passenger motor car exports

Calculated based on: J.D. Power Initial Quality Studies for 2012-2017

Fig. 2 – Dynamics of the average quality rating for Japanese and Korean cars

The motor vehicles sector is an aggregate from 48 commodities at the 6-digit HS-1992 classification (**Tab. 1**).

Tab. 1 – The commodity composition of motor vehicles industry

HS code	**HS commodity group name**	**No. of 6-digit commodities**
87	Vehicles other than railway, tramway	48
8701	Tractors (other than works, warehouse equipment)	1
870110	Pedestrian controlled tractors	-
870120	Road tractors for semi-trailers (truck tractors)	1
870130	Track-laying tractors (crawlers)	-
870190	Wheeled tractors nes	-
8702	Public-transport type passenger motor vehicles	2 (all)
8703	Motor vehicles for transport of persons (except buses	9 (all)
8704	Motor vehicles for the transport of goods	7 (all)
8705	Special purpose motor vehicles	-
8706	Motor vehicle chassis fitted with engine	1 (all)
8707	Bodies (including cabs), for motor vehicles	2 (all)
8708	Parts and accessories for motor vehicles	15 (all)
8709	Work truck, self-propelled, except lift trucks etc	3 (all)
8710	Tanks and other armoured fighting vehicles	-
8711	Motorcycles, bicycles etc with auxiliary motor	6 (all)
8712	Bicycles, other cycles, not motorized	-
8713	Invalid carriages, wheelchairs, including motorized	-
8714	Parts and accessories of bicycles, motorcycles, etc	2
871411	Motorcycle saddles	1
871419	Motorcycle parts except saddles	1
871420	Wheelchair parts	-
871491	Bicycle frames and forks, and parts thereof	-
871492	Bicycle wheel rims and spokes	-
871493	Bicycle hubs, free-wheel sprocket wheels	-
871494	Bicycle brakes, parts thereof	-
871495	Bicycle saddles	-
871496	Bicycle pedals/crank-gear, parts thereof	-
871499	Bicycle parts nes	-
8715	Baby carriages and parts thereof	-
8716	Trailers and non-mechanically propelled vehicle nes	-

Compiled based on: Harmonized System 1992 classification

We provide calculations for a set of indicators for Korea, Japan, China and Taiwan (the data comes from UN COMTRADE):

- Weighted unit value;
- Number of export lines;
- Export share;
- Grubel-Lloyd index;
- Relative net exports.

2.1. Weighted unit value

Among the indicators listed above, weighted unit value is the most difficult indicator to calculate. Most problems are generated by the poor quality of international trade data on quantities (most often, kilograms[11]) that is mentioned, for example, by *Silver* (2007).[12]

Some countries may report data only on trade values but not on trade quantities for the same product. For instance, China has not reported any trade quantity in kilograms for 2581 out of 5053 product-partner records for motor vehicles sector in 2012 (51.1%), while in 2011 and 2013 product-partner records with unreported trade quantity in kilograms accounted only for 0.8 and 4.2%, respectively. To eliminate such problems, we estimate trade quantity in kilograms by obtaining an unweighted average "net weight per item" coefficient among trade partners for every commodity-year pair.[13]

Other countries may report data on quantities with serious errors (for example, the data in tons may be reported as the data in kilograms). This may result in outliers. Consider a simple case. In 1988, Korean exports of automobiles with spark ignition engine of 1500-3000 cc (HS 870323) to Panama amounted 1027.6 thousand USD and 70112 tons; in 1989, the same trade flow amounted 1366.8 thousand USD and 211 tons! To account for such problems, we perform the following procedure (separately for each commodity-partner record to detect outliers across years and for each commodity to detect outliers across partners). We calculate the ratio of a unit value to the mean for unit values below the mean and the ratio of the mean to a unit value for unit values above the mean. Then we divide the resulting ratio by the ratio of the mean plus three standard deviations to the mean. Thus we obtain the indicator reflecting deviations of unit values from the threshold specific for each commodity-partner pair or each commodity. This helps us to detect outliers. We cautiously treat records with deviations indicator exceeding 0.9995 percentile (over the whole sample) as an outlier. For the case of Korea, this results in only 56 observations excluded (out of 69081).

Finally, weighted unit value for the motor vehicles sector is calculated using quantities in kilograms as weights. Then the resulting figure is decomposed into the contribution of the most important commodities. Analyzing the proportions between commodities may also prove to be a fruitful approach.

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[11] We prefer to use net weight in kilograms rather than units because the former contains much less outliers than the latter.

[12] He also notes that unit values may be biased due to changes in the mix of product varieties. However, it seems impossible to track such changes at the 6-digit level. Unfortunately, 10-digit level trade statistics is not standardized by countries (EU is the exception) and is not readily available worldwide. Though, a possibility of changes in the mix of product varieties should be kept in mind.

[13] By averaging the coefficients for trade partners, we mitigate the effect of outliers.

2.2. Number of export lines

The number of export lines (commodity-partner records) may correlate both with costs of production and quality. To distinguish between these cases, we propose to look at the number of export lines and the weighted unit value simultaneously. If high growth rate of number of export lines reflects low costs of production, the increase in unit value should be rather small. Otherwise, the unit value should grow faster.

We calculate the number of export lines to reflect export diversification. Note that we intentionally prefer this way of accounting for diversification to a standard approach of calculating concentration indices, such as Herfindahl-Hirschman index. The motivation is simple: the values of standard concentration indices are affected by changes in the shares of top importers (such changes may be often driven by business cycles in these countries, not quality).

The number of export lines is also a good indicator to account for differences in tastes, since a high-quality product can gain its market position in a large number of countries, irrespective of variation in tastes.

2.3. Export share

The share of a country in the world exports for a commodity is the well-known indicator often used to estimate quality while combined with unit value. However, in our opinion, this indicator is quite noisy, since it is affected by the level of competition on the world market (the shares of other exporter countries), direction of trade, costs of production and some other factors. Nevertheless, it may partially reflect quality as well, so we have decided to calculate this indicator for our pool of countries.

2.4. Grubel-Lloyd index

Grubel and Lloyd (1975) index was originally proposed to calculate the share of intra-industry trade – that is, the degree of trade overlap between export and import trade flows at the commodity level. At the detailed product level, the high degree of such overlap is possible only for trade in differentiated products (a country may export and import varieties of the same product that differ in characteristics such as quality, design, etc.). So, we suppose that countries intensively involved into intra-industry trade should, *ceteris paribus*, export higher-quality products.

We calculate Grubel-Lloyd index for motor vehicles sector as the weighted sum of the indices for 6-digit commodities using trade turnover for weighting.

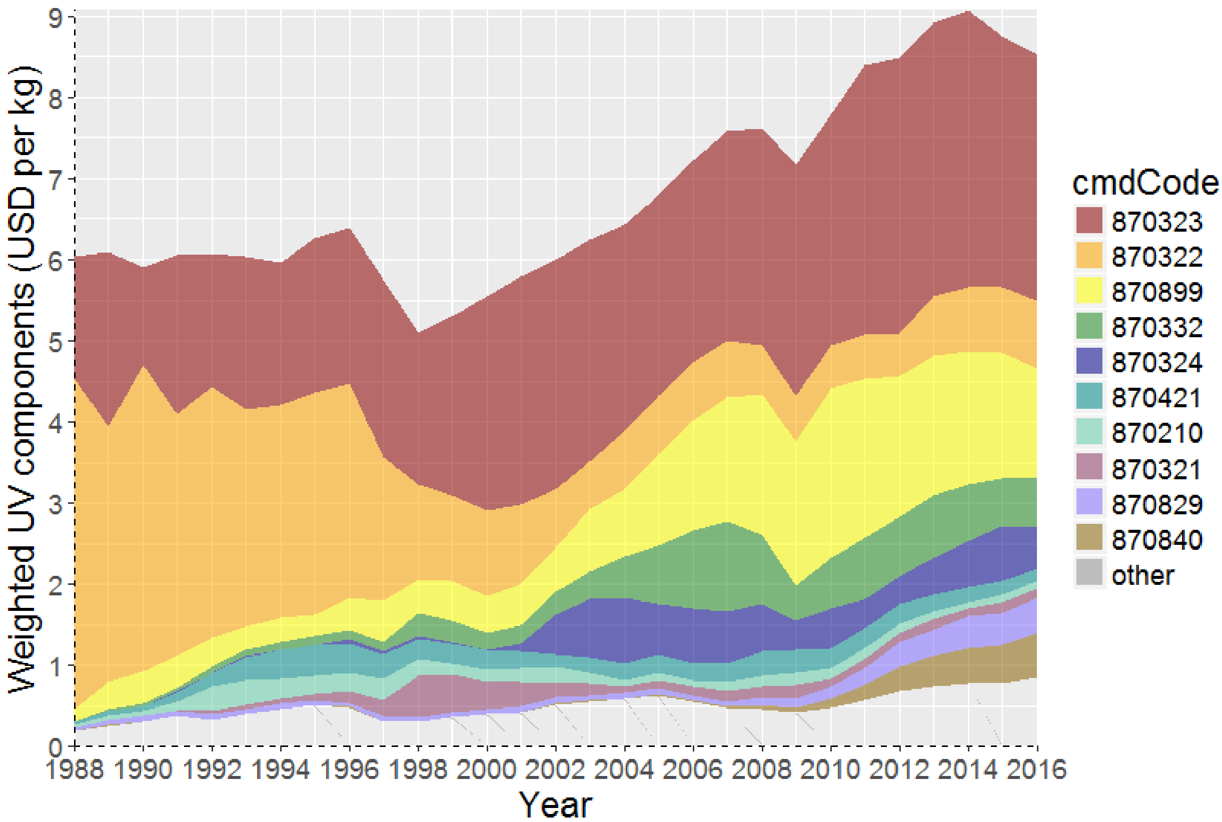
2.5. Relative net exports

We calculate relative net exports as the ratio of trade balance to trade turnover for the whole sector (varies from -100 to 100). This indicator helps to approximate the dynamics of the relative value added generated by motor vehicles trade. First, net exports are one of the components of GDP. Second, net exports for aggregated sector reflect both the key imported inputs (parts and components) and exports. Note that the absolute value of relative net exports and Grubel-Lloyd index are linear combinations of each other at the detailed product level, but may not correlate at the sector level due to different aggregation procedures that we apply to these indicators.

3. Results

3.1. Korea

During the 2000s, Korea experienced growth in its weighted unit value for the sector, after the drop in 1997-1998 (**Fig. 3**). The drop was primarily associated with the decline of US imports for automobiles with spark ignition engine of 1000-1500 cc (HS 870322) due to oil shock: some consumers switched to buying automobiles with spark ignition engine of 1500-3000 cc (HS 870323). See **Fig. 4** and *Ramey and Vine* (2011) for discussion of the impact of oil shocks on the US economy and on the motor vehicles industry.



Calculated based on: UN COMTRADE

Fig. 3 – Decomposition of Korean weighted unit value for motor vehicles sector

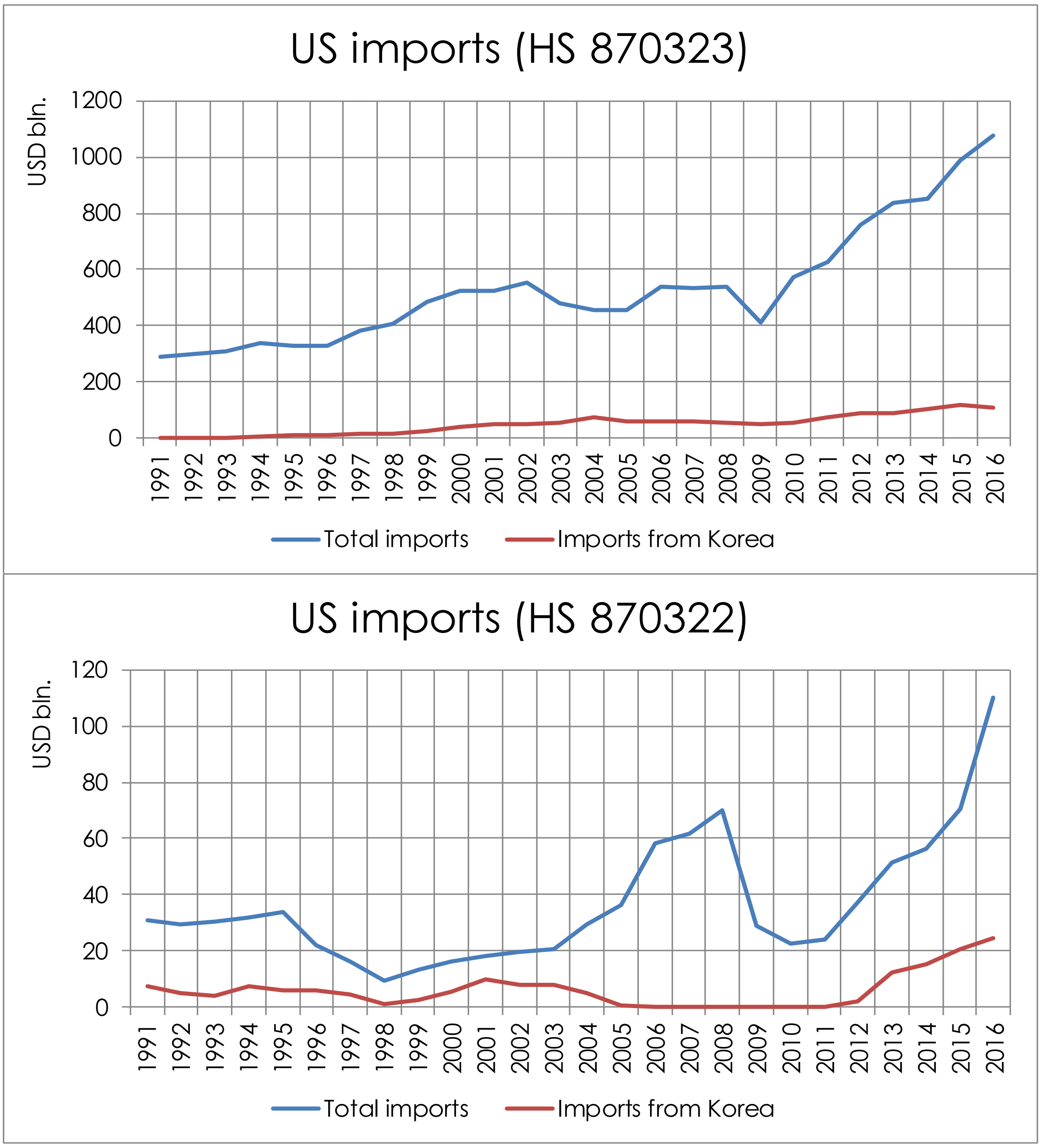


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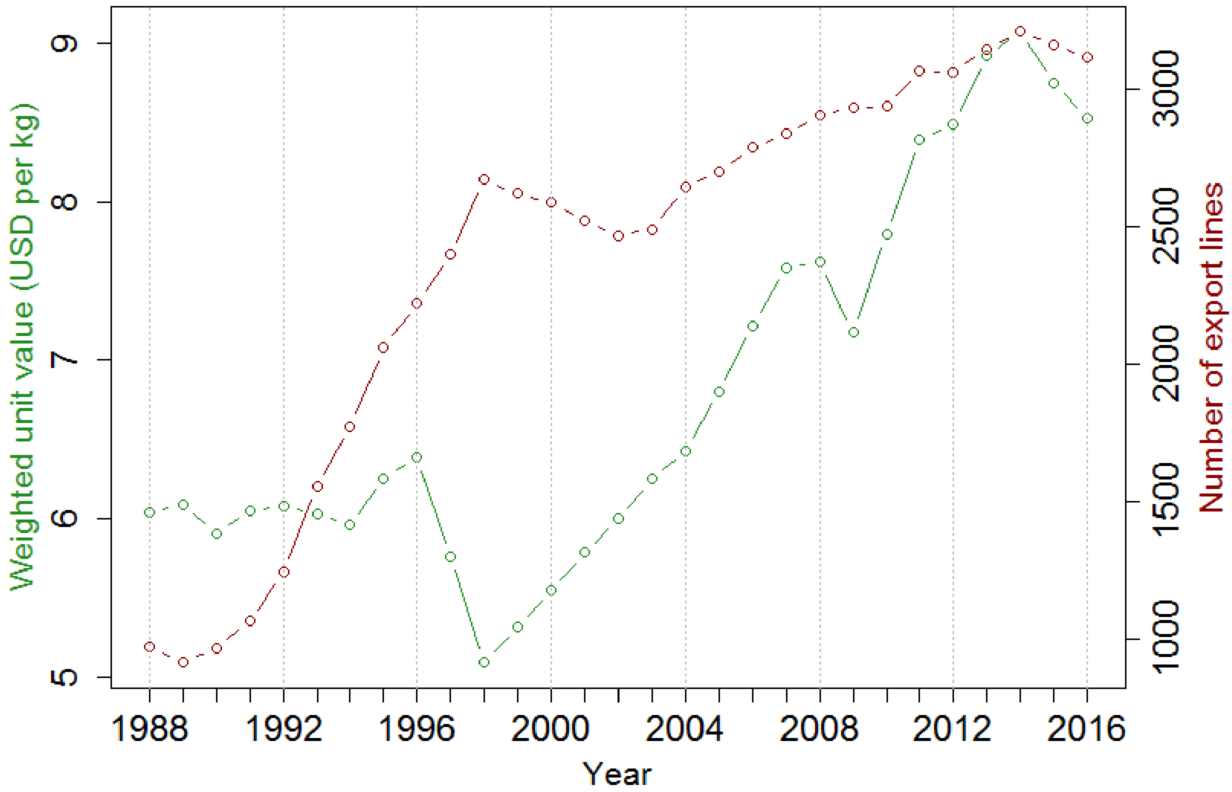
Fig. 4 – US imports of automobiles with spark ignition engine of 1000-3000 cc

The dynamics of the sector's weighted unit value components is ambiguous. First, there is a clear trend that automobiles with spark ignition engine of 1500-3000 cc (HS 870323) and motor vehicle parts not either specified (HS 870899) are becoming more and more important for the dynamics of the weighted unit value. Second, parts and accessories of bodies for motor vehicles (HS 870829) and transmissions for motor vehicles (HS 870840) are quickly gaining importance in recent years. Finally, automobiles with spark ignition engine of 1000-1500 cc (HS 870322) affect the unit value for the sector less than before.

Generally, it seems that unit values correlate with quality. However, it may also reflect macro shocks. The drop in the unit value is also pronounced at the HS 6-digit level – for example, for automobiles with spark ignition engine of 1000-1500 cc (HS 870322).

So, we combine the information on the weighted unit value and export diversification (**Fig. 5**). One can distinguish the three stages of Korean motor vehicles exports. During the first stage (1988-1998), the number of export lines expanded rapidly, though the unit value remained stable. During the second stage (1999-2003), the weighted unit value grew quickly, though export diversification even declined. During the third stage (2004-2016), Korea experienced growth for both indicators. Interestingly, Kia historical IQS rank performance published by J.D. Power in Special Power Report on Kia in July 2016 shows that the ranks were improving during 2002-2006 and 2011-2016 (the dates quite close to the third stage).[14] However, according to J.D. Power, quality should peak in 2015-2016, that is not exactly the case in **Fig. 5**.

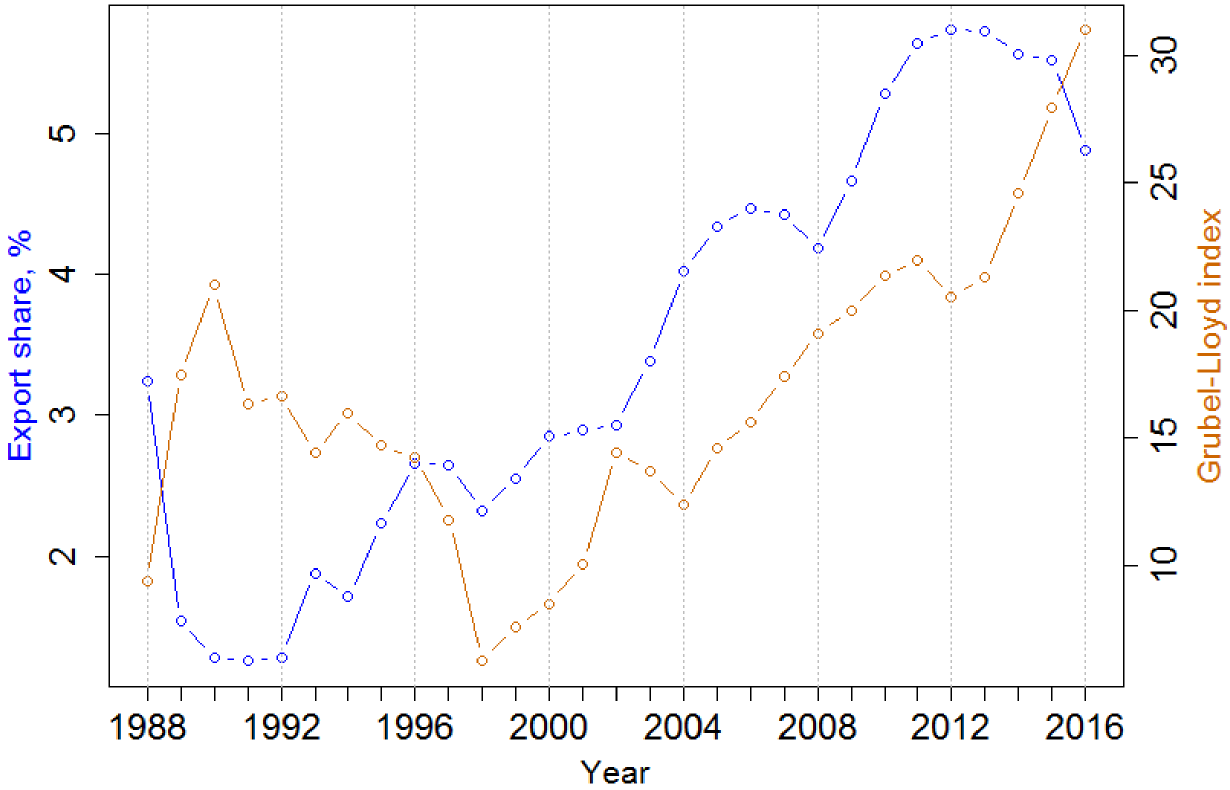


Calculated based on: UN COMTRADE

Fig. 5 – Korean weighted unit value and export diversification for motor vehicles sector

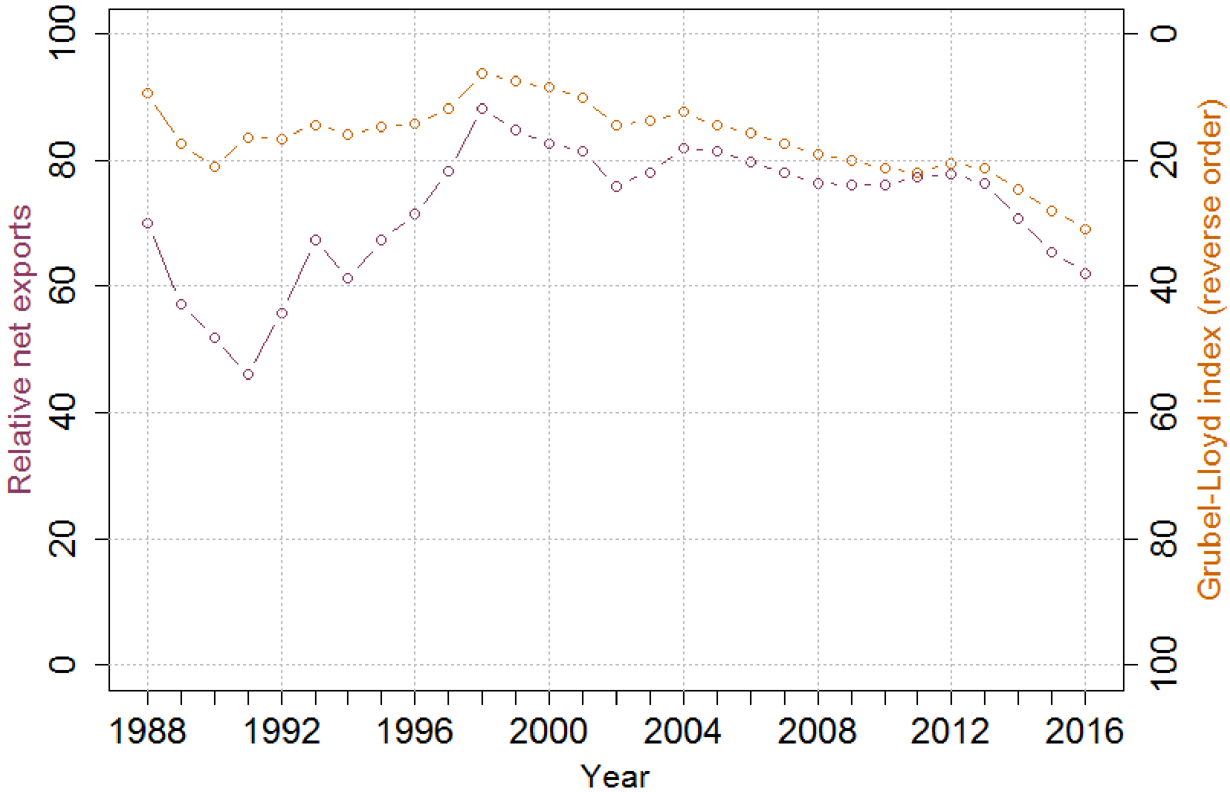
Now look at the export share and Grubel-Lloyd index for Korean motor vehicles sector (**Fig. 6**). It is worth mentioning that Grubel-Lloyd index indicating the extent of product differentiation (intra-industry trade share) surged dramatically in 2014-2016. Considering the results from **Fig. 5**, Grubel-Lloyd index seems to be a very important component for a potential product quality measure. **Fig. 7** demonstrates that the gap between relative net exports and Grubel-Lloyd index has narrowed considerably that marks the growing role of product differentiation compared to participation in supply chains.

[14] http://www.jdpower.com/sites/default/files/kia_2016iqs_spr-2pg_medium.pdf.



Calculated based on: UN COMTRADE

Fig. 6 – Korean export share and Grubel-Lloyd index for motor vehicles sector



Calculated based on: UN COMTRADE

Fig. 7 – Korean relative net exports and Grubel-Lloyd index for motor vehicles sector

3.2. Japan

Primarily, one should bear in mind that Japanese trade in motor vehicles was affected by a number of important circumstances. First, Japan and the US signed a trade agreement on the 29th of June, 1995 (*Katzner and Nikomarvo*, 2005). As a result, the share of American cars at the Japanese market increased sharply (*Atsumi*, 2015). However, "in 1996, Japan decided to scrap all efforts at one-on-one trade negotiations with the United States" (*Katzner and Nikomarvo*, 2005, p. 28). Eventually, the American automotive exports to Japan decreased from the peak of almost 5 billion USD in 1995 to less than 4 billion in 1997 and around 2.5-3 in 1999-2003 (*McAlinden and Chen*, 2012). At the same time, the American auto parts exports to Japan remained quite stable.

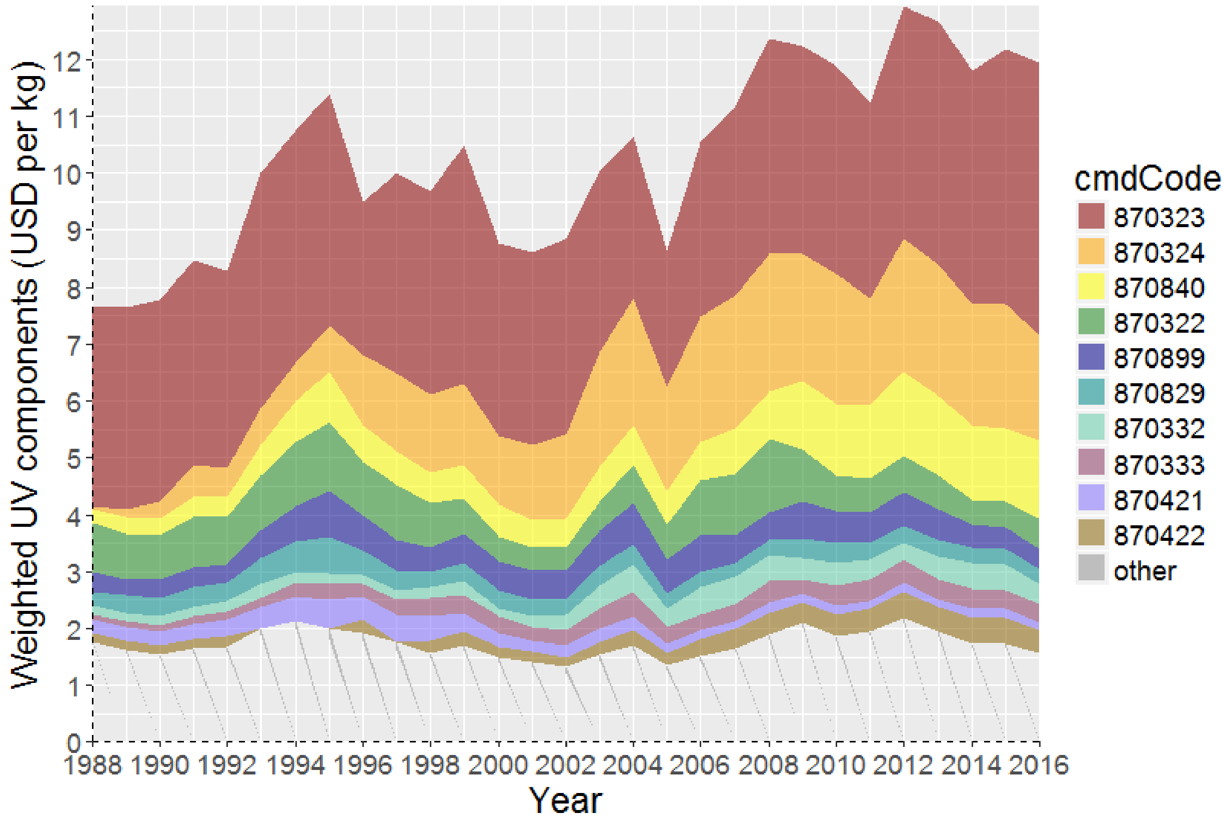
Second, Japanese car exports and production were hit severely by the 2008-2009 world crisis. During 2010-2014, Japanese car production has not recovered even to the level of 2001 that is the lowest level of production for the period 1993-2008 (*Atsumi*, 2015, p. 67, figure 3). Such a drop was caused by a sharp decline in spending on motor vehicles in many economies, especially the US (*Sommer*, 2009). *Van Biesebroeck and Sturgeon* (2010) state:

> *"High cost and growing longevity of motor vehicles prompted buyers to postpone purchases that they might otherwise have made. Consumers, especially in the world's largest national passenger vehicle market, the United States, found it difficult to obtain loans for purchase and, driven by fear of job loss, moved aggressively to increase their rate of saving. Vehicle sales plunged, and as a result, beginning in the fall of 2008, the industry fell into the most severe crisis experienced since the Great Depression."* (p. 215)

The weighted unit value for the Japanese motor vehicles sector looks quite volatile and do not have a clear upward trend (**Fig. 8**). The low level in 2000-2005 was associated with the decrease in unit value of automobiles with spark ignition engine of 1500-3000 cc (HS 870323), and the subsequent growth was related both to the recovery in the unit value for HS 870323 and to the rapid increase of the contribution of automobiles with spark ignition engine of >3000 cc (HS 870324) and transmissions (HS 870840).[15]

Fig. 9 demonstrates that the number of export lines did not have the trend as well. However, it suffered in 2008-2009 much: by 2011, the level of export diversification in Japanese motor vehicles industry became the lowest since 1988! This fact causes some concerns about the resistance of this indicator to macro shocks.

[15] The drop of the unit value for HS 870323 in 2000 was primarily related to the US market, while the recovery in 2006 was associated with the growing importance of other markets such as Russia and China.



Calculated based on: UN COMTRADE

Fig. 8 – Decomposition of Japanese weighted unit value for motor vehicles sector

Calculated based on: UN COMTRADE

Fig. 9 – Japanese weighted unit value and export diversification for motor vehicles sector

Grubel-Lloyd index looks like an indicator that was generally less volatile (**Fig. 10**). At the same time, it was highly affected by the impermanent intensification of motor vehicles trade with the US in 1995-1996, while the change in the weighted unit value and in the number of export lines in the same period was much smaller. Importantly, it was also affected by the 2008-2009 crisis: just after this period, Grubel-Lloyd index started to grow steadily. The market share, on the contrary, has experienced a stable downward trend that indicates the competition strengthening.

Interestingly, the gap between relative net exports and Grubel-Lloyd index is very low (**Fig. 11**). This means that Japan is not heavily involved in exporting final use products relying on intermediate inputs. Note that Japan still maintains a strong comparative advantage in motor vehicles industry marked by high and positive relative net exports. At the same time, according to J.D. Power Initial Quality Studies (see **Fig. 2**), the quality of Japanese cars was about industry average during 2012-2017.

So, Japan is stuck in the situation of the high unit value premium relative to the quality premium. However, its export market share is still larger than the one for South Korea or other Asian countries.

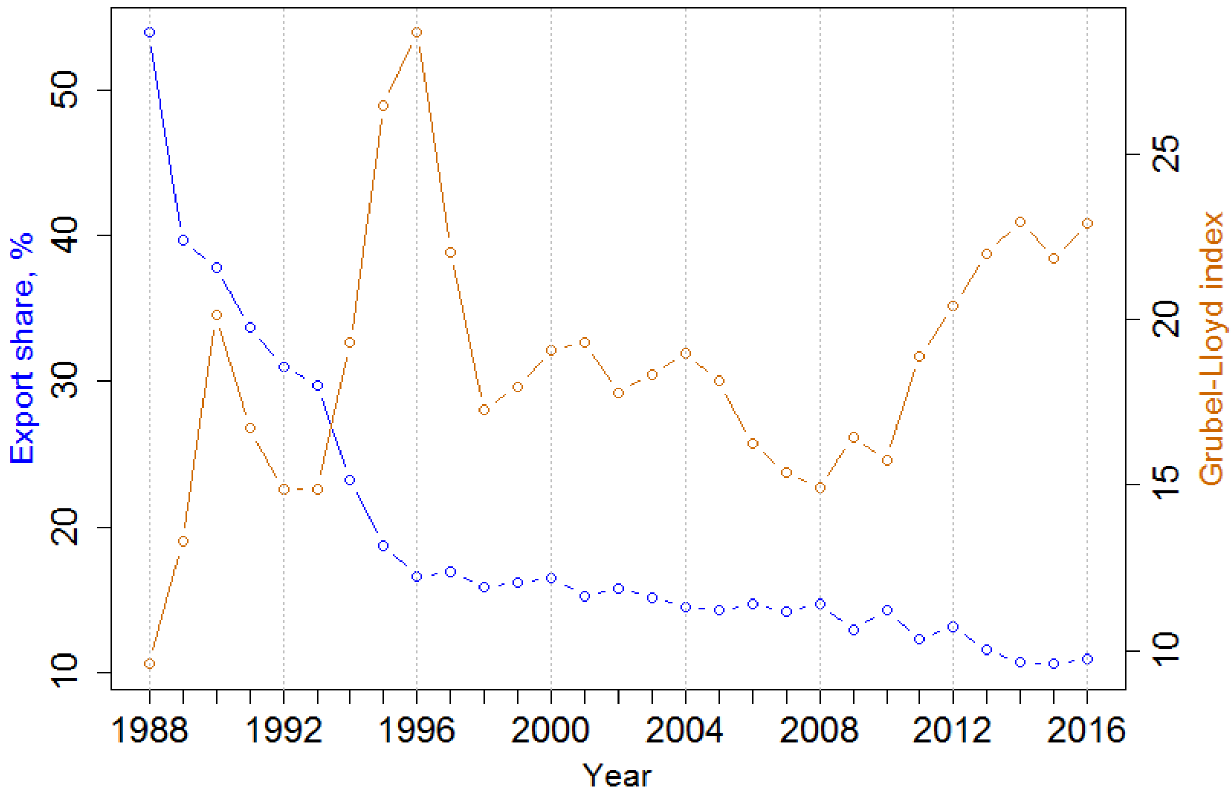


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Fig. 10 – Japanese export share and Grubel-Lloyd index for motor vehicles sector

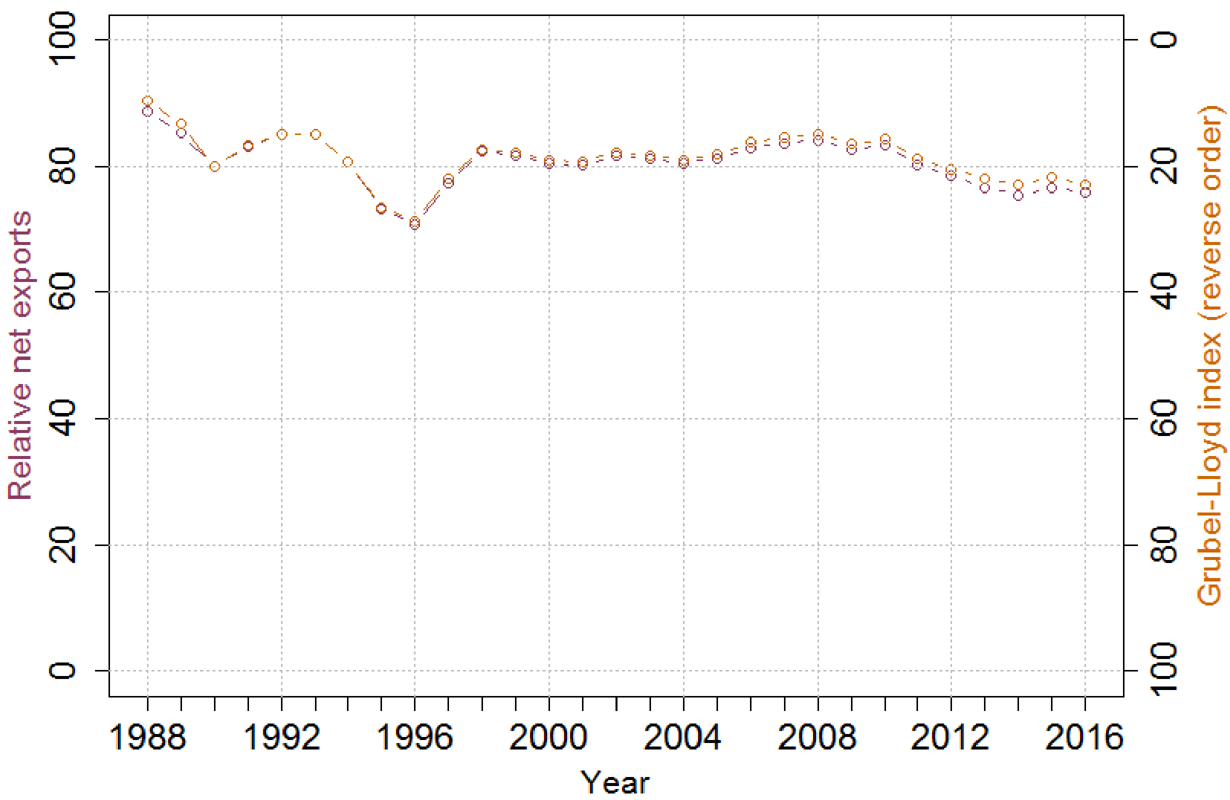

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Fig. 11 – Japanese relative net exports and Grubel-Lloyd index for motor vehicles sector

3.3. China

For China, the contribution of commodities to the weighted unit value for the motor vehicles sector is distributed almost evenly (**Fig. 12**), and the share of other commodities (not depicted in the figure) is high. This means that China simultaneously develop the wide range of products in the sector, unlike Korea or Japan. However, note that top 5 commodities represent parts and accessories for motor vehicles (HS 8708), motorcycles (HS 8711) and parts of motorcycles (HS 8714), while the contribution of passenger motor cars (HS 8703) is rather small.

The number of export lines experienced a spectacular rise from less than 2.5 thousand in 2002 to around 5 thousand in 2008 (**Fig. 13**)! Thus China has reached the level of export diversification typical for Japan. After 2008, the number of export lines grew much slower, while the weighted unit value continued to grow at the same pace, as well as the export share (**Fig. 14**). Grubel-Lloyd index and relative net exports did not go in line with each other (**Fig. 15**). This indicates that trade balance was mainly driven by comparative advantage, not product differentiation. The decline of the relative net exports after 2008 was related to a considerable surge in imports of automobiles with spark ignition engine of >1500 cc (HS 870323, 870324) and transmissions (HS 870840).

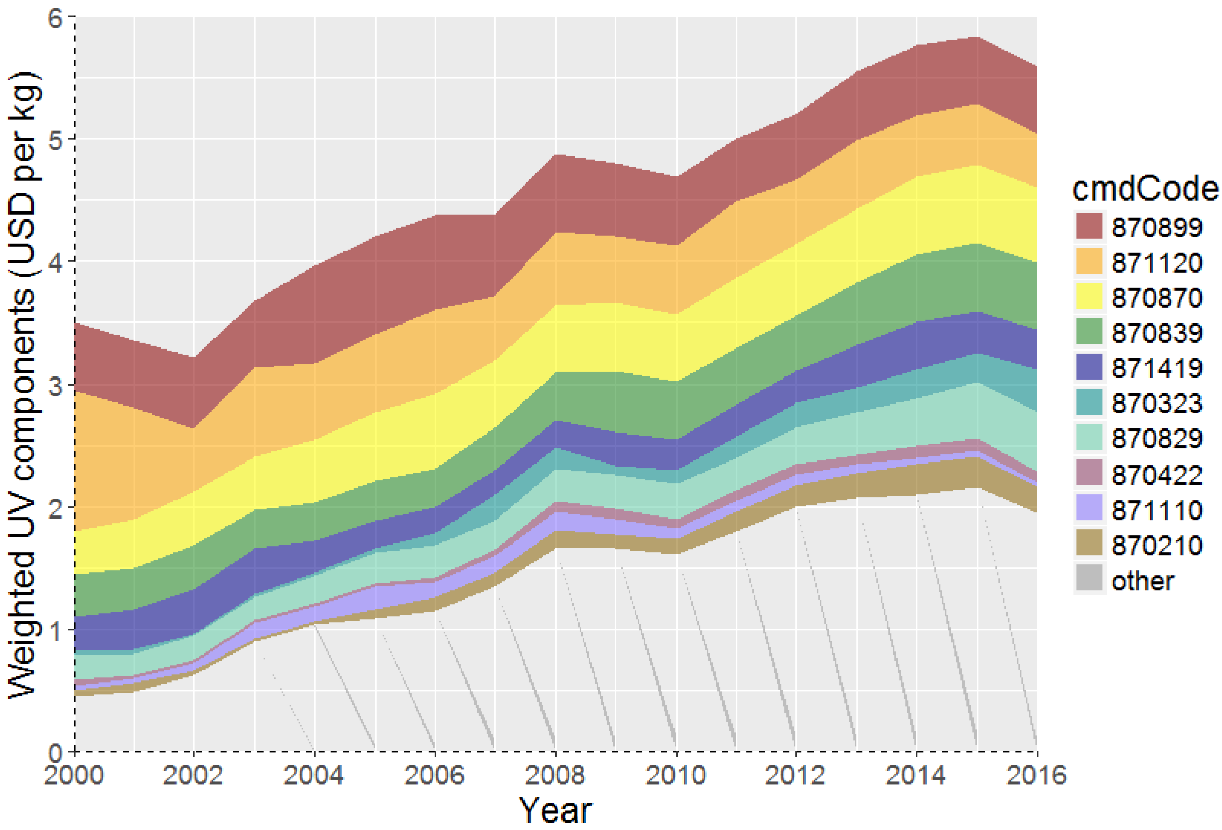

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Fig. 12 – Decomposition of Chinese weighted unit value for motor vehicles sector

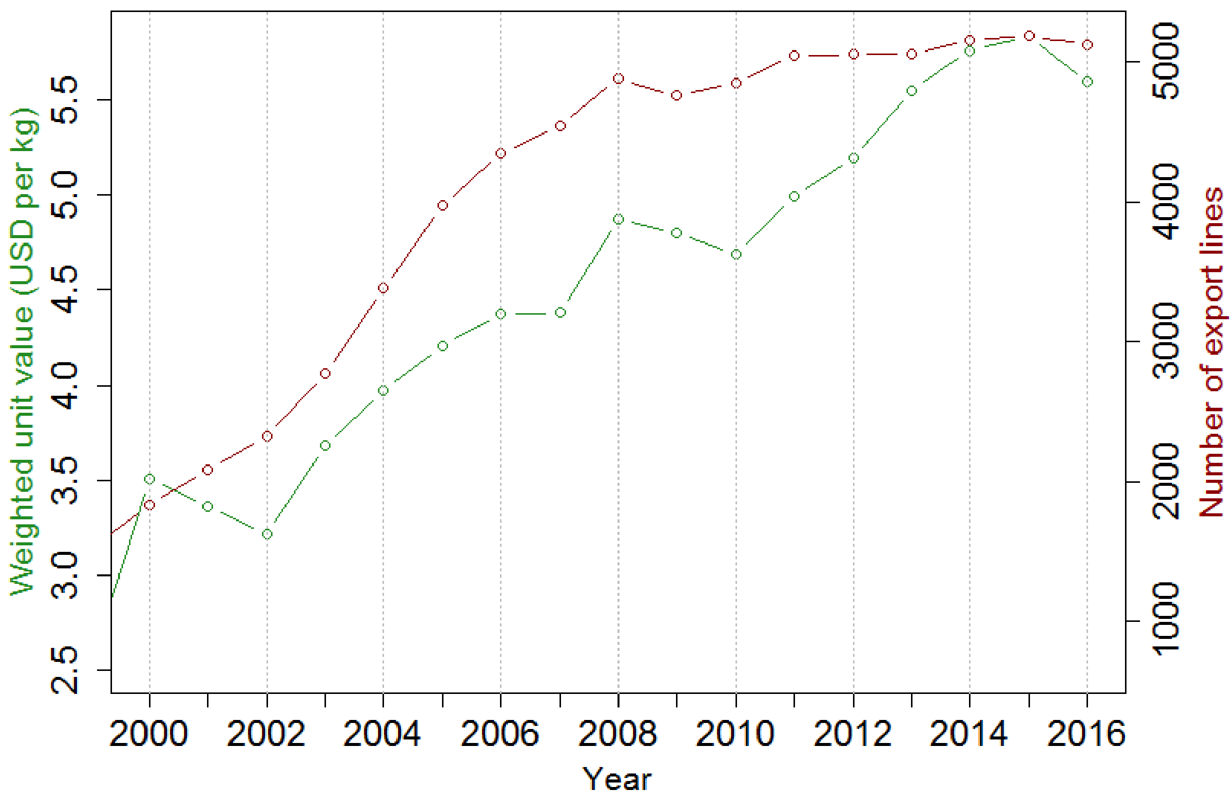

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Fig. 13 – Chinese weighted unit value and export diversification for motor vehicles sector

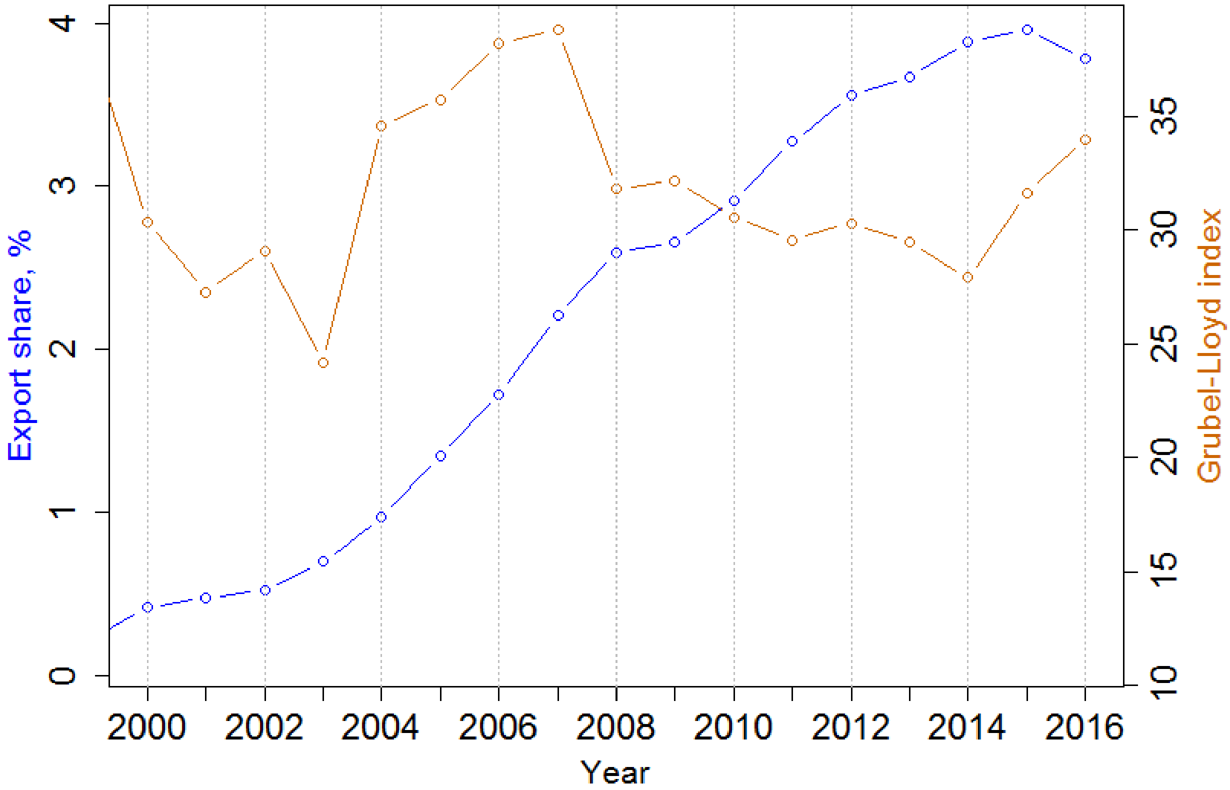

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Fig. 14 – Chinese export share and Grubel-Lloyd index for motor vehicles sector

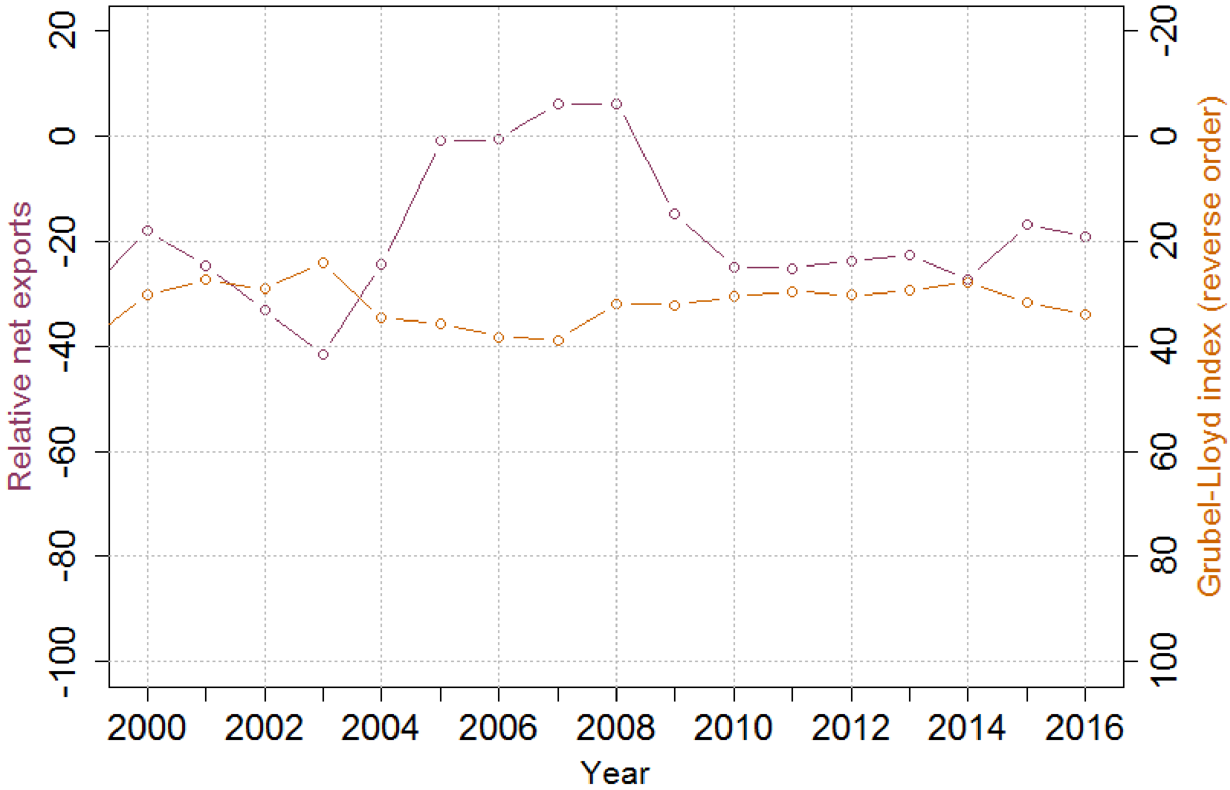

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Fig. 15 – Chinese relative net exports and Grubel-Lloyd index for motor vehicles sector

Note that negative net exports indicate the absence of comparative advantage. It shows that China is still unable to be one of the global leaders of the motor vehicles industry, as the internal market is heavily dependent on imports (local producers are unable to meet the growing needs of consumers). Increasing unit value is currently a weak evidence of quality upgrading in the absence of comparative advantage and an unclear trend in the extent of product differentiation (Grubel-Lloyd index). *Li et al.* (2016) show that the motor vehicles sector in China has undergone a considerable upgrading, though this process was focused primarily on low value-added activities. Also, *Lockstrom et al.* (2011) document the low extent of domestic supplier integration (joint product development and production planning activities) between local buyers and foreign suppliers.

3.4. Thailand

By the mid-2000s, Thailand has become a large regional hub of automotive production for leading carmakers (*Kohpaiboon*, 2008). The country succeeded by relying on the collaboration between firms in the national innovation system and developing intra-industry trade (*Intarakumnerd and Techakanont*, 2016).

The average growth pace of the weighted unit value for Thai motor vehicles sector was notably high (**Fig. 16**). It exceeded the one for Korea, China and Japan. Motor vehicles for the transport of goods (HS 8704) made the largest contribution.

Interestingly, the growth rates of the weighted unit value and the number of export lines nearly mirror each other (**Fig. 17**). They both grew almost twice since 2000, while the export share quadrupled (**Fig. 18**). Intra-industry trade peaked in 2012, reaching the highest level among other Asian countries under consideration.

Note that relative net exports started to grow in 2004 and achieved a level of around 40-50 per cent in 2006, compared to less than 20 per cent in 2000-2003 (**Fig. 19**). This clearly indicates that the country received a considerable bonus in terms of value added, unlike China. Yet, it has managed to combine the growth in relative net exports and intra-industry trade share that looks like an impressive achievement.

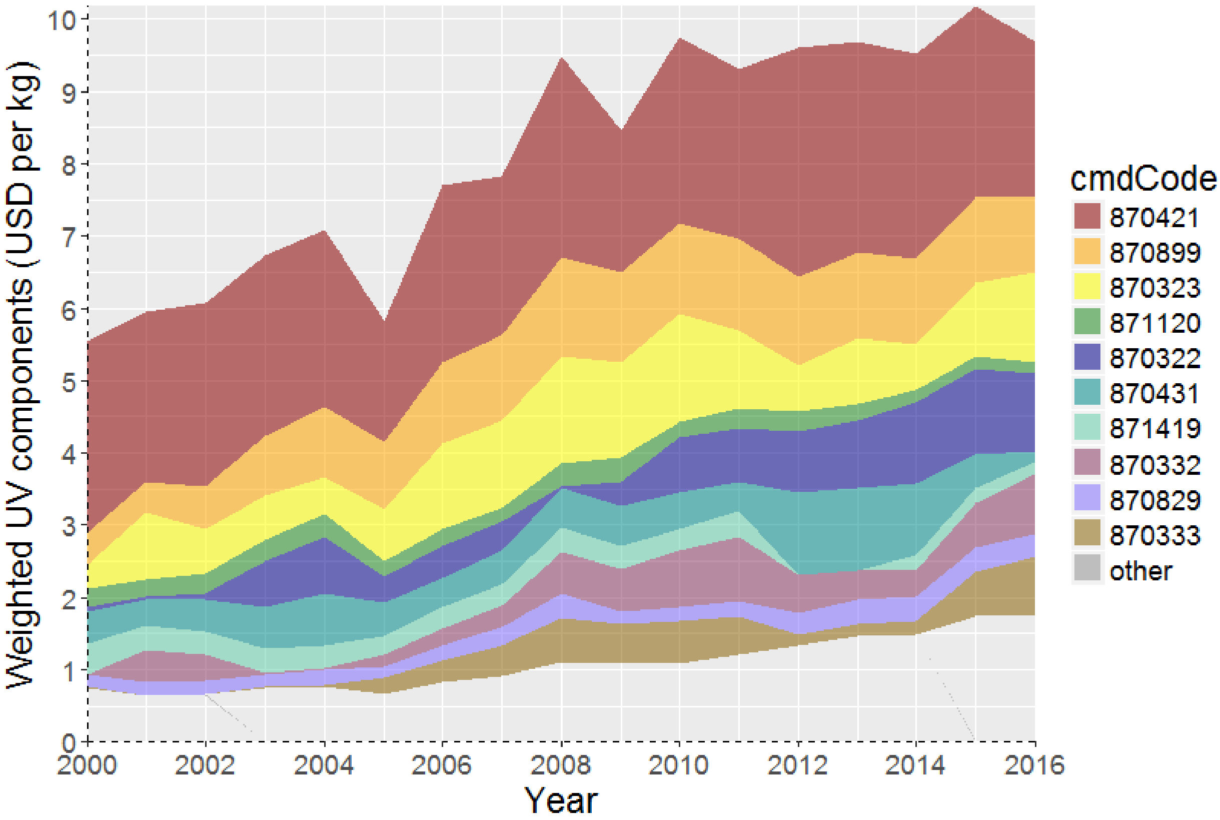

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Fig. 16 – Decomposition of Thai weighted unit value for motor vehicles sector

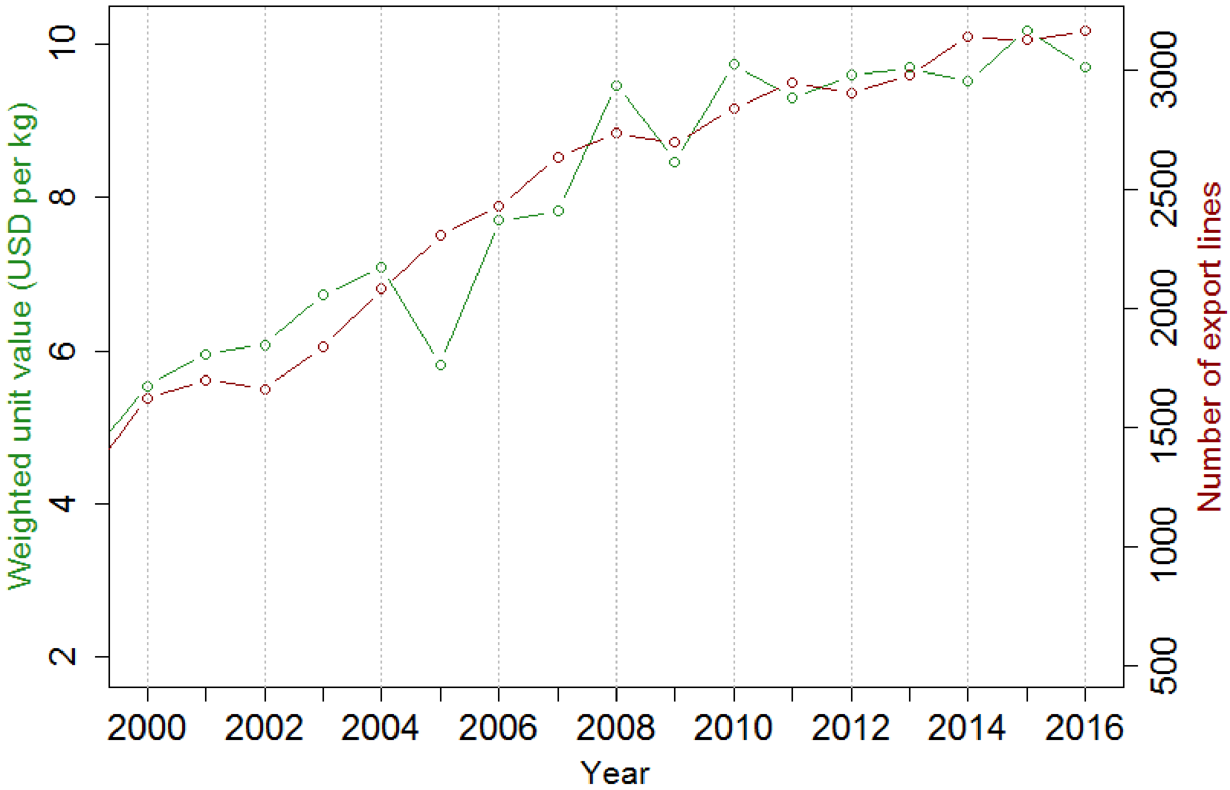

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Fig. 17 – Thai weighted unit value and export diversification for motor vehicles sector

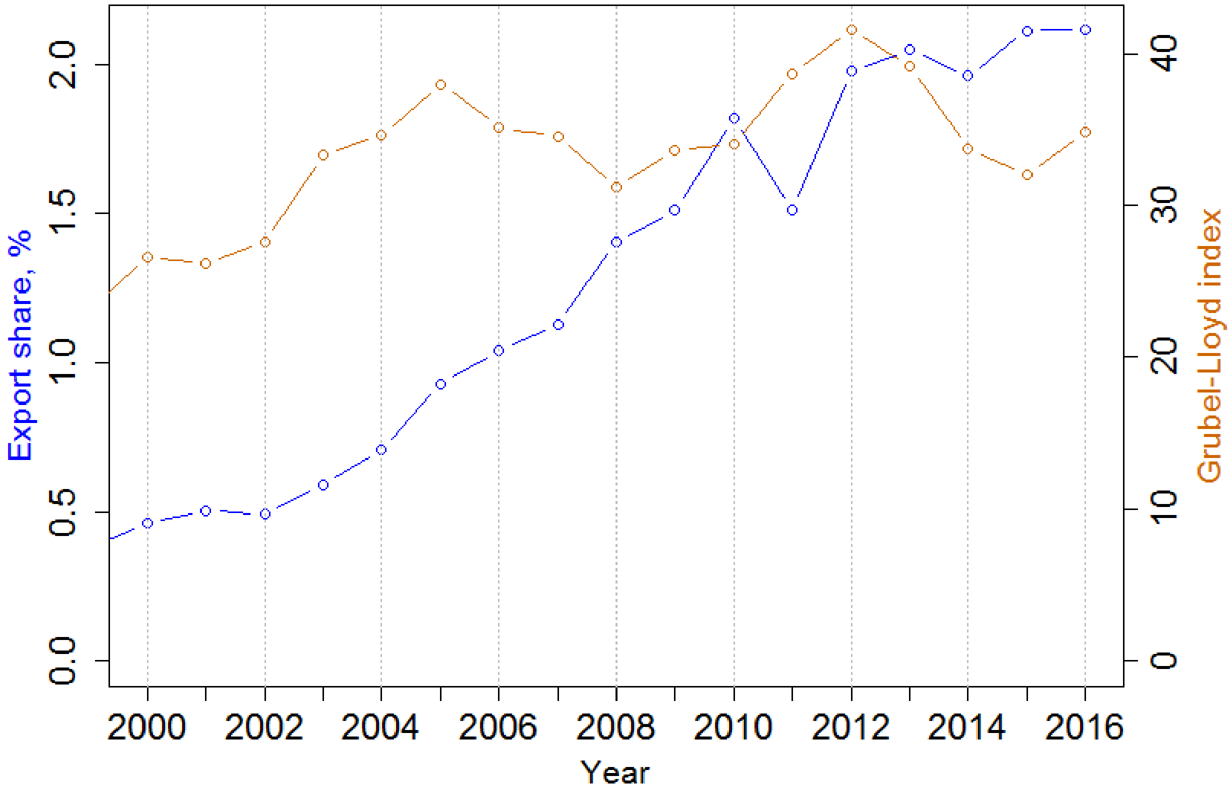

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Fig. 18 – Thai export share and Grubel-Lloyd index for motor vehicles sector

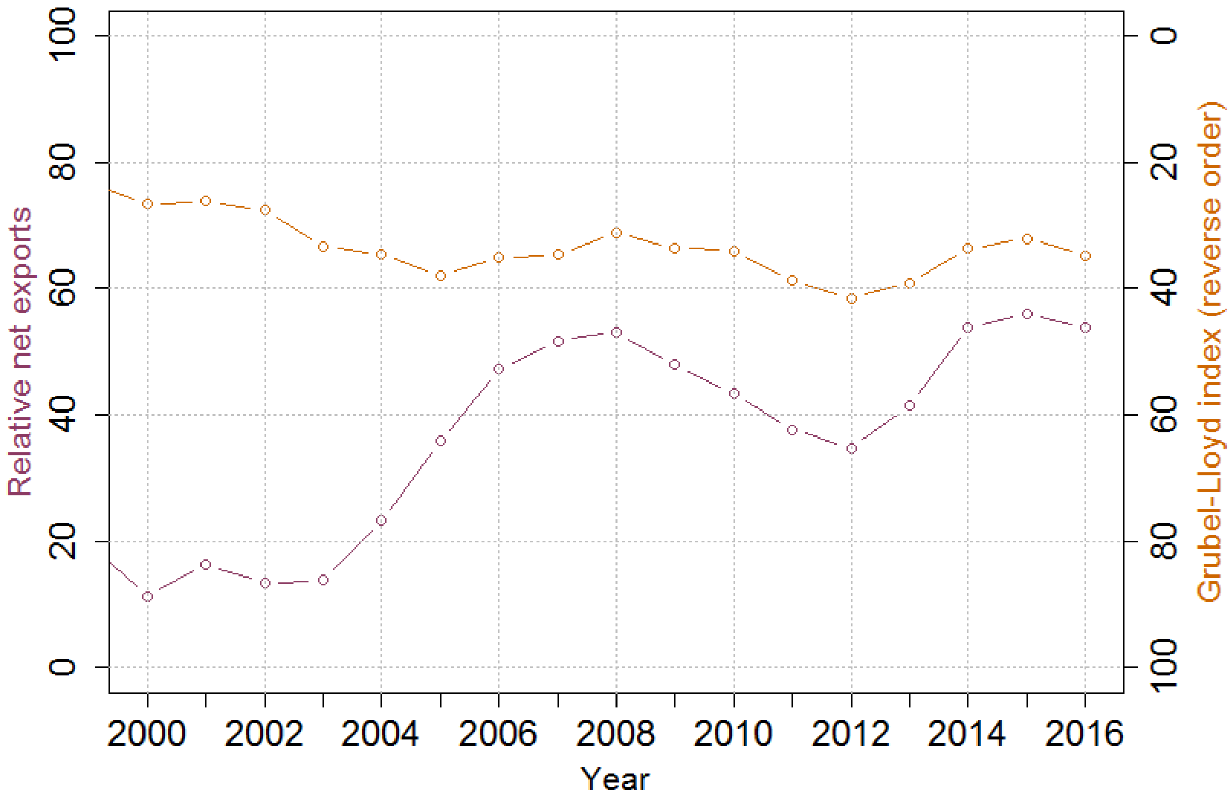

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Fig. 19 – Thai relative net exports and Grubel-Lloyd index for motor vehicles sector

Conclusion

In the paper, we provide an extensive analysis of five indicators that may potentially indicate product quality for the case of Asian automotive industry. These indicators are weighted unit value, number of export lines, market share, Grubel-Lloyd index and relative net exports. In the analysis, we benefit from the well-documented nature of the automotive industry. We demonstrate that all indicators (perhaps, except market share) should be used simultaneously to eliminate the impact of possible shocks originating from macro turbulence or trade policy constraints on quality estimations.

The analysis conducted in this paper shows that a country with increasing unit value, growing number of export lines and Grubel-Lloyd index and positive net exports for a commodity (sector) is likely to experience quality upgrading.

A huge amount of research still should be done to account for these indicators while constructing a new and potentially unbiased quality measure. We hope that our results may be helpful for those willing to tackle this difficult task.

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