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Guannan Miao and Fons Strik

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Re-evaluating South Africa's export sophistication from a value-added perspective

Guannan Miao[*] and Fons Strik[†]

Abstract

The new way of looking at international trade – not by measuring the face value of a product but by where the production takes place – has changed the way we understand international trade. It also changes the way we assess how 'sophisticated' a country's export basket is. This paper uses the latest OECD Trade in Value Added database to re-evaluate cross-country export sophistication as defined in Hausmann et al. (2007). It finds that the gap between the export sophistication of high-income and low-income countries is wider from a value-added perspective. The global financial crisis (GFC) marked a fundamental shift in the ability of low-income countries to catch up: before the GFC, the export sophistication gap between high-income and low-income countries narrowed, but after the GFC export sophistication in high-income countries outgrew export sophistication in low-income countries. A decomposition analysis shows that these trends are underpinned by the basket effect, which measures the extent to which changes in a country's export sophistication are caused by changes in its own export basket. The paper also finds that higher export sophistication positively affects future economic growth, even more so when measuring export sophistication from a value-added perspective. In the early 2000s, South Africa performed relatively well in value-added export sophistication but started to lag behind its peers after the GFC, with the basket effect dragging on export sophistication growth. Nevertheless, South Africa's key strategic industries, such as motor vehicles and chemicals, appear relatively sophisticated.

JEL classification

F10, F14

Keywords

International trade, trade in value added, product sophistication, export sophistication, South Africa

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* Guannan Miao was an independent economist when conducting this research for the South African Reserve Bank (SARB). She is now affiliated with the International Labour Organization. Corresponding author: Miao.Guannan@gmail.com.

† Fons Strik was affiliated with the Ministry of Foreign Affairs of the Netherlands when conducting this research for the SARB. He is now affiliated with the Bank of England. The views expressed in this paper are solely those of the authors and should not be taken to represent those of the Ministry of Foreign Affairs of the Netherlands, or the Bank of England or any of its committees.

1. Introduction

International trade has frequently been used as an indicator of economic performance, in terms of how much a country exports as well as what it exports. However, the rise of globalisation has changed the way goods are produced: instead of going through an end-to-end production process in a single factory, a product is often shaped by multiple pairs of hands and passes through many factories in many countries before it reaches its final consumer. The new way of looking at international trade – not by measuring the face value of a product but by measuring fragmented production according to where production takes place – also changes our understanding of how ‘sophisticated’ a country’s export basket is.

There is no consensus on the definition of export sophistication; it can be measured by the level of technology or research and development (R&D) or the intensity of skilled labour embedded in export products. High-income countries often have more advanced production technologies: despite high labour costs, products exported by these countries can remain competitive in the world market and are still profitable for their producers. Lall, Weiss and Zhang (2005) note that this may be underpinned by the level of technology used for production, as well as by human capital, geographical locations of production, marketing strategies, logistics, trade infrastructure and gains from production fragmentation, among other factors.

Hausmann, Hwang and Rodrik (2007) proposed a widely accepted approach to quantifying export sophistication. It first uses each country’s income level – gross domestic product (GDP) per capita – as an approximation for the technology intensity of a product (PRODY); and then uses PRODY to estimate export sophistication (EXPY) for each country. In simpler terms, PRODY is an indicator of product sophistication in the product space and EXPY is an indicator of export sophistication for all countries. In essence, PRODY is expressed as the aggregated income of all countries that export a particular product, weighted by exporting countries’ relative revealed comparative advantage (RCA). EXPY is the aggregation of a country’s export product sophistication, using product shares in a country’s exports as weights.

However, measurements of EXPY were derailed as trade in intermediate products grew faster than total trade. Export sophistication reflects the sophistication of both imported content and domestic value-added content of exports. In other words, the imported parts and components that make up a country's exports should not count towards the exporter's product sophistication. A better way to look at product sophistication is to restrict the weights of PRODY to what is produced domestically and then estimate EXPY using the domestic value-added content of a country's exports.

This research builds on Haussman, Hwang and Rodrik's (2007) conventional wisdom that "what you export matters", and it argues that value-added exports matter. It draws on two separate strands of literature in economics. The first strand is the debate about product and export sophistication, where it is noted that high-income countries often export products that are more sophisticated. The second concerns the trade in value-added (TiVA) method, which has become a valuable approach now that datasets are widely accessible for more countries.[1] We have benefited from these two fields and created a new measure of export sophistication using a value-added approach.

This paper also reassesses whether Hausmann, Hwang and Rodrik's (2007) prediction of the correlation between EXPY and economic growth holds true from a value-added perspective. It provides a diagnostic analysis of South Africa's mediocre performance in improving its export sophistication over the past years, in particular after the global financial crisis (GFC). The key findings can be summarised as follows:

- The change in product sophistication from the gross perspective to the value-added perspective is largest in the petroleum industry (where median product sophistication is 10% lower in value-added terms) and in the computer and

[1] Trade in Value-Added is a joint initiative by the Organisation for Economic Co-operation and Development (OECD) and the World Trade Organization (WTO) that was launched in 2011 to measure trade not by face value but by where the production has taken place. There are other projects that share the same goal, such as the World Input-Output Database hosted by the University of Groningen, the Multiregional Input-Output Database hosted by the Asian Development Bank, and the Full International and Global Accounts for Research in Input-Output analysis hosted by EUROSTAT.

electronics industry (where median product sophistication is 6% higher in value-added terms). The higher product sophistication of computer and electronics products corroborates Van Assche and Gangnes' (2008) conclusion that China's high score in electronics 'gross' export sophistication is due to its imports of sophisticated inputs.

- Although countries' rankings in export sophistication do not change dramatically when using either value-added or gross export flows, the differences in export sophistication between high- and low-income countries have widened: high-income countries have higher EXPY indicators in value-added terms than in gross terms, while low-income countries exhibit the opposite trend. This result indicates that high-income countries predominantly control the 'sophisticated' part of the value chains despite their outsourcing strategies.
- Before the GFC, low-income countries moved their exports towards more sophisticated products at a faster pace than high-income countries (largely driven by the outsourcing strategies of many multinational businesses). This trend reversed after the GFC: in line with the world economy's remarkably low economic growth during this period, export sophistication in high-income countries has grown faster than that in low-income countries. The reversal could in part be attributable to the technological advancement in these high-income countries (such as investment in R&D), as well as stagnating integration into global value chains and early signs of re-shoring and near-shoring activities.
- Structural decomposition analysis of export sophistication shows that changes in the EXPY ranking between 1997 and 2020 are predominantly attributable to the basket effect (i.e. exports shift to more or less sophisticated products), not the PRODY effect (i.e. increases or decreases in the product sophistication of existing export products).
- The basket effect of value-added export sophistication – and not simply value-added export sophistication – is a good indicator of economic growth.
- South Africa's global ranking in value-added export sophistication declined from 78 in 1997 to 88 in 2020 (according to Hausmann, Hwang and Rodrik's 2007 methodology). This is largely due to the country's inability to export more sophisticated products during this period.

- South Africa's motor vehicle industry, a strategic national industry supported by succeeding government initiatives and generous funding,[2] has started to produce some positive results.
- Similarly, South Africa's chemical industry has demonstrated faster growth in value-added export sophistication than most other countries. However, the industry's share in the country's total merchandise trade has declined from 9% to 6%.

We also use Michaely's (1984) system of measuring product and export sophistication – which inspired Hausmann, Hwang and Rodrik's (2007) paper – as part of the robustness analysis. The contrast between Michaely's and Hausmann, Hwong and Rodrik's methodology sheds light on the weaknesses of PRODY and EXPY as economic performance indicators: Michaely is biased towards large countries, while Hausmann, Hwang and Rodrik are sensitive to changes in export flows due to the hefty weights applied to small high-income countries. We argue that PRODY is a rather simplified concept that can at times be driven by the idiosyncrasy of the data. The policy implications that can be drawn from EXPY analysis are therefore subject to the limitations of the data (i.e. unable to intuitively explain the indicator's volatility in the data).

This paper is organised as follows. Section 2 reviews the existing literature on estimating product and export sophistication. Section 3 describes the methodology for calculating PRODY and EXPY using both conventional and value-added export flows. Section 4 shows the most important patterns and trends derived from PRODY and EXPY indicators using measurements of gross exports and the domestic value-added content of exports. It also delves into South Africa's export sophistication and compares the country's performance to its peers. Section 5 highlights the strengths and weaknesses of Hausmann, Hwang and Rodrik's definition of export sophistication.

[2] Such as through the Motor Industry Development Programme, launched in 1995, and its replacement, the Automotive Production and Development Programme, launched in 2013.

Section 6 discusses the economic significance of the EXPY indicator before the paper concludes in section 7.

2. Literature review

The most notable research to popularise the concept of PRODY and EXPY is that of Hausmann, Hwang and Rodrik (2007), who establish a hierarchy in the traded goods space from the most to the least sophisticated goods to determine the effect of the sophistication of traded goods on economic growth. They argue that "countries that specialise in the type of goods that rich countries export are likely to grow faster than countries that specialise in other goods" (Hausmann, Hwang and Rodrik 2007: 2). They explain that poor countries – often with an undiversified production structure – remain poor due to the issue of "cost discovery": a business that attempts to produce a good for the first time in a developing country faces considerable cost uncertainty. Using the definition established by Hausmann, Hwang and Rodrik in an earlier version of the paper they published in 2007, Rodrik (2006) finds that Chinese manufacturing exports have the same level of sophistication as the manufacturing exports of high-income countries, which might explain China's rapid economic growth since the 1990s. Other variants used to estimate a country's export sophistication include those proposed by Michaely (1984), Lall, Weiss and Zhang (2005), Xu (2010) and Huber (2017).

The export similarity index, an alternative metric introduced by Finger and Kreinin (1979), assesses the difference between countries' export product spaces from a different starting point: two countries with similar incomes should have comparable technologies and hence share a similar export structure. The authors note that Japan's exports to the United States (US) had increasingly matched those of old European Economic Community countries and industrialised Europe between the 1960s and 1970s. Schott, Fuest and O'Rourke (2008) compare the set of products China exports to the US with the bundle of products that countries in the Organisation for Economic Co-operation and Development (OECD) export to the US, concluding that Chinese manufacturing exports overlap with OECD exports and thus that Chinese export sophistication is relatively high.

Criticism of PRODY and EXPY is not uncommon (see, for example, Kumakura (2007), Weiss (2010) and Huber (2017)). Kumakura (2007) argues that the calculation of EXPY drives Rodrik's (2006) empirical results, and proves that the export sophistication of poorer countries with large baskets of export products is overestimated. When countries' export baskets overlap, PRODY values tend to be relatively higher for poor countries with a low GDP per capita (as rich countries with a higher GDP per capita largely contribute to this figure); there is therefore an upward bias on EXPY in poorer countries. This is particularly pronounced in relatively large and populous countries, as they tend to have a larger range of products in their export baskets. For example, Chinese EXPY had been exaggerated due to this bias. Moreover, Huber (2017) argues that what also matters are changes to the sample, the aggregation level, the construction of the indicator and the Harmonised System (HS) classification over time. The unequal size of different economies can also introduce bias. A small, open economy is more likely to specialise in a few products due to abundant (natural) resources or other endowments, so this does not necessarily reflect the country's technological advancement.

In contrast to Hausmann, Hwang and Rodrik's approach, researchers such as Findlay and Grubert (1959) have attempted to answer the question of product and export competitiveness using the concept of factor intensities. They argue that input intensities – the combination of capital, labour, R&D content or intermediate goods used for production – underpin the variance in export sophistication and competitiveness. Input-output tables play a special role in research that aims to address export competitiveness using labour and capital intensity. The most renowned historical work is by Leontief (1956), Vanek (1963) and Baldwin (1971). The approach was refined in a series of studies that allow for the incorporation of input-output data from more countries (see, for example, Bowen, Leamer and Sveikauskas (1987), Trefler (1993, 1995, 2002), Davis and Weinstein (2001) and Trefler and Zhu (2010)). Some researchers interpret human capital as product sophistication (see Michaely (1984), Shirotori, Bolormma and Cadot (2010) and Wang and Wei (2010)). Wang and Wei (2010) find that rising product sophistication in China is a result of improved human capital and government policies in the form of tax-favoured high-tech zones.

Another approach is to assign products to specific categories according to the mix of skills, technology, R&D expenditure or resources used in production (see Hatzichronoglou (1997), Lall (2000) and Galindo-Rueda and Verger (2016)). Lall (2000) divides 225 products with a three-digit Standard International Trade Classification (STIC) code into groups, including primary commodities, labour-intensive and resource-based manufactures, and manufactures with low-, medium- or high-skill and technology intensity. However, OECD research (such as Hatzichronoglou (1997) and Galindo-Rueda and Verger (2016)) pivoted to R&D expenditure. Hatzichronoglou (1997) defines high-technology sectors using the ratio of R&D expenditure to value-added and R&D expenditure embodied in purchases of intermediate and capital goods (also using input-output tables),while Galindo-Rueda and Verger (2016) only use the first criteria.

Similarly, criticism has been made of these alternatives to Hausmann's approach to export sophistication and export competitiveness. This criticism includes that studies focusing on factor intensities are restricted to industry-level analysis and cannot capture the variation of factor intensities within detailed products, which can bias the calculation of the factor content of trade (see Feenstra and Hanson (2000) for this critique). In addition, when assigning products to skill categories, expert judgement is inevitably involved, which may bias results. Technology intensity has often been used based loosely on industrial knowledge rather than as a scientific measure. The classification is largely based on available indicators of technological activity, such as R&D expenditure and skill labour intensity from the countries where data are available. Other types of factor intensities, including patents, innovation expenditures and knowledge-based capital, could be determinants of export success too, but data limitation often restricts the development of a technology taxonomy in a much broader context.

Our study addresses research that uses the approach popularised by Hausmann. Our contribution to this literature is twofold. First, we argue that using gross trade flows to measure PRODY and EXPY as a country's export sophistication is not accurate given the rise of globalisation, as the gross export flows neither show the magnitude of production activities that take place in the exporting country nor provide any information as to the type of activities, for example, R&D versus processing. This paper introduces new measures of product and export sophistication using value-added trade flows (sourced from the OECD TiVA database) as weights to measure PRODY and EXPY – what we call value-added PRODY and value-added EXPY. These new ways of estimating PRODY and EXPY provide more insights into why Chinese exports are so special (see Van Assche and Gangnes (2008) and Amiti and Freund (2010)).[3]

Our second contribution is to show that Hausmann, Hwang and Rodrik's (2007) PRODY estimation may statistically significantly project economic growth but lacks stability and is subject to data idiosyncrasy. We illustrate this by directly comparing Hausmann, Hwang and Rodrik's approach to Michaely's in the robustness analysis. For example, when measuring product and export sophistication, mining and energy products such as uranium, thorium, gold, gas, crude petroleum and petroleum products are often treated in isolation. Trade in these commodities reflects country endowments or natural resources – usually a stand-alone category in studies using technology or factor intensities. Countries with rich crude petroleum or gas reserves often have high (per capita) incomes, but these natural oil and gas reserves do not reflect product or export sophistication.

3. Methodology and data

3.1 Calculating PRODY and EXPY

The intuition behind the concepts of export sophistication in Hausmann, Hwang and Rodrik (2007) and in Michaely (1984) is identical: products largely exported by high-income countries are regarded as more sophisticated, while those exported by low-income countries are considered less sophisticated (due to the rationales outlined in the introduction). However, the difference between these two methodologies

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[3] Both papers separate Chinese processing exports from ordinary exports and find that the high sophistication of China's exports is simply a result of the high sophistication of imported intermediate inputs used in the processing trade. Once this is corrected for, no evidence points to Chinese export sophistication being an outlier given China's income level. Van Assche and Gangnes (2008) demonstrate this using the electronics sector as an example. Amiti and Freund (2010) show that the skill content of China's total exports increased significantly from 1992 to 2005 but find little evidence of higher skill content when processing exports are excluded from total (gross) exports.

essentially lies in the choice of weights. Michaely assigns market share in international product markets as weights, whereas Hausmann, Hwang and Rodrik refine the weighting scheme using an RCA index. For simplicity, this paper calls both measures PRODY (although PRODY only became a popular concept after Hausmann, Hwang and Rodrik published their paper in 2007). PRODY – using Michaely's (labelled M) or Hausmann, Hwang and Rodrik's (labelled H) methods – is expressed as follows:

$$PRODY_k(M) = \sum_{c=1}^{n} Y_c\left(\frac{X_c^k}{X^k}\right) \tag{1M}$$

$$PRODY_k(H) = \sum_{c=1}^{n} Y_c\left(\frac{X_c^k/X_c}{\sum_c(X_c^k/X_c)}\right) \tag{1H}$$

where Y_c is GDP per capita and represents the endowment of country *c*. X_c^k denotes country *c*'s exports of product *k*. X^k in Michaely is the sum of the exports of product *k* by all countries; in Hausmann, X_c denotes country *c*'s exports. Total weights in both methods add up to one.[4]

Given that absolute values of PRODY change as the structure of exports changes, PRODY should not be seen as an absolute measure but as an indicator of product sophistication in rank or in relative terms.

Based on the proposals of Michaely and Hausmann, Hwang and Rodrik, we suggest measuring PRODY using the domestic value-added content of exports as weights as follows:

$$DVAPRODY_k(M) = \sum_{c=1}^{n} Y_c\left(\frac{DVAX_c^k}{DVAX^k}\right) \tag{2M}$$

$$DVAPRODY_k(H) = \sum_{c=1}^{n} Y_c\left(\frac{DVAX_c^k/DVAX_c}{\sum_c(DVAX_c^k/DVAX_c)}\right) \tag{2H}$$

4 Small countries often record infrequent trade flows that cause fluctuations in the PRODY estimation. To avoid this problem, the three-year moving average was applied to all export data when calculating PRODY and EXPY (see Hausmann, Hwang and Rodrik (2007)).

where $DVAX_c^k$ denotes country *c*'s value-added exports in goods *k*.[5] $DVAX^k$ and $DVAX_c$ denote the sum of the value-added exports of product *k* by all countries and country *c*'s total value-added exports respectively.

This new value-added approach to measure PRODY emphasises a country's 'real' market share and 'real' RCA by separating those exports produced domestically from imported intermediates (as highlighted in Van Assche and Gangnes (2008) and Amiti and Freund (2010)).

Using Michaely's approach and Hausmann, Hwang and Rodrik's approach, we use the following equations to calculate export sophistication (EXPY) and *value-added* export sophistication (DVAEXPY):

$$EXPY_c(M,H) = \sum_{k=1}^{m} \left(\frac{X_c^k}{X_c}\right) PRODY^k(M,H) \tag{3}$$

$$DVAEXPY_c(M,H) = \sum_{k=1}^{m} \left(\frac{DVAX_c^k}{DVAX_c}\right) DVAPRODY^k(M,H) \tag{4}$$

Essentially, these are weighted averages of PRODY using gross exports or domestic value-added content of exports for a country or industry.

3.2 Data sources for calculating PRODY and EXPY

International trade data are sourced from the CEPII BACI database. BACI provides data on bilateral trade flows for more than 200 countries at the product level (over 5 000 products). Products correspond to the Harmonized System nomenclature (6-digit code). BACI uses United Nations Statistics Division Comtrade data and makes several adjustments to provide a balanced view of international trade to reconcile the discrepancies between reported import and export flows.[6] GDP per capita in constant prices (in natural logarithm) is from the World Bank's World Development Index.

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5 $DVAX_c^k$ is the product of the domestic value-added share of exports (available at the industry level) and exports of a product (available at HS 6-digit level) mapped into a particular industry classification.

6 As countries report both their imports and exports to the United Nations Statistics Division, discrepancies may arise from the two mirrored flows: what country *i* exports to *j* may be different

The domestic value-added share of gross exports is the key indicator for estimating value-added PRODY and value-added EXPY, which we call DVAPRODY and DVAEXPY respectively. The data are sourced from the OECD Trade in Value-Added (TiVA) database. The indicator is available at industry level from 1995 to 2020 for 75 countries/economies. The conversion tables between industry classification (ISIC rev. 4) and product classification (HS1992, HS1996, HS2002, HS2007, HS2012, HS2017) are also put in place to map products to industry level to calculate domestic value-added content for exports at the product level. Not all countries report trade flows consistently over the years – for example, country *i* might report trade flows at t-1 and t+1, but not at time t; PRODY and EXPY values fluctuate without representing any significant economic phenomenon. To solve this data issue and provide more stability, we use three-year moving average trade flows to calculate PRODY and EXPY.

3.3 Different measurements of EXPY and PRODY

We suggest several alternative measures to address the criticism of PRODY and EXPY in product sophistication literature. First, we restrict our coverage to 135 countries by eliminating those with small populations, a low volume of exports (as exports are not stable over time) and a high share in oil or gas exports (where high income per capita is a reflection of endowment). Second, we further restrict the sample to 75 countries explicitly covered in the OECD's TiVA database, where precise estimates for domestic value-added exports are available at industry level (see Annex 1 for country coverage). While the baseline estimates used all countries with data available (full country coverage), the two samples with country restrictions are referred to as the restricted sample and the TiVA country sample.

from what country *j* imports from *i*. There are several well-documented reasons for this: the different valuations between cost, insurance and freight for imports and free on board for exports; the country of origin for imports and country of consignment for exports; and the possible misclassification of certain products.

In summary, we propose the following variations of PRODY and of EXPY in both gross and value-added exports for the years 1997–2020 with respect to the full sample, restrictive sample and value-added sample:

- PRODY time series using Hausmann, Hwang and Rodrik's and Michaely's methods;[7]
- EXPY by country based on yearly PRODY using either Hausmann, Hwang and Rodrik's method or Michaely's method; and
- EXPY by industry based on yearly PRODY using either Hausmann, Hwang and Rodrik's method or Michaely's method.

3.4 Decomposition: PRODY effect and basket effect

Measuring a country's export baskets in value-added terms affects EXPY both directly and indirectly. Part of the change in EXPY comes through PRODY, as relative product weights are different from a value-added – as compared to a gross – perspective; this is what we call the PRODY effect or indirect effect. Another part of the change in EXPY is driven by the change in a country's export basket in value-added terms; this is what we call the basket effect or direct effect. The domestic economy has a minor influence on the former but a direct influence on the latter.

Structural decomposition analysis helps distinguish between two different effects on EXPY:

$$\frac{1}{2*EXPY_c} * \sum_k (DVAPRODY_k - PRODY_k) * \left(\left(\frac{X_c^k}{X^k}\right) + \left(\frac{DVAX_c^k}{DVAX^k}\right) \right) * 100\% \qquad (5)$$

$$\frac{1}{2*EXPY_c} * \sum_k \left(\left(\frac{DVAX_c^k}{DVAX^k}\right) - \left(\frac{X_c^k}{X^k}\right) \right) * (PRODY_k + DVAPRODY_k) * 100\% \qquad (6)$$

The first term measures the PRODY effect (i.e. the effect of a change in global product sophistication on a country's export sophistication), and the second term measures the

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7 Because export flows can be volatile at the 6-digit product level, a three-year moving average is used to calculate PRODY and value-added PRODY.

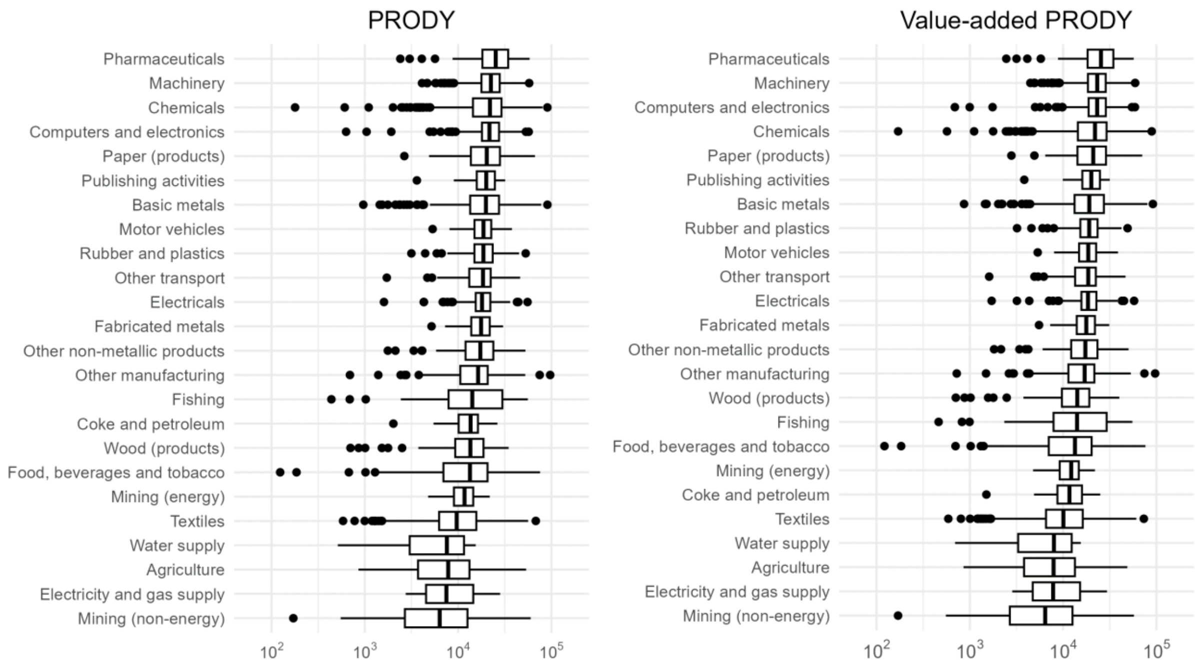
basket effect (i.e. the effect of a country's export-basket changes on a country's export sophistication). The total effect is the sum of the two terms.

4. An evaluation of export sophistication using a value-added trade approach

4.1 Product sophistication (PRODY): how trade in value-added changes our understanding

Figure 1 depicts median PRODY and median value-added PRODY at the HS 6-digit level, grouped by industry.[8] Ranked by the median value of all products classified under an industry, pharmaceuticals was the most sophisticated in 2020, whereas the mining of non-energy commodities – a wide variety of ores including cobalt, iron and uranium – was the least sophisticated when evaluating PRODY both from a conventional gross exports approach and from a value-added approach.

Figure 1: Pharmaceuticals are the most sophisticated, non-energy mining the least, 2020



There is considerable intra-industry variation in product sophistication. PRODY and value-added PRODY distributions of different industries largely overlap. For instance, a few commodities in the most sophisticated pharmaceuticals industry have scores as

8 Products are available at the HS 6-digit level. These products are mapped into International Standard Industrial Classification (ISIC) Rev. 4 according to the OECD conversion table.

high as some of the products in the least sophisticated industries, such as agriculture and mining of non-energy commodities. This indicates that industry-level aggregation masks product-level diversity in product sophistication – and that, in general, industry policy should take these product diversifications into consideration.

Outliers are prevalent in different industries, particularly in the food, textiles, chemicals and basic metals sectors. In the food sector, most outliers are fish products (e.g. fresh or chilled fish, frozen fish and dried fish) with sophistication scores equal to some of the most sophisticated machinery. For example, fish represented 17 of the 20 most sophisticated products in this sector in 2019. This is because Norway, with one of the highest GDPs per capita, determines around 77% of the PRODY value of dried fish. In other words, given Norway's strong relative RCA and high GDP per capita, dried fish has a very high product sophistication score. This reveals that as a measure of product sophistication, PRODY can at times be driven by the idiosyncrasy of the data.

Figure 2 illustrates how measuring TiVA affects different industries' sophistication by showing changes in sectors' median PRODY value when measuring PRODY in TiVA terms instead of gross terms. The increase of sophistication in the computer and electronics industry stands out. Our data show that China has the largest absolute decrease in gross to value-added exports, with a relatively low value-added-to-gross-sophistication ratio. The sophistication of these electronics exports is increased if China adds less value to its electronics exports while other countries with higher GDP per capita add more. This supports Van Assche and Gangnes' (2008) conclusion that China's high electronics export sophistication is due to the import of sophisticated intermediate inputs. Indeed, in 2019, China's RCA in the computer and electronics industry decreased by about 3 percentage points from gross to value-added.[9] This figure was only about 1 percentage point in 1997 – before China became a member of

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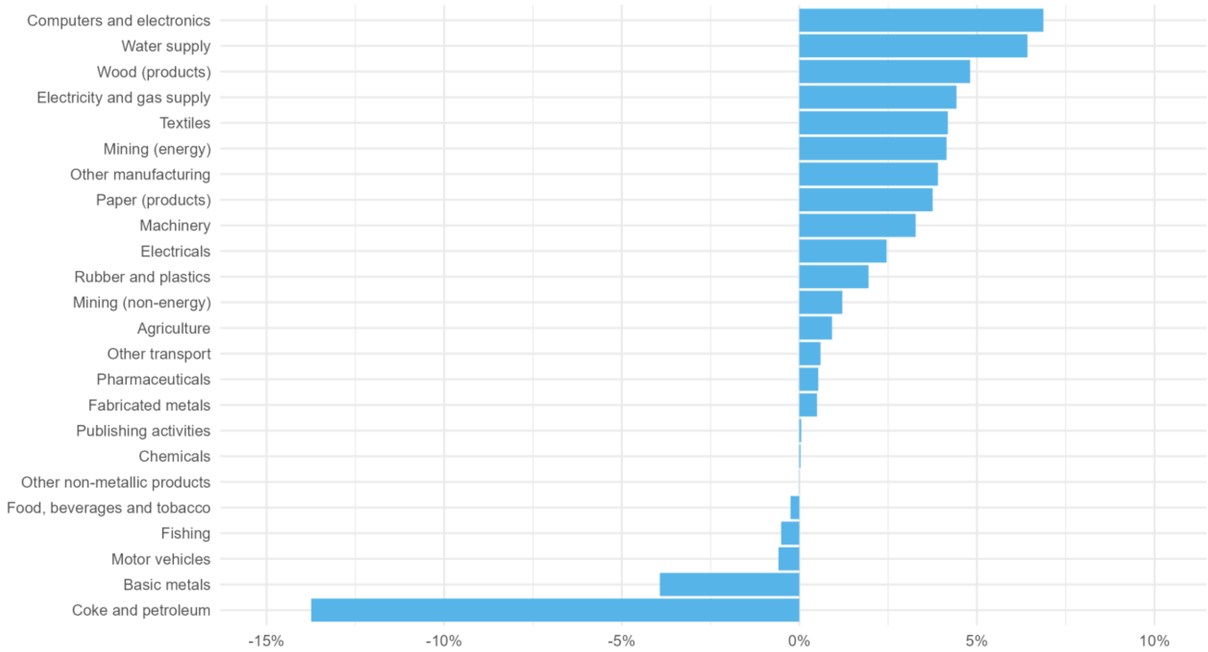
9 Although China has the largest absolute decrease in gross to value-added exports, its effect on PRODY is relatively muted. In Hausmann's methodology for calculating PRODY, a country's relative RCA determines to what extent a country's GDP per capita affects the PRODY value. (Smaller) countries with a smaller absolute decrease in gross to value-added exports but larger changes in their RCA will therefore have a larger impact on PRODY changes. In Michaely's methodology, however, a country's share in world exports determines the country's sway over PRODY.

the World Trade Organization (WTO) in 2001 and participated less in global value chains. Malaysia and Hong Kong also have lower relative RCAs – meaning both determine less of the industry's sophistication. Relatively rich countries whose relative RCAs increase, such as Korea, the US and the United Kingdom, further support this reasoning, as these countries' GDP per capita levels are significantly higher than China's.

Figure 2: Changes in median PRODY from gross to value-added exports, 2020

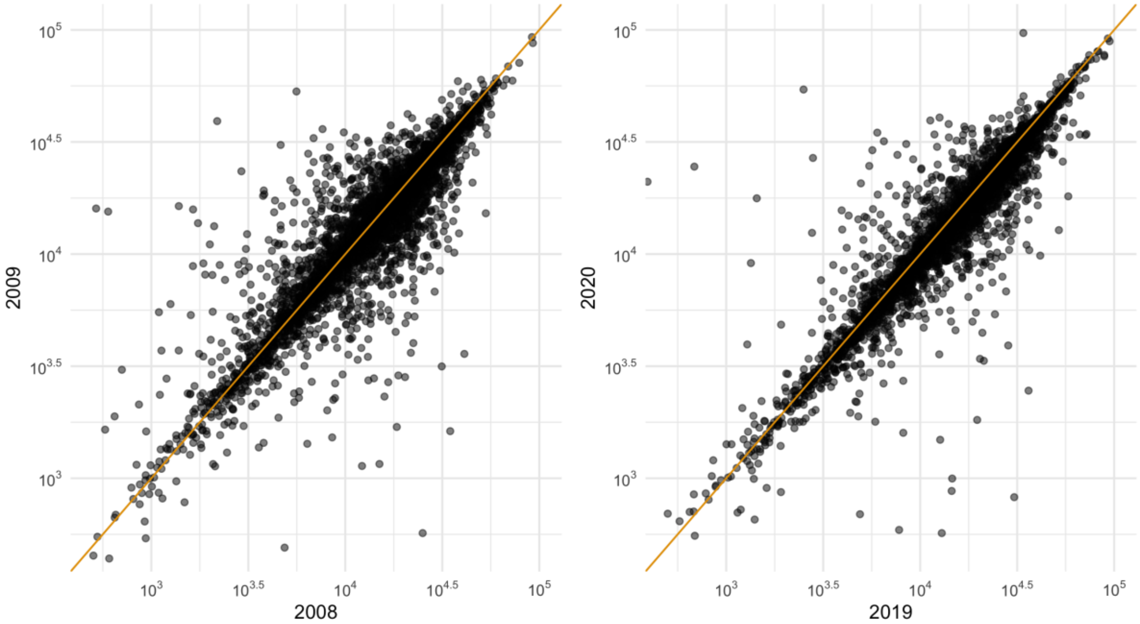


At the detailed product level, about 40% of the HS 6-digit commodities experienced a decrease in product sophistication between 1997 and 2000, both in gross and value-added trade measures. This contrasts with Lall, Weiss and Zhang's (2005) finding (with the conventional measure of PRODY), which highlights that product sophistication declined across approximately 80% of all products from 1990 to 2000. This contrast is likely because our sample period is much shorter.

Lall, Weiss and Zhang (2005) suggest that the decline in product sophistication reflects an increase in exports of relatively complex products by lower-income countries (e.g. China as a manufacturing hub) and, more generally, the fragmentation of production processes (i.e. integration with global value chains).

The broad absolute increase of PRODY from 1997 to 2020 (74% of all HS 6-digit commodities) likely reflects that the growth effect (i.e. the growth of GDP per capita) in PRODY prevails. Another way to demonstrate PRODY's sensitivity to economic growth is to illustrate how PRODY changes during crisis years. About 60% of products experienced declining PRODY values during the GFC (in 2008 and 2009), and over three-quarters of products had lower PRODY values during the COVID-19 pandemic in 2019 and 2020 (Figure 3).

Figure 3: Impact of crises on PRODY, 2008–2009 and 2019–2020



Note: Observations below the 45-degree line indicate that the sophistication of the products decreased from 2008 to 2009 (left) or from 2019 to 2020 (right). From 2008 to 2009, 60% of all products saw their sophistication decrease; from 2019 to 2020, this was true for 75% of all products.

4.2 Export sophistication (EXPY): how trade in value-added changes our understanding

There is by definition a positive relationship between (value-added) EXPY and GDP per capita, as the former is calculated from the latter. The correlation coefficient is over 80% (see Annex 5).[10] In other words, countries with high export sophistication tend to be relatively developed countries and vice versa.

10 Rodrik (2006) and Kumakura (2007) also demonstrate the positive correlations between GDP per capita and traditional EXPY.

Export sophistication rankings do not change dramatically using gross or value-added flows: the 10 most and 10 least sophisticated countries are often the same from both a value-added and gross EXPY perspective,[11] but countries' export sophistication scores do change. For instance, the three countries with the most sophisticated exports in value-added terms in 2020 were Ireland, Switzerland and Singapore, while the most sophisticated exports in gross terms were Ireland, Switzerland and Denmark (with Singapore ranked fourth).

When measuring EXPY using value-added exports instead of gross exports, EXPY scores increased for about 41% of countries and decreased for the remaining 59% in 2020. The largest share of high-income countries saw their EXPY value increase (55%) from a gross to value-added perspective, while this share was the lowest for low-income countries (12%). This suggests that high-income countries have a relatively higher EXPY in value-added terms, while low-income countries' valued-added EXPY tends to be lower than their gross EXPY.

Figure 4 confirms this finding: the change from gross to value-added EXPY is positively correlated with GDP per capita in 2020. This implies that high-income countries have relatively more sophisticated export baskets when measured from a value-added perspective than one would expect from their gross exports. For example, the export sophistication of the US is 1.8% higher, while India's export sophistication from a value-added perspective is 0.9% lower in 2020.

[11] This applies to the restricted sample, so countries with a small population, infrequent export statistics or high incomes from petroleum are excluded here – otherwise we would have included some volatility in country rankings as a result of the unstable trade flows of small, less-populous countries.

Figure 4: Higher-income countries are most sophisticated from a value-added perspective, 2020

Note: Countries are abbreviated using their ISO3 standard. See Annex 1 for the full list of countries.

Moreover, the basket effect underpins the positive correlation between GDP per capita and the total EXPY change from gross to value-added terms. The basket effect shows the extent to which a change in a country's export basket from a gross to a value-added exports perspective increases its export sophistication. Figure 5a illustrates the basket effect's positive association with countries' GDP per capita, while Figure 5b illustrates the PRODY effect's lack thereof.[12] These findings suggest that although lower-income countries participate in global value chains, they appear to add relatively little value to 'sophisticated' products in these value chains.

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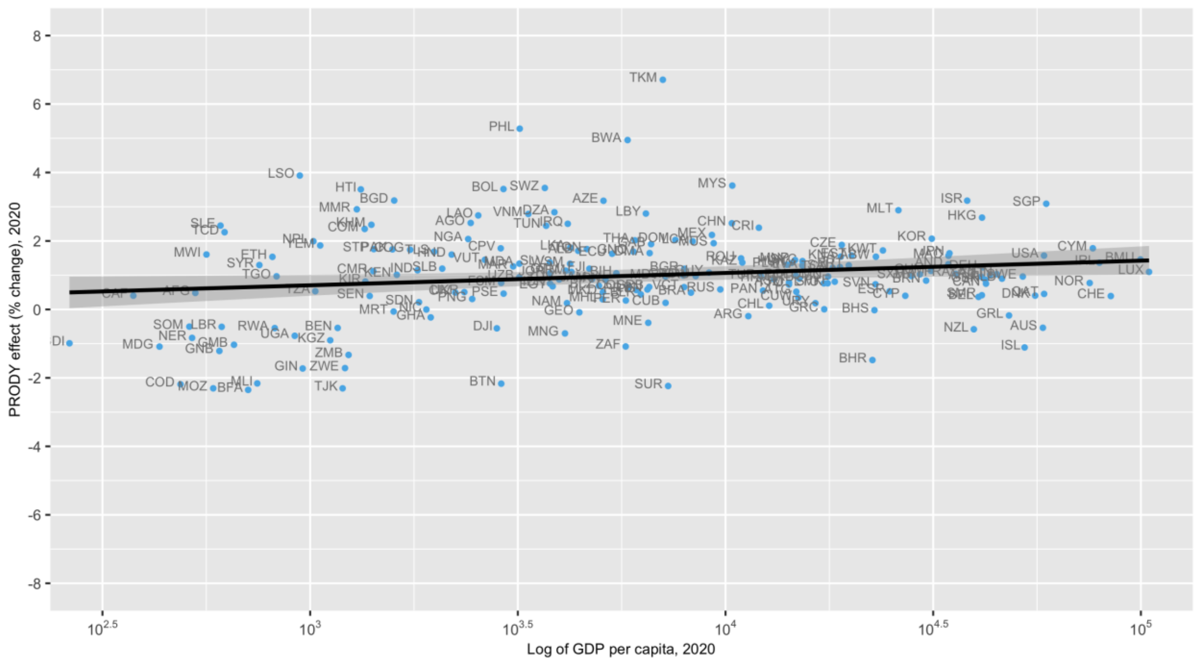
12 The correlation coefficients of GDP per capita with the basket effect and with the PRODY effect are 0.30 and 0.03 respectively.

Figure 5: Basket effects drive EXPY changes from a gross to a value-added perspective, 2020

a. Basket effect

b. PRODY effect



Note: Countries are abbreviated using their ISO3 standard. The full list of countries is given in Annex 1. The decomposition of total effect into PRODY and basket effects is calculated based on equations (5) and (6) respectively.

For example, Singapore is among the countries with the biggest changes in basket effect when value-added trade is accounted for. This is because the domestic value-added content in gross exports for Singapore is lower than other countries in the OECD TiVA database, at 56% in 2020.[13]

While Singapore and Hong Kong have much in common (e.g. geographical location and the size of their ports), the drivers of the changes between value-added EXPY and EXPY are not identical. Although their exports appear more sophisticated from the value-added perspective than the conventional measure, structural decomposition analysis shows that their export sophistication have increased for different reasons. The basket effect explains part (32%) of Singapore's increase in EXPY from gross to value-added. For Hong Kong, however, the basket effect is limited (5%), and the PRODY effect is able to compensate for the basket effect. Hong Kong's strong PRODY effect relates directly to the re-export of Chinese computer and electronics products. About one-third of Hong Kong's EXPY depends on the PRODY of computer and electronics products, and rising value-added PRODYs in this sector indirectly contribute to the increase of Hong Kong's value-added EXPY.[14]

4.3 Temporal developments of export sophistication

There is a clear upward trend in value-added EXPY for all economies. From 1997 to 2019, 94% of all countries saw their value-added EXPY increase.[15] This increase was particularly pronounced in 1997–2008, with a larger number of countries experiencing an increased value-added EXPY and stronger average value-added EXPY growth.

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13 OECD (2023). Trade in Value-Added (TiVA) 2023 ed: Principal Indicators.

14 As noted in section 1, China's low domestic value-added share in computers and electronics increases the industry's PRODY from a gross to value-added exports perspective.

15 We use 2019 data as the latest for the time series analysis, because the results in the pandemic year are atypical and do not necessarily represent general trends. The COVID-19 pandemic (starting in 2020) led to a temporary shift in trading patterns and sudden declines in GDP. This had a temporary effect on PRODY (Figure 3) and EXPY values. To illustrate, from 2018 to 2019, 64% of all products saw their EXPY increase, while this share was only 24% from 2019 to 2020. This reflects a decline in GDP per capita. It also matters for the PRODY at the industry level. While the median PRODY in coke and petroleum increased from 2018 to 2019, it strongly decreased from 2019 to 2020. The median PRODY of the mining of energy products fared comparatively better, as it performed similarly in 2019 and 2020.

This is most likely related to stronger global growth and increased globalisation from 1997 to 2008.

Figure 6 shows the total change in EXPY (total effect) and the basket effect of EXPY (in value-added terms) before and after the GFC.[16] The figure plots these changes by GDP per capita. First, it illustrates that differences in export sophistication growth are driven by changes in countries' export baskets. The similar slope of the total effect and basket effect reveals that basket effects determine the direction of the total effect. This conclusion corresponds to what is observed in EXPY changes from gross to value-added exports (see Figure 5). Second, the relationship between GDP per capita and the basket effect changes from 1997–2008 to 2009–2019. In the former period, poorer countries have higher growth through basket (and total) effects. In the latter period, however, richer countries experience higher growth through basket (and total) effects. Meanwhile, lower-income countries clearly underperform, with far more variation in their EXPY developments as well.

This suggests that countries increase their export sophistication over time by shifting their exports into more sophisticated products. It also shows that lower-income countries were initially able to export more sophisticated products in a period characterised by increased globalisation. However, this trend has reversed since the GFC. Lower-income countries have increasingly moved towards exporting products that are relatively less sophisticated. This coincides with the stagnation of global value chain integration since 2009 (via re-shoring or near-shoring).

When looking at value-added EXPY at sectoral level,[17] most countries have seen an increase in value-added EXPY for a majority of their industries, again likely reflecting upward trends in economic growth (i.e. GDP per capita). China stands out, as its export sophistication grew in 23 of its 24 industries, meaning almost all of its exporting

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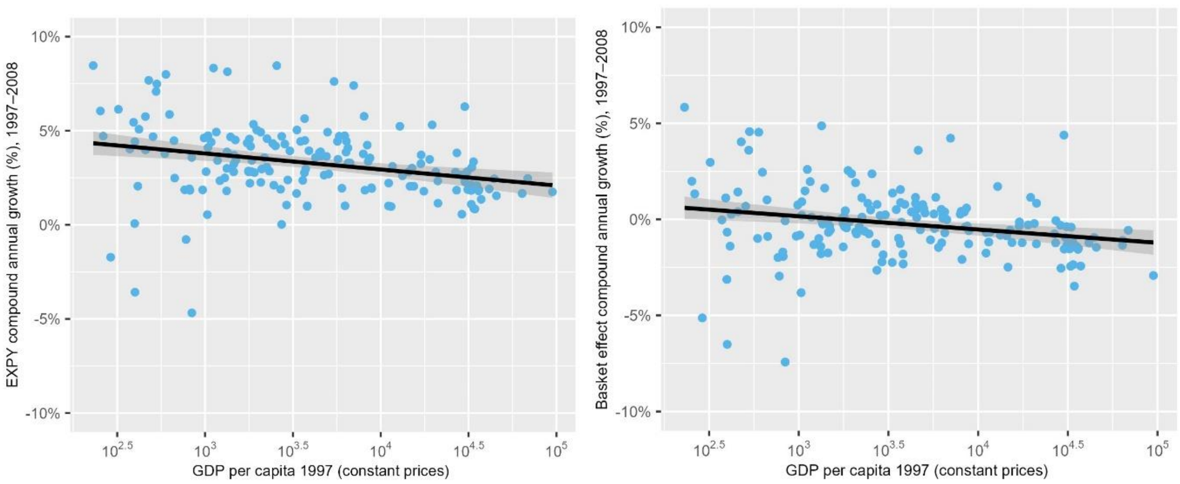
16 The basket effect in the time series analysis is estimated by keeping GDP per capita unchanged (set to the 1997 level) to calculate PRODY and EXPY in value-added terms.

17 Value-added EXPY at sectoral level is defined in a similar way to value-added EXPY at country level: that is, value-added exports weighted PRODY for a group of products that is considered the export sophistication of a particular sector.

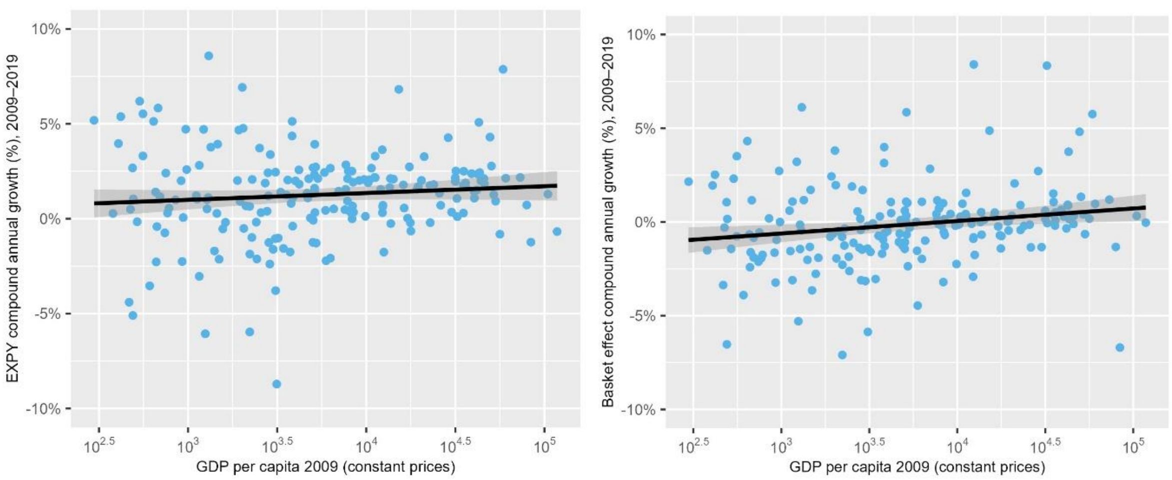
industries contributed to its higher export sophistication. Other countries that experienced a broad increase in the sophistication of their exporting industries are predominantly high-income or upper-middle-income countries.[18]

Figure 6: Basket effects also explain temporal changes in export sophistication

a) Total effect, 1997–2008 **b) Basket effect, 1997–2008**



c) Total effect, 2009–2019 **d) Basket effect, 2009–2019**



Note: The basket effect in the time series analysis is estimated by keeping GDP per capita unchanged (set to the 1997 level) to calculate PRODY and EXPY. We use 2019 data as the latest for the time series analysis, because the results from the pandemic year (2020) are atypical and do not necessarily represent general trends.

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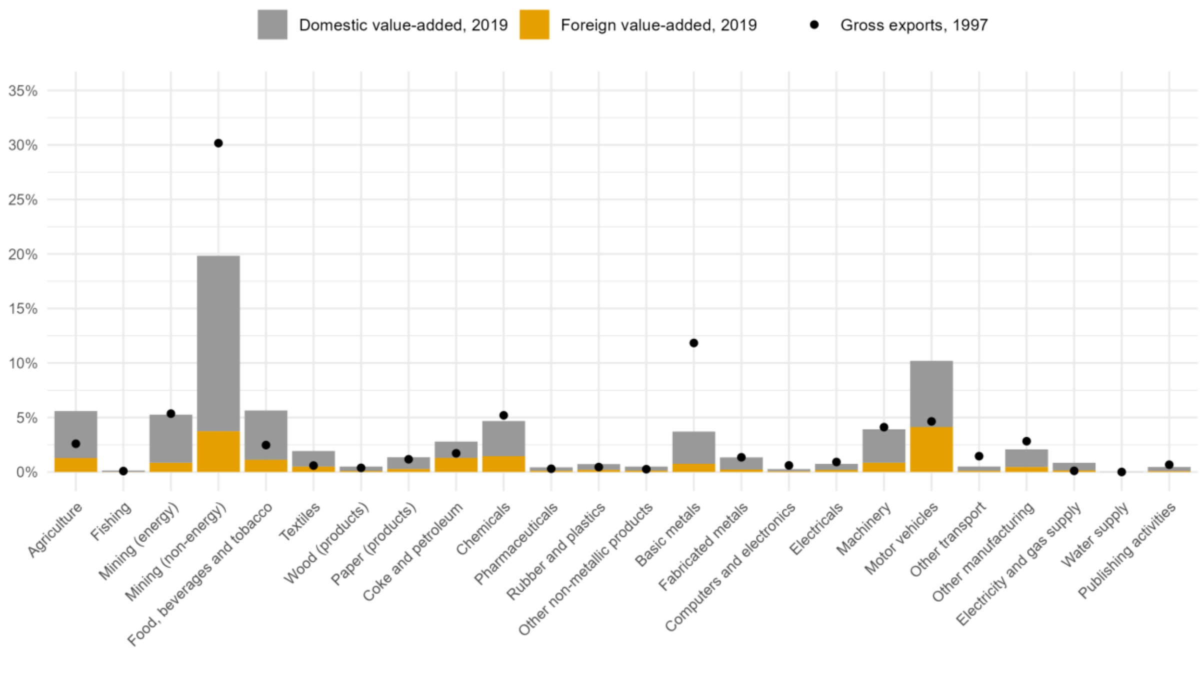
18 From 1997 to 2019, higher-income, upper-middle-income, lower-middle-income and low-income countries saw EXPY increase on average for 86%, 83%, 79% and 73% of their industries respectively.

4.4 The case of South Africa

4.4.1 South Africa's export structure

In 2019, around a quarter of South Africa's gross exports were mining products, most of which were non-energy related (Figure 7). A further 4% of South Africa's gross exports consisted of basic metals. Mining and basic metals' relative importance in South Africa's export basket declined significantly in the examined period from 1997 to 2019. This decrease was partially offset by larger exports of motor vehicles, which doubled from 1997. Other key goods exported include agricultural products and machinery, capturing 6% and 4% of South Africa's gross exports respectively.

Figure 7: Declining natural resource exports, rising motor vehicles exports, 1997 and 2019



Source: OECD TiVA database (accessed February 2024)

Note: Export flows are reported as a share of total gross exports. The values presented in this figure do not add up to 100%, as services sectors have been omitted. We use 2019 data as the latest for the time series analysis, because the results in the pandemic year (2020) are atypical and do not necessarily represent general trends.

South Africa's main exporting industries have a comparatively low sophistication, which likely weighs on South Africa's EXPY. The mining industry to a large extent determines its own lacklustre performance in EXPY score, as the PRODY value of mining products, especially non-energy-related mining products, is the lowest of all industries (see Figure 1). Examining South Africa's exports from a value-added perspective further lowers our expectations: the share of mining in total domestic value-added exports is higher, while the share of motor vehicle exports is lower.

Looking at South Africa's export structure using industries' PRODY value reveals that there has been little change in the share of highly sophisticated industries' exports since 1997 (Figure 8).[19] Using Brazil, India and China as examples reflects a clear shift in export structure towards more sophisticated products.

Figure 8: PRODY profiles for South Africa and other selected countries

a) South Africa **b) Brazil, China and India**

Note: High: the highest level of sophistication; higher-med: higher-medium level of sophistication; lower-med: lower-medium level of sophistication; low: the lowest level of sophistication.

4.4.2 South Africa's value-added EXPY

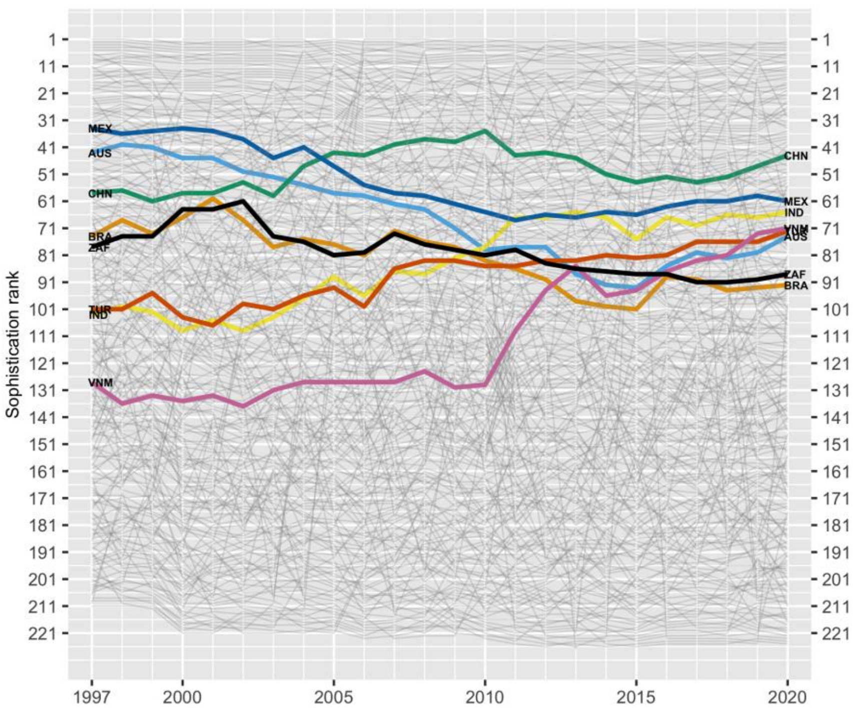
South Africa's value-added EXPY grew by 48% from 1997 to 2008 and has flattened since then without any substantial growth. As a result, South Africa's value-added EXPY ranking dropped slowly relative to other countries/economies, falling from 78 in 1997 to 88 in 2020 (see Figure 9). As the PRODY of non-energy mining products –

19 Industries are ranked based on their PRODY scores, from the most sophisticated to the least sophisticated in a given year, using PRODY data with full country coverage. The top six (of 24) industries are classified as the most sophisticated, and the bottom six are considered the least sophisticated.

which represent 20% of South Africa's total exports – declines from gross to value-added, South Africa's value-added EXPY is lower than its gross EXPY (see Annex 2, Table A2.3a).

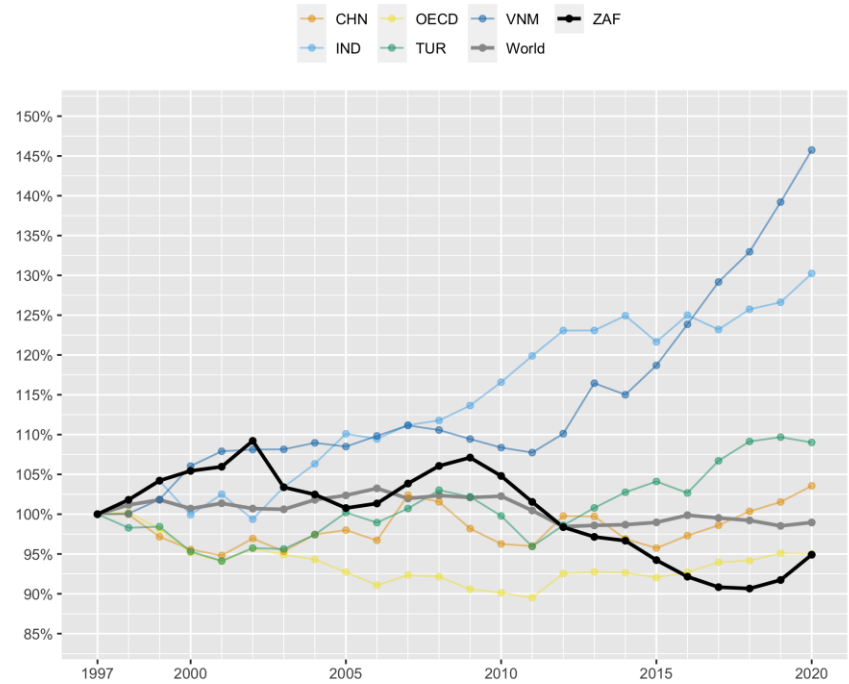
Figure 9 shows that South Africa is outperformed by China and India, while Brazil experiences similarly stagnating value-added EXPY growth. The developments in India, Turkey and Vietnam are noteworthy: while these countries had lower levels of value-added EXPY than South Africa in 1997, their value-added EXPY grew significantly from 1997 to 2020 and surpassed South Africa's.

Figure 9: South Africa's value-added EXPY ranking lags behind, 1997–2020



When separating basket effect from total value-added EXPY growth, South Africa's basket effect remained somewhat stable from 1997 to 2008 but started to decline from 2009 onwards (Figure 10). In contrast, Vietnam experienced a particularly strong increase in its basket effect. This is not surprising: from 1997 to 2020 it had comparative advantages in computer and electronics exports, and its motor vehicles exports increased significantly – both have a relatively high product sophistication. Although this effect diminishes from a domestic value-added exports perspective, Vietnam's export growth in these two sectors strongly outweighs increased exports in other sectors.

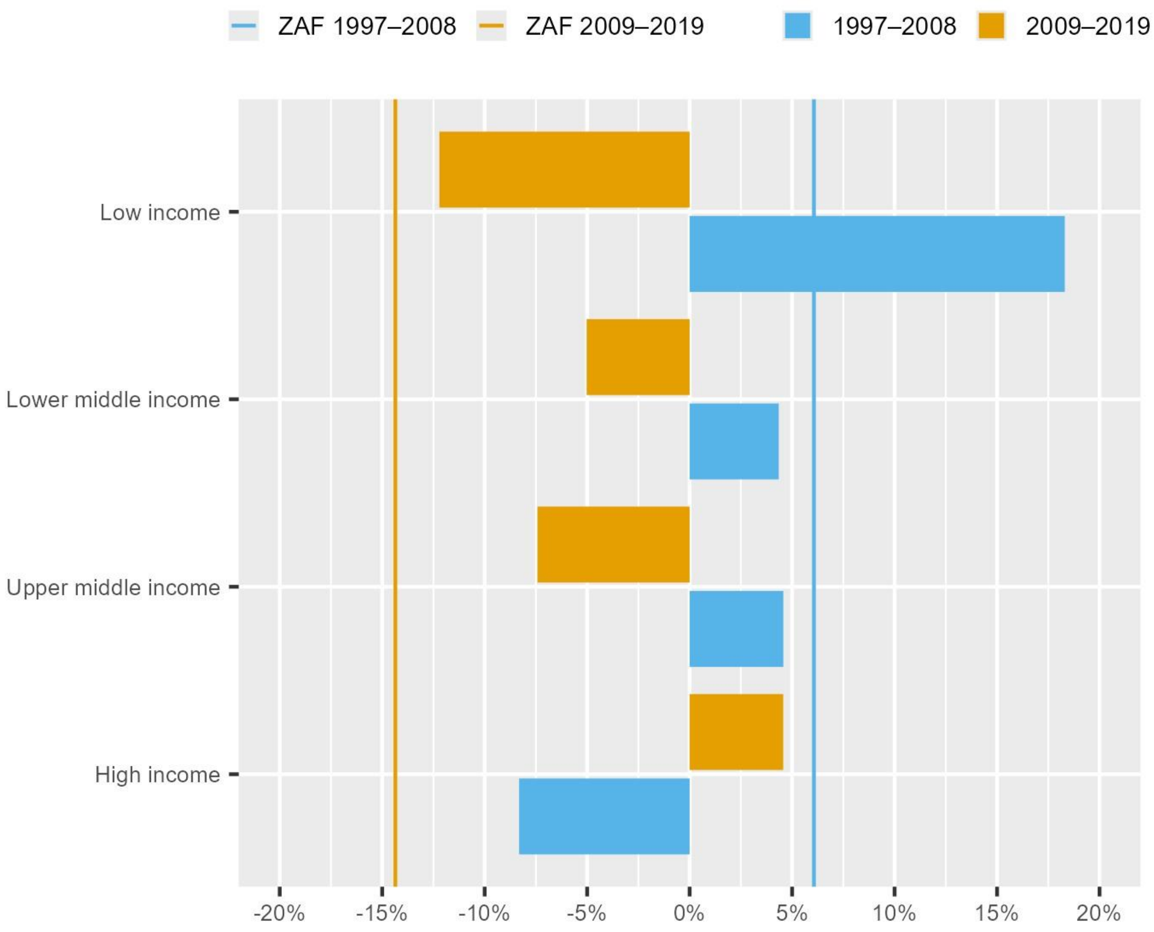
Figure 10: Basket effect drags South Africa's sophistication, 1997–2020



Note: The basket effect in the time series analysis is estimated by keeping GDP per capita unchanged (set to the 1997 level) to calculate value-added PRODY and value-added EXPY. Here, value-added EXPY is expressed relative to value-added EXPY in 1997 (i.e. EXPY in 1997 = 100%).

Furthermore, South Africa's export basket improved (grew by 6%) between 1997 and 2008, above the average basket-effect growth of high-income, upper-middle-income and lower-middle-income countries. Since the GFC, the trend has reversed – South Africa underperforms relative to countries of all income groups (Figure 11). In contrast, since 2009 high-income countries have switched to more sophisticated export baskets.

Figure 11: South Africa trails after the GFC
Growth in basket effect of value-added EXPY between 1997–2008 and 2009–2019

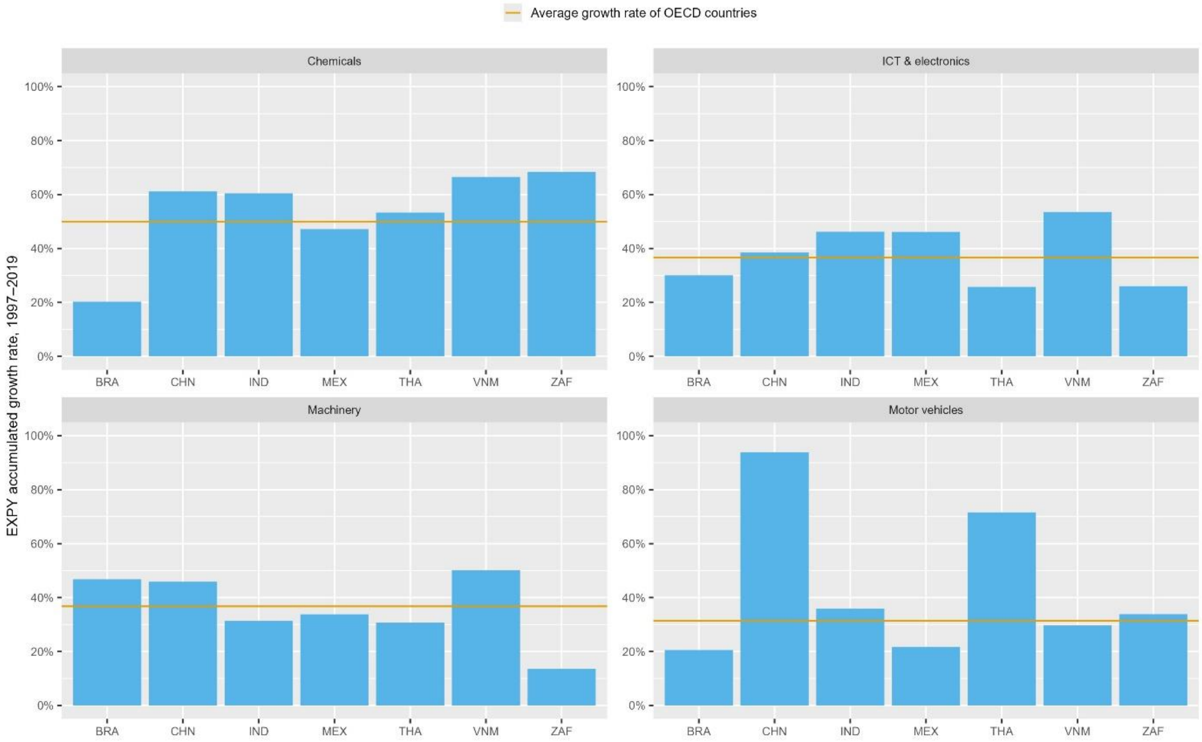


Note: The basket effect in the time series analysis is estimated by keeping GDP per capita unchanged (set to the 1997 level) to calculate value-added PRODY and value-added EXPY. We use 2019 data as the latest for the time series analysis, because the results in the pandemic year (2020) are atypical and do not necessarily represent general trends.

4.4.3 South Africa's value-added EXPY: sectoral-level breakdown

The value-added EXPY of country-industry pairs was also computed for South Africa. Twenty-two of 24 of South Africa's industries saw their value-added EXPY increase from 1997 to 2020. Among the highly sophisticated industries, South Africa did relatively well in the chemical and motor vehicle sectors, where their value-added EXPY score grew faster than OECD countries'. The chemical sector showed the highest value-added EXPY growth among the countries we examined (Figure 12), but it represents less than 5% of the country's exports (see Figure 7).

Figure 12: South Africa fares well in the chemical and motor vehicle sectors



Note: We use 2019 data as the latest for the time series analysis, because the results in the pandemic year (2020) are atypical and do not necessarily represent general trends.

South Africa's main exporting industries have not become less sophisticated relative to the same sectors in other countries. For example, South Africa's export sophistication of non-energy mining products outgrew those of China, Chile and Indonesia. A similar picture arises in the motor vehicle industry, which has become more sophisticated than Mexico's automotive sector. Therefore, it is fair to say that the relative decline of South Africa's export sophistication (relative to other countries) is not a consequence of declines in the sophistication of South Africa's main exporting industries.

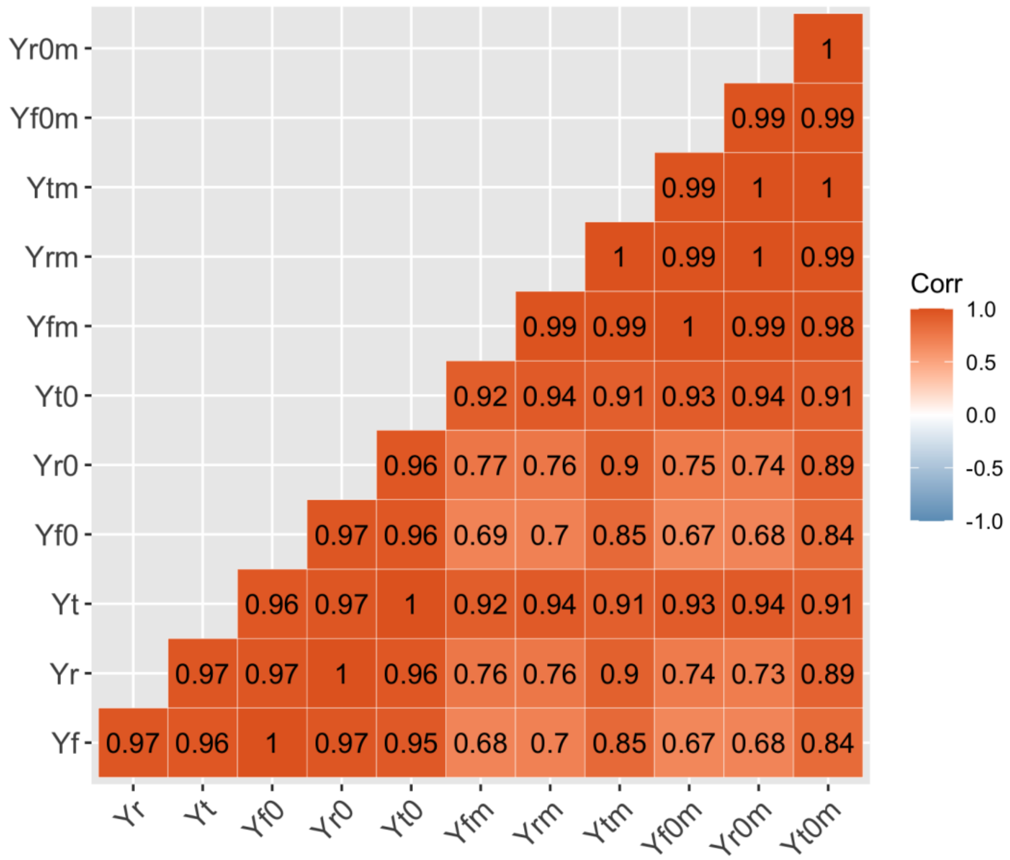
Instead, the decline of South Africa's export sophistication over time is mostly due to its inability to shift its own exports to more sophisticated products. The sophistication of non-energy mining products remains far lower than the sophistication of other industries despite the non-energy mining industry's impressive EXPY growth over the sample period. According to these descriptive results, South Africa would have to increase exports in sophisticated industries to grow its export sophistication. Developments of export sophistication in Vietnam serve as a clear example.

5. Robustness of EXPY: Hausmann, Hwang and Rodrik versus Michaely, and various sample selections

5.1 EXPY and its robustness

The high correlations between the various measures, regardless of country coverage, indicate that EXPY is relatively robust as an indicator (see Figure 13). While the choice of country coverage does not significantly affect EXPY, the choice of methodology to some extent does: the lowest correlation coefficients, as shown by the lightest-shaded colour, are between Hausmann, Hwang and Rodrik's and Michaely's methods with respect to the full country coverage (both for value-added EXPY and EXPY).

Figure 13: EXPY variance-covariance matrix



Note: Yf denotes value-added EXPY with respect to full country coverage using Hausmann, Hwang and Rodrik's method.

Yr: value-added EXPY with respect to restricted sample using Hausmann, Hwang and Rodrik's method.

Yt: value-added EXPY with respect to value-added sample using Hausmann, Hwang and Rodrik's method.

Yf0: conventional EXPY with respect to full country coverage using Hausmann, Hwang and Rodrik's method.

Yr0: conventional EXPY with respect to restrictive sample using Hausmann, Hwang and Rodrik's method.

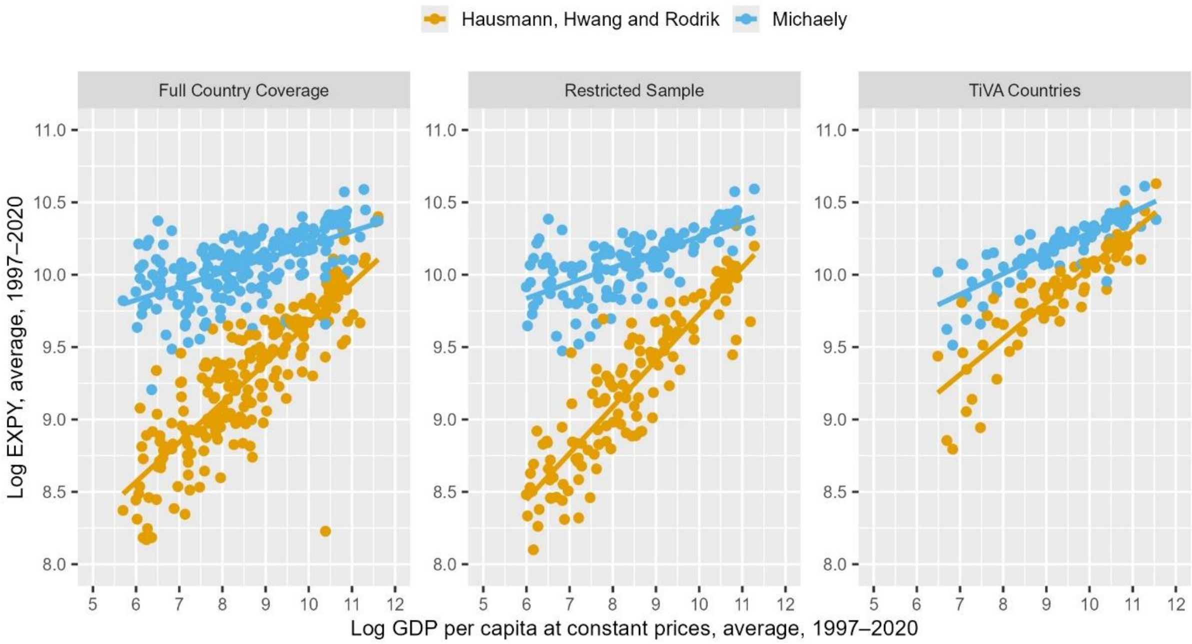
Yt0: conventional EXPY with respect to TiVA country coverage using Hausmann, Hwang and Rodrik's method.

Yfm, Yf0m, Yrm, Yr0m, Ytm, Yt0m: denote value-added or conventional EXPY calculated with respect to full, restrictive and TiVA country coverage using Michaely's method.

Using both Hausmann, Hwang and Rodrik's and Michaely's definitions, EXPY increased during the period 1997–2020 (Annex 2, Table A2.1), which could be driven by the real growth of GDP per capita (i.e. in constant prices), the shift of exports from low- to high-income countries or a combination of the two. However, mean EXPY is higher when it is calculated using Michaely's definition. While the minimum values of EXPY are higher for Michaely, the maximum values of EXPY are similar. Michaely's method of estimating EXPY also presents a slightly higher standard deviation.

Michaely's calculation is biased towards large countries, while Hausmann, Hwang and Rodrik's is volatile over time. In Michaely's measure, large countries generally have an influence on the outcome, regardless of the country sample (see Figure 14). The advantage of using Hausmann, Hwang and Rodrik's theory is that country size does not distort the ranking of a product, as the weights – countries' RCAs – are no longer sensitive to the size of the country. However, this increases the weights of small countries and makes the estimation of PRODY volatile (i.e. highly sensitive to small changes in export flows). The volatility associated with PRODY is thus transmitted to EXPY.

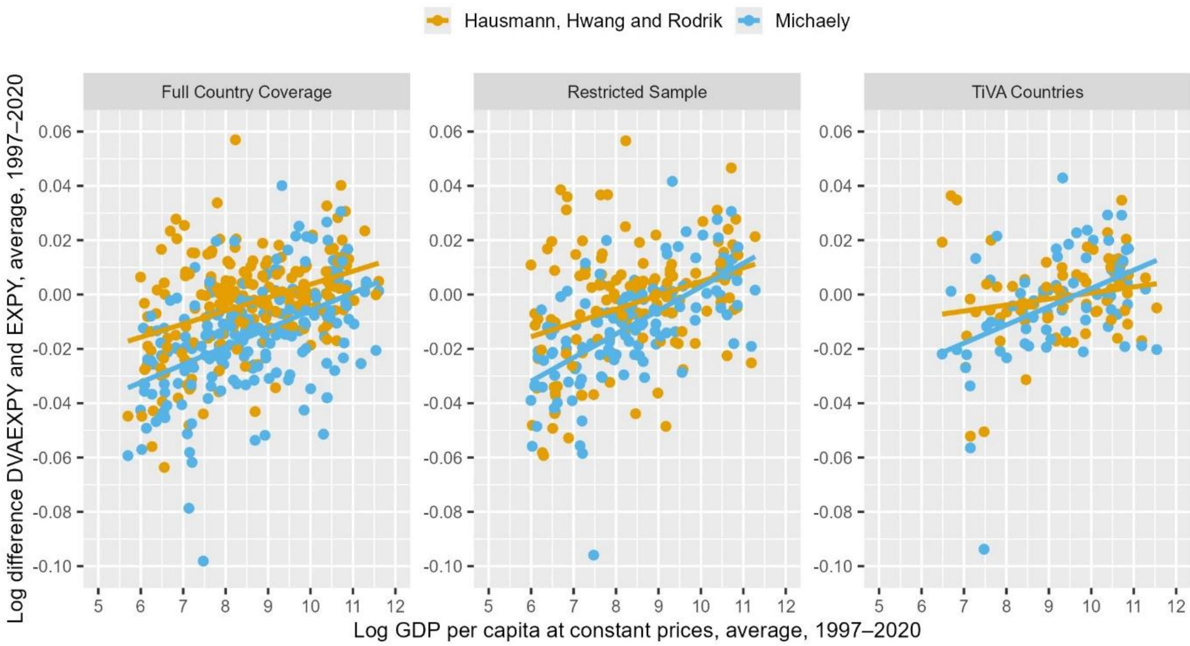
Figure 14: Value-added EXPY according to Hausmann, Hwang and Rodrik is lower than that according to Michaely



Moreover, Hausmann, Hwang and Rodrik's definition contains two critical, counter-intuitive aspects to PRODY (Huber 2017). First, increasing exports of a particular product changes PRODY not just for that product but for all products. Second, if a fraction of a country's exports of one particular product is replaced with exports from another country with an identical endowment (i.e. GDP per capita), PRODY changes regardless. In these cases, Michaely's methodology is not affected and is therefore more intuitive.

Table A2.2 in Annex 2 highlights another distinct difference between the methodologies. Using Hausmann, Hwang and Rodrik's method, nearly half the countries experienced an increase in EXPY when evaluating it using value-added exports as opposed to calculating it using conventional exports. However, fewer countries saw their value-added EXPY increase relative to their conventional counterpart when using Michaely's approach. Figure 15 shows that GDP per capita is more strongly correlated with changes in EXPY from a gross to a value-added export approach when using Michaely's methodology. This finding is observed across all three country samples and is especially pronounced in restrictive and TiVA country coverages.

Figure 15: Gaps between value-added export sophistication and export sophistication



5.2 The robustness of South Africa's export sophistication

South Africa has exported fewer sophisticated goods in value-added terms, regardless of choice of methodology or country coverage. According to Hausmann, Hwang and Rodrik's method, South Africa's value-added EXPY was higher than its conventional measure in 1997, 1998 and 2001, and the opposite is true for the rest of the period (Annex 2, Table A2.3a). The restricted sample and TiVA country sample show that value-added EXPY is always lower than the conventional measure from 1999 onwards. Michaely's method reinforces the same finding: South Africa's value-added export sophistication is almost always lower than the conventional measure (except for 2002 using the TiVA country sample) (Annex 2, Table A2.3b).

The values of EXPY in Hausmann, Hwang and Rodrik's definition are highest when we restrict country coverage to TiVA, and they are lowest when we include all countries. This is underpinned by the GDP per capita of those countries included in the calculation – countries included in the TiVA sample have a relatively higher GDP per capita. This shows that the levels of index are sensitive to the choice of country coverage, whereas the rank is not. In contrast, the value of EXPY is relatively stable across various country samples when using Michaely's definition. Due to its bias towards large countries, EXPY values vary less than Hausmann, Hwang and Rodrik's measure when sample coverages change (Annex 2, Table A2.3).

6. Can value-added export sophistication predict economic growth?

In essence, value-added EXPY measures the extent to which a country's value-added exports overlap with those of richer countries by participating in relatively more (technologically) sophisticated value chains. This section re-examines Hausmann, Hwang and Rodrik's (2007) question as to whether value-added EXPY predicts a country's GDP growth. In other words, we ask whether a country's value-added exports matter.

In this empirical analysis, we are interested in: (i) whether there is any economic rationale behind the difference between export sophistication calculated using value-added exports and using gross exports; (ii) what determines faster growth of a country's value-added export sophistication; and (iii) whether value-added export sophistication can predict economic growth better than the indicator measured in gross terms.

Data used for the regression analyses come from various sources, including the World Bank's World Development Indicators (WDI), the OECD TiVA database, the Bilateral Trade Database by Industry and End-use, the WTO regional trade agreement database and the CEPII distance database. Educational attainment represents the quality of the labour market and is proxied by the average years of schooling attained (see Barro and Lee (2013)). The institution quality variables are from Economic Freedom of the World (EFW) from the Fraser Institute. The qualitative measures of business climate are from the logistics performance index (LPI), the Doing Business survey (both sourced from the World Bank) and global competitiveness indicators (sourced from the World Economic Forum) (see Annex 3 for a summary of the characteristics of data and their abbreviations).

6.1 Hausmann, Hwang and Rodrik's estimates

Hausmann, Hwang and Rodrik ask what some of the fundamental determinants of the variation across countries in levels of EXPY might be. Setting aside the idiosyncrasy of the data and looking only at possible explanations using economic variables, the authors tested several possibilities, including national GDP per capita, human capital, rule of law index, size of labour force (proxied by the total population) and land area (an approximation for economic diversification). They found that EXPY is highly correlated with GDP per capita and human capital, yet human capital becomes a statistically insignificant determinant of EXPY once controlling for countries' size (population and land area). However, the exercise was only done with respect to data for one year (2001).

We revisited the empirical question with regard to both value-added EXPY and conventional EXPY. Our results show that both GDP per capita in constant prices (GDPPC) and human capital (proxied by years of schooling, YRSCH) are significant explanatory variables, even after controlling for countries' sizes – both population and land area (POPL and AREA respectively).[20] Although the summary index of EFW (SUM.EFW) – a replacement for Hausmann, Hwang and Rodrik's rule of law index – is also significant, it appears to be negatively associated with EXPY (Annex 4, Table A4.1, models 3–4), possibly due to variables being omitted in the regression.[21]

6.2 What determines the changes between value-added export sophistication and export sophistication?

While EXPY and value-added EXPY are strongly positively associated with GDP per capita and years of schooling, the difference between value-added EXPY and EXPY is not (see Annex 5). Our results show that countries' GDP per capita and years of schooling are significant and positively associated with the difference between value-

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[20] Years of schooling is estimated by Barro and Lee (2013) using GDP per capita and is thus an indicator also correlated with a country's GDP per capita.

[21] The signs switch to positives when additional explanatory variables are included (see Annex 4, Table A4.2).

added EXPY and EXPY (denote Δ*Yf*) too, even after controlling for population and land area (Annex 4, Table A4.1, models 7–8).

We further explore countries' economic structure and policy variables – including the share of income from natural resources (RESRC), the share of the manufacturing sector in the total economy (MFGSH), trade-weighted distance from partner countries (DISTW), the number of partner countries with which a country has an active free trade agreement (FTA), and trade-weighted applied tariff rate (TARIFF) – to see whether these variables influence the differences between value-added EXPY and EXPY for both Hausmann, Hwang and Rodrik's measure and Michaely's measure, with the dependent variables denoted as Δ*Yf* and Δ*Yfm* respectively.

Model 2 (for Hausmann, Hwang and Rodrik's definition) and model 5 (for Michaely's definition) return the most plausible estimates (see Annex 4, Table A4.2a).[22] The results show that, controlling for other factors, countries with a larger manufacturing share are likely to have more sophisticated value-added exports. This is likely because manufacturing products often have higher sophistication scores than non-manufacturing products. Trade-weighted distance with trading partners is positive and significant in both models. Countries with a resource-based economic structure improve their value-added EXPY score (more than EXPY) in Michaely's system but not in Hausmann, Hwang and Rodrik's. The results for FTA and TARIFF are consistent with the expectations in Michaely's model: having higher active trading agreements increases the gap between value-added EXPY and EXPY, while a higher tariff rate lowers such a gap.

We further examine the variables related to business operating environment, including the ease of doing businesses (BNS.CST, BNS.CUS and BNS.DUR), logistic performance index (LPI.ALL) and quality of infrastructure (QINFS_ROAD, QINFS_PORT and QINFS_RAIL), to gauge whether these can influence the gap between value-added EXPY and EXPY. These variables did not significantly improve

[22] By including country fixed effect, models 3 and 6 increased the finesse of the model but lost the purpose of testing country-specific economic or policy variables.

models' fitness, nor did they show a strong correlation with the dependent variables (ΔYf and ΔYfm) (Annex 4, Table A4.2b).

6.3 What determines the development of export sophistication over time?

We are also interested in what explains value-added export sophistication growth over time with regard to Hausmann, Hwang and Rodrik's measure. Years of schooling and level of resource as a share of GDP are significant in predicting both value-added EXPY and EXPY five-year growth (Annex 4, Table A4.3a, models 1–2 and models 5–6). Higher nature resource as a share of GDP points to lower value-added EXPY growth and EXPY growth, which corresponds to the common belief of the resource trap.

We also tested the different trends in value-added EXPY growth and EXPY growth before and after the GFC (Annex 4, Table A4.3a – see models 3–4 and models 7–8 respectively). The variables (the manufacturing share, number of partner countries with whom there is a free trade agreement and applied tariff rates) that were not significant before have become significant in both models but with opposite signs. For the period before the GFC, the regression results confirm the early finding that low-income countries – countries with a low manufacturing share, a low number of free-trade partners and high tariffs – experienced much faster EXPY and value-added EXPY growth than others. However, the opposite trend holds after the GFC. This suggests that it was not the specific economic characteristics that determined faster EXPY growth but the wider economic trends at the time – rapid globalisation through global value chain integration – that gave a chance to the poorer countries to catch up before the GFC.

The catching-up narrative changes if we only look at the basket effect (shift to more sophisticated export products) of value-added EXPY and EXPY growth. The most distinctive outcome is that countries with high GDP per capita experience significant improvements in export sophistication relative to low-income countries (Annex 4, Table A4.3b).

6.4 Is value-added export sophistication an indicator of growth?

Hausmann, Hwang and Rodrik also used GDP per capita growth rate as a dependent variable to show that higher levels of EXPY determine subsequent economic growth. Other research has returned similar findings (see Jarreau and Poncet (2012) and Fortunato and Razo (2014)).[23] Similarly, we look for empirical evidence of whether value-added EXPY can predict economic growth better than EXPY. We find that the initial levels of value-added EXPY and EXPY positively influence the subsequent economic growth of a country, and that these results are robust across all models (Annex 4, Table A4.4a, models 1–2). Value-added EXPY is a better predictor (given the higher coefficients) of economic growth.

As indicated previously, lower initial levels of GDP per capita are often associated with higher-level growth due to the catching-up effect. Years of schooling and the economic freedom index both positively influence economic growth, even after controlling for income level (GDP per capita). Population, a close proxy for the size of a country's labour force, is also positively correlated with real economic growth. Incorporating additional economic structures and policy variables in the models improves the models' fitness (R square) and significance (F-statistics) (Annex 4, Table A4.4a, models 3–4), and shows that a higher manufacturing share of the economy and lower tariff rate influence economic growth.

Our results show that the basket effect also predicts economic growth (Annex 4, Table A4.4b). This implies that countries that have switched to exporting more sophisticated products experience a higher economic growth rate. Splitting the time series before and after the GFC shows that, in all cases, an improvement of the basket (to export more sophisticated products) from a value-added perspective can predict economic growth better than conventional measures (Annex 4, Table A4.4c).

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23 Other research (see Abdmoulah (2023)) investigates the determinants of countries' ability to converge at their potential income level (defined as lnGDPPC/lnEXPY).

7. Conclusion

PRODY and EXPY are indices for product and export sophistication; both concepts were established by Hausmann, Hwang and Rodrik (2007), who also showed that EXPY is a predictor of economic growth. We argue that value-added EXPY is a slightly better predictor of economic growth than traditional EXPY. Moreover, by re-evaluating EXPY using the domestic value-added content of exports from 1997 to 2020 we gained three important new insights.

First, we find that product sophistication increased for most of the HS 6-digit products using GDP per capita in constant prices (i.e. after controlling for price effect), because the PRODY effect of EXPY prevails. This is the opposite of what Lall, Weiss and Zhang (2005) identified in their study, where the data range is from 1990 to 2000. The decline in product sophistication in the 1990s reflects an increase in both exports of relatively complex products by low-income countries (e.g. China as a manufacturing hub) and, more generally, the fragmentation of production processes (i.e. global value chain integration).

Second, high-income countries appear to have slightly higher export sophistication when their exports are measured in value-added terms than when they are measured in gross terms. These countries thus produce higher value-added content of products, and often higher value-added content of more sophisticated products.

Third, the basket effect separates countries with an increased EXPY from those with a decreased EXPY. In other words, countries that have improved their EXPY tend to do so by shifting the composition of their export basket to more sophisticated products. Moreover, the basket effect of value-added export sophistication is a better indicator of economic growth than export sophistication in value-added or gross terms.

As one of the resource-rich countries, South Africa’s EXPY fell in the global ranking during the period of our investigation. This is mainly due to South Africa’s inability to switch its export basket to more sophisticated products – especially evident when we separate the basket effect from the total growth of EXPY. South Africa’s chemical and motor vehicle industries offer promise, however, with both showing signs of faster EXPY growth than OECD countries and some other developing countries.

In addition to revealing that value-added flow is a better approach to quantifying PRODY and EXPY, this paper demonstrates the strengths and weaknesses of these two concepts as economic performance indicators, comparing the results of Hausmann, Hwang and Rodrik's system to Michaely's using various restrictive and non-restrictive country samples. While the former method is not biased towards large economies, it is very sensitive to country coverage and thus yields lower estimates for the PRODY effect than Michaely's method. The most significant changes in PRODY were caused by small, high-income countries, as captured by the RCA-weighted PRODY values. As an indicator, PRODY is also vulnerable to data idiosyncrasies, which do not necessarily arise in Michaely's methodology, which uses relative exports instead of RCA as weights. These effects on PRODY are automatically transmitted to the EXPY. Putting aside the data idiosyncrasy issue, however, EXPY is relatively robust and is highly correlated with Hausmann et al.'s (2013) Economic Complexity Index (see Annex 6).

Many studies that use factor intensity or an income approach to measure product sophistication do not consider the important factor of export prices, which can also reflect product sophistication (see Schott (2004) and Schott, Fuest and O'Rourke (2008), who use unit values to compare the different sophistication levels of items in the same product category). The prices of products in a cross-country study are often based on unit values – a debatable research subject in its own right. This is beyond our research scope but could be integrated into value-added PRODY and value-added EXPY analysis in the future to differentiate products of the same level of sophistication.

Annexures

Annex 1: Country coverage

Table A1.1: List of countries included in analysis and in each sample

ISO3	*Full coverage*	*Restricted sample*	*TiVA countries*	*ISO3*	*Full coverage*	*Restricted sample*	*TiVA countries*	*ISO3*	*Full coverage*	*Restricted sample*	*TiVA countries*
ABW	1			GHA	1	1		NPL	1	1	
AFG	1	1		GIB	1			NRU	1		
AGO	1			GIN	1	1		NZL	1	1	1
AIA	1			GMB	1			OMN	1		
ALB	1	1		GNB	1			PAK	1	1	1
AND	1			GNQ	1			PAN	1	1	
ANT	1	1		GRC	1	1	1	PCN	1		
ARE	1	1		GRD	1			PER	1	1	1
ARG	1	1	1	GRL	1			PHL	1	1	1
ARM	1	1		GTM	1	1		PLW	1		
ASM	1			GUM	1			PNG	1	1	
ATF	1			GUY	1			POL	1	1	1
ATG	1			HKG	1	1	1	PRK	1	1	
AUS	1	1	1	HND	1	1		PRT	1	1	1
AUT	1	1	1	HRV	1	1	1	PRY	1	1	
AZE	1			HTI	1	1		PSE	1	1	
BDI	1			HUN	1	1	1	PYF	1		
BEL	1	1	1	IDN	1	1	1	QAT	1		
BEN	1	1		IND	1	1	1	ROU	1	1	1
BES	1			IOT	1			RUS	1	1	1
BFA	1	1		IRL	1	1	1	RWA	1	1	
BGD	1	1	1	IRN	1			SAU	1		1
BGR	1	1	1	IRQ	1			SCG	1	1	
BHR	1			ISL	1		1	SDN	1	1	
BHS	1			ISR	1	1	1	SEN	1	1	1
BIH	1	1		ITA	1	1	1	SGP	1	1	1
BLM	1			JAM	1	1		SHN	1		
BLR	1	1	1	JOR	1	1	1	SLB	1		
BLZ	1			JPN	1	1	1	SLE	1	1	
BMU	1			KAZ	1	1	1	SLV	1	1	
BOL	1	1		KEN	1	1		SMR	1		
BRA	1	1	1	KGZ	1	1		SOM	1		
BRB	1			KHM	1	1	1	SPM	1		
BRN	1		1	KIR	1			SRB	1	1	
BTN	1			KNA	1			SSD	1		
BWA	1	1		KOR	1	1	1	STP	1		
CAF	1			KWT	1			SUR	1		
CAN	1	1	1	LAO	1	1	1	SVK	1	1	1

ISO3	*Full coverage*	*Restricted sample*	*TiVA countries*	*ISO3*	*Full coverage*	*Restricted sample*	*TiVA countries*	*ISO3*	*Full coverage*	*Restricted sample*	*TiVA countries*
CCK	1			LBN	1	1		SVN	1	1	1
CHE	1	1	1	LBR	1	1		SWE	1	1	1
CHL	1	1	1	LBY	1			SWZ	1		
CHN	1	1	1	LCA	1			SXM	1		
CIV	1	1	1	LKA	1	1		SYC	1		
CMR	1	1	1	LSO	1	1		SYR	1	1	
COD	1	1		LTU	1	1	1	TCA	1		
COG	1			LUX	1		1	TCD	1	1	
COK	1			LVA	1	1	1	TGO	1	1	
COL	1	1	1	MAC	1			THA	1	1	1
COM	1			MAR	1	1	1	TJK	1	1	
CPV	1			MDA	1	1		TKL	1		
CRI	1	1	1	MDG	1	1		TKM	1	1	
CUB	1	1		MDV	1			TLS	1		
CUW	1			MEX	1	1	1	TON	1		
CXR	1			MHL	1			TTO	1	1	
CYM	1			MKD	1	1		TUN	1	1	1
CYP	1		1	MLI	1	1		TUR	1	1	1
CZE	1	1	1	MLT	1		1	TUV	1		
DEU	1	1	1	MMR	1	1	1	TZA	1	1	
DJI	1			MNE	1			UGA	1	1	
DMA	1			MNG	1	1		UKR	1	1	1
DNK	1	1	1	MNP	1			URY	1	1	
DOM	1	1		MOZ	1	1		USA	1	1	1
DZA	1	1		MRT	1	1		UZB	1	1	
ECU	1	1		MSR	1			VCT	1		
EGY	1	1	1	MUS	1	1		VEN	1	1	
ERI	1			MWI	1	1		VGB	1		
ESP	1	1	1	MYS	1	1	1	VNM	1	1	1
EST	1	1	1	MYT	1			VUT	1		
ETH	1	1		NAM	1	1		WLF	1		
FIN	1	1	1	NCL	1			WSM	1		
FJI	1			NER	1	1		YEM	1		
FLK	1			NFK	1			ZAF	1	1	1
FRA	1	1	1	NGA	1	1	1	ZMB	1	1	
FSM	1			NIC	1	1		ZWE	1	1	
GAB	1			NIU	1						
GBR	1	1	1	NLD	1	1	1				
GEO	1	1		NOR	1	1	1	Total	228	135	75

Note: Countries are abbreviated using their ISO3 standard. ‘1’ means the country is included.

Annex 2: Summary statistics

Table A2.1a Hausmann: Summary statistics of EXPY weighted by value-added exports and exports

Year	N	Value-added export sophistication (Yf)				Export sophistication (Yf0)			
		Mean	SD	Max.	Min.	Mean	SD	Max.	Min.
1997	211	8 692	4 464	30 516	1 651	8 692	4 409	30 502	1 755
1998	211	8 849	4 600	36 007	1 885	8 849	4 508	35 308	2 025
1999	212	9 442	4 753	29 644	2 128	9 442	4 669	29 667	2 184
2000	221	10 036	5 067	33 338	2 287	10 036	4 984	33 176	2 362
2001	221	10 174	5 008	33 078	2 488	10 174	4 928	32 971	2 568
2002	221	10 557	5 137	31 707	2 144	10 557	5 045	31 553	2 259
2003	221	10 781	5 284	37 366	2 589	10 781	5 182	36 643	2 755
2004	221	11 235	5 252	31 655	2 580	11 235	5 169	31 119	2 769
2005	221	11 505	5 035	32 402	2 758	11 505	4 950	31 998	2 875
2006	223	12 268	5 650	39 793	2 785	12 268	5 581	39 897	2 921
2007	223	12 627	6 137	42 033	1 927	12 627	6 047	41 747	2 057
2008	222	12 689	6 244	39 725	2 492	12 689	6 177	39 294	2 657
2009	222	12 118	5 924	38 995	2 028	12 118	5 880	39 269	2 126
2010	223	12 374	5 733	37 757	2 480	12 374	5 664	38 274	2 562
2011	225	12 737	6 088	45 399	2 374	12 737	6 051	45 325	2 373
2012	226	12 735	6 359	41 675	2 583	12 735	6 275	41 437	2 565
2013	227	12 775	6 262	36 065	1 701	12 775	6 165	35 518	2 041
2014	226	12 947	6 454	48 317	2 743	12 947	6 360	47 340	2 766
2015	226	13 176	6 363	45 214	2 263	13 176	6 269	44 644	2 333
2016	225	13 267	6 277	35 028	2 143	13 267	6 192	35 043	2 175
2017	225	13 509	6 486	37 264	1 970	13 509	6 407	37 219	1 993
2018	225	13 700	6 728	38 870	2 117	13 700	6 627	38 792	2 146
2019	225	13 839	7 079	41 080	2 431	13 839	7 000	41 018	2 469
2020	225	12 808	6 636	41 821	2 333	12 808	6 542	41 815	2 396

Table A2.1b Michaely: Summary statistics of EXPY weighted by value-added exports and exports

Year	N	Value-added export sophistication (Yfm)				Export sophistication (Yf0m)			
		Mean	SD	Max.	Min.	Mean	SD	Max.	Min.
1997	211	21 783	5 178	37 039	9 198	22 053	4 973	36 335	9 675
1998	211	22 020	5 297	35 450	9 985	22 253	5 103	35 303	10 418
1999	212	22 803	5 376	36 132	9 421	23 089	5 156	35 986	10 005
2000	221	23 477	5 295	36 686	10 078	23 782	5 062	36 601	10 704
2001	221	23 484	5 307	36 996	11 034	23 686	5 080	36 874	11 586
2002	221	23 697	5 300	38 416	11 422	23 864	5 067	37 398	12 321
2003	221	23 745	5 313	38 934	10 170	23 856	5 060	37 817	11 033
2004	221	23 927	5 425	39 036	9 866	24 070	5 175	37 971	10 159
2005	221	24 268	5 421	40 026	9 277	24 454	5 159	38 486	9 529
2006	223	24 609	5 462	40 750	8 929	24 913	5 210	39 441	9 162
2007	223	24 943	5 618	40 794	6 248	25 138	5 359	40 315	6 867
2008	222	24 769	5 584	40 748	9 871	24 983	5 354	40 315	10 769
2009	222	23 717	5 507	38 857	7 675	23 986	5 321	38 600	8 348
2010	223	23 962	5 416	39 576	10 532	24 272	5 245	39 393	11 229
2011	225	24 332	5 720	40 403	10 107	24 628	5 550	40 147	10 296
2012	226	24 257	5 538	40 226	11 165	24 677	5 426	40 227	11 809
2013	227	24 635	5 592	40 646	9 764	25 095	5 567	41 175	10 226
2014	226	25 123	5 808	41 685	8 024	25 540	5 761	42 011	8 647
2015	226	25 383	5 952	42 261	6 447	25 834	5 897	42 834	6 997
2016	225	25 607	6 026	42 111	6 851	26 044	5 946	42 711	7 226
2017	225	26 138	6 415	43 956	6 563	26 529	6 288	44 329	6 928
2018	225	26 678	6 456	46 061	7 440	27 087	6 316	45 746	7 934
2019	225	26 934	6 352	45 849	10 297	27 412	6 231	46 349	11 509
2020	225	25 928	5 898	45 439	10 254	26 310	5 743	45 599	10 864

Table A2.2: Difference between value-added export sophistication and conventional export sophistication

Year	Hausmann (Yf-Yf0)		Michaely (Yfm-Yf0m)	
	Decrease	Increase	Decrease	Increase
1997	119	92	172	39
1998	118	93	165	46
1999	119	93	168	44
2000	126	95	176	45
2001	118	103	160	61
2002	121	100	155	66
2003	123	98	143	78
2004	116	105	151	70
2005	112	109	149	72
2006	115	108	173	50
2007	122	101	166	57
2008	113	109	158	64
2009	110	112	170	52
2010	115	108	181	42
2011	115	110	181	44
2012	123	103	183	43
2013	123	104	181	46
2014	121	105	183	43
2015	127	99	184	42
2016	129	96	183	42
2017	127	98	179	46
2018	126	99	174	51
2019	130	95	178	47
2020	132	93	167	58

Table A2.3a Hausmann: South Africa's export sophistication

Year	Full country coverage			Restricted sample			TiVA country		
	Yf	Yf0	Diff.	Yf	Yf0	Diff.	Yf	Yf0	Diff.
1997	9 490	9 489	+	10 390	10 396	-	16 135	16 157	-
1998	9 875	9 848	+	10 711	10 693	+	16 623	16 618	+
1999	10 967	10 996	-	11 349	11 367	-	17 960	18 017	-
2000	11 788	11 823	-	11 895	11 923	-	18 737	18 815	-
2001	12 021	12 008	+	12 004	12 013	-	19 065	19 100	-
2002	12 617	12 618	-	12 428	12 452	-	19 118	19 143	-
2003	12 209	12 267	-	12 465	12 543	-	19 177	19 236	-
2004	12 510	12 649	-	12 933	13 089	-	19 867	19 974	-
2005	12 632	12 771	-	13 076	13 251	-	20 446	20 582	-
2006	13 232	13 462	-	13 690	13 939	-	21 123	21 368	-
2007	14 029	14 261	-	13 947	14 269	-	21 539	21 769	-
2008	14 082	14 321	-	14 412	14 760	-	21 516	21 715	-
2009	13 366	13 625	-	13 900	14 200	-	20 543	20 789	-
2010	13 279	13 582	-	13 734	14 079	-	20 965	21 308	-
2011	13 664	13 891	-	13 802	14 085	-	21 645	21 892	-
2012	13 547	13 766	-	13 378	13 672	-	21 555	21 880	-
2013	13 611	13 862	-	13 458	13 780	-	22 137	22 492	-
2014	13 727	13 957	-	13 693	13 965	-	22 645	22 891	-
2015	13 946	14 150	-	13 674	13 985	-	23 703	23 957	-
2016	13 862	14 029	-	13 515	13 792	-	23 754	23 986	-
2017	14 175	14 351	-	13 510	13 807	-	23 846	23 991	-
2018	14 136	14 374	-	13 652	13 988	-	23 934	24 066	-
2019	13 964	14 301	-	13 835	14 270	-	23 924	24 166	-
2020	13 238	13 602	-	13 481	13 905	-	22 370	22 770	-

Table A2.3b Michaely: South Africa's export sophistication

Year	Full country coverage			Restricted sample			TiVA country		
	Yfm	Yf0m	Diff.	Yfm	Yf0m	Diff.	Yfm	Yf0m	Diff.
1997	25 315	25 507	-	25 475	25 660	-	26 196	26 352	-
1998	26 066	26 148	-	26 200	26 273	-	26 914	26 959	-
1999	27 039	27 272	-	27 110	27 315	-	27 856	28 052	-
2000	25 805	26 160	-	25 853	26 176	-	26 689	26 989	-
2001	25 999	26 186	-	26 061	26 209	-	26 929	27 054	-
2002	27 574	27 643	-	27 647	27 674	-	28 592	28 587	+
2003	27 508	27 593	-	27 563	27 613	-	28 404	28 440	-
2004	27 578	27 737	-	27 643	27 760	-	28 391	28 506	-
2005	27 653	27 850	-	27 712	27 870	-	28 463	28 618	-
2006	27 946	28 301	-	28 002	28 311	-	28 790	29 080	-
2007	28 272	28 649	-	28 318	28 653	-	29 098	29 414	-
2008	28 186	28 461	-	28 255	28 477	-	28 902	29 102	-
2009	26 933	27 350	-	27 019	27 393	-	27 607	27 982	-
2010	27 272	27 781	-	27 352	27 815	-	28 043	28 499	-
2011	27 996	28 376	-	28 077	28 412	-	28 910	29 187	-
2012	27 663	28 219	-	27 782	28 287	-	28 716	29 164	-
2013	28 567	29 199	-	28 722	29 301	-	29 762	30 262	-
2014	29 365	29 790	-	29 569	29 930	-	30 670	30 933	-
2015	30 214	30 801	-	30 409	30 939	-	31 762	32 153	-
2016	30 016	30 570	-	30 235	30 730	-	31 714	32 076	-
2017	30 417	30 826	-	30 670	31 019	-	32 166	32 378	-
2018	30 497	30 909	-	30 768	31 118	-	32 300	32 518	-
2019	30 265	30 781	-	30 540	30 993	-	32 188	32 503	-
2020	28 554	28 965	-	28 806	29 158	-	30 448	30 665	-

Annex 3: Variables used for regression analysis

Level of economic development and real GDP growth (GDPPC and GDPPC_G)

The level of development is represented by GDP per capita in constant prices (in natural logarithm and available from the World Bank's WDI). GDP growth is calculated as the growth of real GDP per capita with a 5- or 10-year interval.

Labour market conditions (YRSCH)

Educational attainment represents labour market conditions and is proxied by the average years of schooling attained (Barro and Lee 2013). Data are available from 1950 to 2015 at five-year intervals. Missing data between the collections, for instance during 2006–2009 and 2011–2014, are linearly extrapolated. The 2015 data are simply carried forward for the years 2016–2020.

Quality of institutions (SUM.EFW and SUM.EFS)

The institutional quality indicator is used as a proxy for economic policy, over which governments typically exercise control. The data come from Economic Freedom of the World (EFW) by the Fraser Institute and include one summary statistic and scores on five sub-areas.[24] The scores range between 0 and 10, with 10 being the highest freedom.

Country characteristics (AREA and POPL)

Country land areas are sourced from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), and a country's total population from the World Bank's WDI. Both are expressed in natural logarithms. Working-age population (between 15 and 64) is an alternative to the total population and is used as an alternative to be tested in the model.

Degree of industrialisation and natural resources rents (RESCH and MFGSH)

A country's economic structure is proxied by manufacturing as a share of a country's total value-added production (authors' calculation using OECD TiVA) and natural resources rents

[24] The data consist of economic freedom measures in the following areas: (i) size of government; (ii) legal system and security of property rights; (iii) sound money; (iv) freedom to trade internationally; and (v) regulation. A summary index is also provided based on the score of these five areas. For more details, visit https://www.fraserinstitute.org/economic-freedom/

(the sum of oil, natural gas, coal, mineral and forest rents) as a percentage of nominal GDP (sourced from the World Bank's WDI). *Natural resources rents* measure the difference between the value of the production at regional prices and the total costs of production for oil, natural gas, coal, minerals and forests.

Distance to market (DISTW)

The distance to market measures the trade-weighted distance of a country from all of its trading partners, expressed in natural logarithm. Bilateral distance data refer to the weighted distance between the largest cities of two countries (sourced from CEPII). The distance data are then aggregated using merchandise trade (sourced from the OECD's Bilateral Trade Database by Industry and End-use) as weights.

Regional trade agreements and applied tariff rates (FTA and TARIFF)

The trade policy indicators are sourced from the WTO and the World Bank. The WTO Regional Trade Agreement database provides a list of existing regional trade agreements since the establishment of the WTO (which replaced the General Agreement on Trade and Tariffs). These agreements amount to nearly 800 accumulative notifications, of which about 350 are currently in force. The database contains information such as the date of signature, the date of entry into force, the inactive date if appropriate and all signatories (countries or territories) involved. The active agreements between countries are treated as dummy variables: if there is at least one active agreement between two countries, it is assigned the value of 1 regardless of coverage (goods, services or both). The dummies of 1 are then summed by country and represent the number of partner countries with which the country has at least one active preferential trade agreement. A country's trade policy is also measured by the applied tariff rates (sourced from the World Bank's WDI). The applied tariff is the average of effectively applied rates weighted by the product import shares corresponding to each partner country.

Business operation and border-related procedures (BNS.CST, BNS.DUR and BUR.CUS)

Doing-business indicators of choice for this research are: (i) the ease of doing business; (ii) the time required to start a business; and (iii) the cost of business start-up procedures. The ease of doing business scores benchmark economies with respect to regulatory best practice, showing the proximity to the best regulatory performance on each doing-business indicator. An economy's score is indicated on a scale of 0 to 100, with 100 being the best regulatory performance. The time required to start a business is the number of calendar days needed to complete the procedures to legally operate a business. Lastly, the cost of business start-up procedures indicates the expense of registering a business, normalised by presenting it as a percentage of gross national income per capita. The burden of customs procedures (ranging from 1 to 7, with 7 being the best) are from global competitiveness indicators (sourced from the World Economic Forum).

Logistics performance (LPI.ALL)

Quantitative measures of business climate are from the logistics performance index (LPI), the Doing Business survey (both sourced from the World Bank) and global competitiveness indicators (World Economic Forum). The LPI summarises the logistics professional's perception of a country's logistic business services, and scores (ranging from 1 to 5, with 5 being the best) are averaged across all respondents. The evaluations consist of one score for overall logistics services and six sub-areas. The sub-areas are: (i) efficiency of customs clearance process; (ii) quality of trade and transport-related infrastructure; (iii) ease of arranging competitively priced shipments; (iv) competence and quality of logistics services; (v) frequency with which shipments reach consignee within scheduled or expected time; and (vi) ability to track and trace consignments.

The quality of transport infrastructure (QINFS_ROAD, QINFS_RAIL and QINFS_PORT)

The quality of transport infrastructure, such as the quality of roads, railways, ports and air transport, is important to facilitate the movement of goods and services. The indicators for the quality of infrastructure are sourced from the global competitiveness indicators. Like some of the logistics and institutional quality variables explained earlier, the quality of transport infrastructure also has an overall index.

Annex 4: Regression results

Table A4.1: Correlates of value-added EXPY and of the difference between value-added EXPY and EXPY

	Dependent variable							
	Yf				*ΔYf (Yf-Yf0)*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDPPC	0.2829***	0.2449***	0.2585***	0.2685***	0.0052***	0.0061***	0.0056***	0.0057***
	(0.0027)	(0.0045)	(0.0059)	(0.0056)	(0.0002)	(0.0004)	(0.0005)	(0.0005)
YRSCH		0.0166***	0.0187***	0.0197***		-0.0003*	0.0007***	0.0008***
		(0.0021)	(0.0026)	(0.0024)		(0.0002)	(0.0002)	(0.0002)
SUM.EFW			-0.0024***	-0.0037***			-0.0002***	-0.0003***
			(0.0007)	(0.0006)			(0.0001)	(0.0001)
POPL				0.0673***				0.0011***
				(0.0038)				(0.0003)
AREA				-0.0299***				-0.0010***
				(0.0031)				(0.0003)
Constant	6.6287***	6.8404***	6.9889***	6.2510***	-0.0449***	-0.0495***	-0.0393***	-0.0419***
	(0.0306)	(0.0348)	(0.0419)	(0.0639)	(0.0022)	(0.0028)	(0.0035)	(0.0056)
Observations	4 679	3 357	2 687	2 687	4 679	3 357	2 687	2 687
R^2	0.7176	0.7509	0.7617	0.7878	0.1262	0.1531	0.1578	0.1624
Adjusted R^2	0.7162	0.7491	0.7596	0.7858	0.1217	0.1467	0.1506	0.1545
Residual std. error	0.2718	0.2460	0.2349	0.2217	0.0200	0.0197	0.0196	0.0195
F statistic	492.7981***	401.6969***	369.9886***	395.2269***	28.0008***	24.0836***	21.7007***	20.6402***

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$. Due to high correlation, the regression results for EXPY and value-added EXPY results are very similar.

Table A4.2 Determinants of the difference between value-added EXPY and EXPY

a) Baseline estimates

	Dependent variable					
	ΔYf (Yf-Yf0)			*ΔYfm (Yfm-Yfm0)*		
	(1)	(2)	(3)	(4)	(5)	(6)
GDPPC	0.0030***	0.0030***	0.0004	0.0004	-0.0012	-0.0039
	(0.0008)	(0.0008)	(0.0034)	(0.0009)	(0.0009)	(0.0029)
YRSCH	0.0015***	0.0015***	-0.0002	0.0037***	0.0043***	-0.0024***
	(0.0003)	(0.0003)	(0.0009)	(0.0003)	(0.0003)	(0.0008)
SUM.EFW	0.0002**	0.0002**	0.0003*	0.0004***	0.0003***	0.0003**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
POPL	0.0025***	0.0025***	-0.0212***	0.0026***	0.0026***	-0.0557***
	(0.0005)	(0.0005)	(0.0068)	(0.0005)	(0.0005)	(0.0058)
AREA	-0.0038***	-0.0038***	-0.0049	-0.0030***	-0.0030***	-0.0084*
	(0.0003)	(0.0004)	(0.0058)	(0.0004)	(0.0004)	(0.0050)
RESRC	0.0001	0.0001	0.0001	-0.0003**	-0.0002**	-0.0007***
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002)
MFGSH	0.0008***	0.0008***	0.0009***	0.0014***	0.0012***	0.0001
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002)
DISTW	0.0044***	0.0045***	0.0025	0.0015	0.0033***	0.0147***
	(0.0011)	(0.0011)	(0.0041)	(0.0012)	(0.0011)	(0.0035)
FTA	-0.00002	-0.00001	-0.0001	-0.00004*	0.00004**	-0.0001***
	(0.00002)	(0.00002)	(0.00004)	(0.00002)	(0.00002)	(0.00004)
TARIFF	0.0001	0.0001	-0.0003*	-0.0003*	-0.0008***	-0.0007***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)
Constant	-0.1026***	-0.1022***	0.3774**	-0.1098***	-0.1068***	0.9956***
	(0.0102)	(0.0105)	(0.1606)	(0.0108)	(0.0107)	(0.1383)
Observations	1 243	1 243	1 243	1 243	1 243	1 243
R^2	0.3033	0.3086	0.7487	0.4661	0.5095	0.8733
Adjusted R^2	0.2976	0.2926	0.7269	0.4618	0.4982	0.8624
Year fixed effect	NO	YES	YES	NO	YES	YES
COU fixed effect	NO	NO	YES	NO	NO	YES
Residual std. error	0.0159	0.0159	0.0099	0.0169	0.0163	0.0085
F statistic	53.6345***	19.3504***	34.3976***	107.5529***	45.0451***	79.6084***

Note: *p<0.1; **p<0.05; ***p<0.01.

b) Additional variables

	Dependent variable					
	ΔYf ***(Yf-Yf0)***			*ΔYfm* ***(Yfm-Yfm0)***		
	(1)	(2)	(3)	(4)	(5)	(6)
GDPPC	0.0024**	0.0034*	0.0009	-0.0036***	-0.0013	-0.0016
	(0.0012)	(0.0020)	(0.0014)	(0.0012)	(0.0021)	(0.0015)
YRSCH	0.0012**	0.0004	0.0011**	0.0045***	0.0041***	0.0045***
	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0006)	(0.0006)
SUM.EFW	0.0005***	0.0004**	0.0006***	0.0005***	0.0005***	0.0005***
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
POPL	0.0022***	0.0024**	0.0032***	0.0015**	0.0025**	0.0017*
	(0.0006)	(0.0010)	(0.0009)	(0.0007)	(0.0010)	(0.0009)
AREA	-0.0029***	-0.0032***	-0.0043***	-0.0012**	-0.0011*	-0.0003
	(0.0005)	(0.0006)	(0.0006)	(0.0005)	(0.0007)	(0.0006)
RESRC	0.0001	0.0001	0.0001	-0.0001	-0.0002	-0.0001
	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
MFGSH	0.0006***	0.0006***	0.0004***	0.0010***	0.0012***	0.0011***
	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
DISTW	-0.0010	-0.0013	0.0002	-0.0023	-0.0014	-0.0030
	(0.0015)	(0.0021)	(0.0020)	(0.0016)	(0.0022)	(0.0021)
FTA	-0.0001***	-0.0001**	-0.0001***	0.0001**	0.00004	0.0001**
	(0.00003)	(0.00004)	(0.00003)	(0.00003)	(0.00004)	(0.00003)
TARIFF	0.0007**	0.0004	0.0010***	-0.0007*	-0.0019***	-0.0007*
	(0.0003)	(0.0005)	(0.0004)	(0.0003)	(0.0005)	(0.0004)
BNS.CST	0.0001			-0.0001**		
	(0.00004)			(0.00004)		
BNS.DUR	0.000004			0.0002***		
	(0.00003)			(0.00003)		
BUR.CUS	-0.0001			-0.0001		
	(0.0001)			(0.0001)		
LPI.ALL		-0.00003			-0.0004**	
		(0.0002)			(0.0002)	
QINFS_PORT			-0.0003***			-0.0003***
			(0.0001)			(0.0001)
QINFS_RAIL			0.0002***			-0.00002
			(0.0001)			(0.0001)
QINFS_ROAD			0.0000			-0.000000
			(0.000000)			(0.000000)
Constant	-0.0734***	-0.0592***	-0.0635***	-0.0492***	-0.0715***	-0.0747***
	(0.0147)	(0.0203)	(0.0168)	(0.0154)	(0.0210)	(0.0176)
Observations	614	387	499	614	387	499
R^2	0.2770	0.2514	0.3379	0.5032	0.5057	0.5119
Adjusted R^2	0.2501	0.2190	0.3102	0.4847	0.4844	0.4915
Year fixed effect	YES	YES	YES	YES	YES	YES
Residual std. error	0.0146	0.0156	0.0147	0.0152	0.0162	0.0154
F statistic	10.2920***	7.7659***	12.1949***	27.2062***	23.6626***	25.0688***

Note: *p<0.1; **p<0.05; ***p<0.01.

Table A4.3: What determines the growth of EXPY?

a) Growth of value-added EXPY and EXPY

	Dependent variable							
	5-year growth Yf (Yf_{t+5}-Yf_t)				**5-year growth Yf0 ($Yf0_{t+5}$-$Yf0_t$)**			
	(1)	(2)	(3) before	(4) after	(5)	(6)	(7) before	(8) after
$GDPPC_{t-1}$	-0.0056		-0.0094	-0.0043	-0.0045		-0.0101	-0.0026
	(0.0046)		(0.0087)	(0.0050)	(0.0045)		(0.0087)	(0.0049)
$YRSCH_{t-1}$	0.0043^{**}	0.0032^{**}	-0.0031	0.0033^{*}	0.0046^{***}	0.0037^{**}	0.00005	0.0030
	(0.0018)	(0.0016)	(0.0032)	(0.0020)	(0.0018)	(0.0015)	(0.0032)	(0.0020)
$SUM.EFW_{t-1}$	-0.0007	-0.0010^{**}	-0.0032^{***}	0.0003	-0.0006	-0.0009^{**}	-0.0030^{***}	0.0002
	(0.0005)	(0.0005)	(0.0009)	(0.0006)	(0.0005)	(0.0005)	(0.0009)	(0.0006)
$POPL_{t-1}$	-0.0037	-0.0033	-0.0037	-0.0039	-0.0039	-0.0035	-0.0014	-0.0046^{*}
	(0.0026)	(0.0026)	(0.0054)	(0.0028)	(0.0025)	(0.0025)	(0.0054)	(0.0027)
AREA	-0.0014	-0.0017	-0.0052	0.00002	-0.0010	-0.0013	-0.0056	0.0005
	(0.0019)	(0.0019)	(0.0041)	(0.0021)	(0.0019)	(0.0019)	(0.0041)	(0.0020)
$RESRC_{t-1}$	-0.0016^{***}	-0.0016^{***}	-0.0028	-0.0010^{*}	-0.0015^{***}	-0.0015^{**}	-0.0028	-0.0010
	(0.0006)	(0.0006)	(0.0019)	(0.0006)	(0.0006)	(0.0006)	(0.0019)	(0.0006)
$MFGSH_{t-1}$	0.0002	0.0003	-0.0034^{***}	0.0013^{**}	0.0004	0.0005	-0.0028^{**}	0.0014^{**}
	(0.0005)	(0.0005)	(0.0011)	(0.0006)	(0.0005)	(0.0005)	(0.0011)	(0.0005)
$DISTW_{t-1}$	-0.0033	-0.0036	-0.0166	-0.0012	-0.0007	-0.0010	-0.0090	0.0001
	(0.0060)	(0.0060)	(0.0108)	(0.0067)	(0.0059)	(0.0059)	(0.0108)	(0.0066)
FTA_{t-1}	0.0002	0.0001	-0.0006^{**}	0.0002^{*}	0.0002^{*}	0.0002	-0.0005^{*}	0.0003^{**}
	(0.0001)	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0001)
$TARIFF_{t-1}$	0.0006	0.0008	0.0026^{**}	-0.0018^{*}	0.0004	0.0006	0.0026^{**}	-0.0020^{*}
	(0.0009)	(0.0008)	(0.0012)	(0.0011)	(0.0008)	(0.0008)	(0.0012)	(0.0011)
Constant	0.2946^{***}	0.2714^{***}	0.8288^{***}	0.0954	0.2510^{***}	0.2323^{***}	0.6805^{***}	0.0733
	(0.0570)	(0.0537)	(0.1065)	(0.0628)	(0.0561)	(0.0528)	(0.1057)	(0.0621)
Observations	985	985	182	803	985	985	182	803
R^2	0.2642	0.2631	0.4094	0.1558	0.2695	0.2688	0.3454	0.1686
Adjusted R^2	0.2458	0.2454	0.3675	0.1331	0.2513	0.2513	0.3071	0.1462
Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Residual std. error	0.0767	0.0767	0.0637	0.0751	0.0755	0.0755	0.0635	0.0743
F statistic	14.3631^{***}	14.9151^{***}	9.7643^{***}	6.8621^{***}	14.7599^{***}	15.3583^{***}	9.0216^{***}	7.5394^{***}

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

before: before the GFC.

after: after the GFC.

b) Basket effect of value-added EXPY and basket effect of EXPY

	Dependent variable							
	Basket effect of Yf (Yf.bkt/Yf)				Basket effect of Yf (Yf.bkt/Yf)			
	(1)	(2)	(3) before	(4) after	(5)	(6)	(7) before	(8) after
$GDPPC_{t-1}$	0.0017***		0.0030***	0.0014***	0.0017***		0.0029***	0.0014***
	(0.0002)		(0.0004)	(0.0002)	(0.0002)		(0.0004)	(0.0002)
$YRSCH_{t-1}$	-0.0001	0.0002***	-0.0004**	0.00005	-0.0001	0.0002***	-0.0004**	0.00003
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
$SUM.EFW_{t-1}$	-0.0001***	-0.000004	-0.0001	-0.0001***	-0.0001***	-0.00001	-0.0001	-0.0001***
	(0.00002)	(0.00002)	(0.00005)	(0.00002)	(0.00002)	(0.00002)	(0.00005)	(0.00002)
$POPL_{t-1}$	-0.00002	-0.0002	0.0004*	-0.0001	-0.00003	-0.0002*	0.0004	-0.0001
	(0.0001)	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0001)
AREA	0.0002***	0.0003***	-0.0001	0.0003***	0.0002***	0.0003***	-0.0001	0.0003***
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
$RESRC_{t-1}$	0.0002***	0.0002***	0.0003***	0.0002***	0.0002***	0.0002***	0.0003***	0.0002***
	(0.00002)	(0.00002)	(0.0001)	(0.00002)	(0.00002)	(0.00002)	(0.0001)	(0.00002)
$MFGSH_{t-1}$	-0.00004**	-0.0001***	0.0001*	-0.0001***	-0.00004**	-0.0001***	0.0001	-0.0001***
	(0.00002)	(0.00002)	(0.0001)	(0.00002)	(0.00002)	(0.00002)	(0.0001)	(0.00002)
$DISTW_{t-1}$	-0.0014***	-0.0013***	-0.0008	-0.0015***	-0.0014***	-0.0012***	-0.0007	-0.0014***
	(0.0002)	(0.0002)	(0.0005)	(0.0002)	(0.0002)	(0.0002)	(0.0005)	(0.0003)
FTA_{t-1}	-0.00001**	0.000003	-0.00002	-0.00001	-0.00001**	0.000002	-0.00002	-0.00001*
	(0.000005)	(0.000005)	(0.00001)	(0.000005)	(0.000005)	(0.000005)	(0.00001)	(0.000005)
$TARIFF_{t-1}$	-0.0001**	-0.0001***	-0.0001	-0.00004	-0.0001**	-0.0001***	-0.0001	-0.0001
	(0.00003)	(0.00003)	(0.0001)	(0.00004)	(0.00003)	(0.00003)	(0.0001)	(0.00004)
Constant	0.9836***	0.9908***	0.9613***	0.9955***	0.9839***	0.9910***	0.9619***	0.9958***
	(0.0022)	(0.0021)	(0.0052)	(0.0023)	(0.0022)	(0.0021)	(0.0052)	(0.0023)
Observations	985	985	182	803	985	985	182	803
R^2	0.7887	0.7673	0.4726	0.6464	0.7881	0.7666	0.4679	0.6447
Adjusted R^2	0.7834	0.7618	0.4352	0.6369	0.7828	0.7610	0.4301	0.6351
Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Residual std. error	0.0029	0.0031	0.0031	0.0028	0.0029	0.0031	0.0031	0.0028
F statistic	149.3115***	137.7992***	12.6213***	67.9759***	148.7811***	137.2174***	12.3848***	67.4711***

Note: *p<0.1; **p<0.05; ***p<0.01.

The dependent variable is a relative measure expressed using the basket effect of EXPY as a share of total EXPY in value-added terms.

Yf.bkt: basket effect of Yf, calculated using lagged GDP per capita constant (i.e. at time t) to estimatevalue-added EXPY at t+5.

before: before the GFC.

after: after the GFC.

Table A4.4: Is value-added EXPY a better indicator for growth?

a) Value-added EXPY and EXPY

	Dependent variable			
	GDP per capita growth rate between t+5 and t			
	(1)	(2)	(3)	(4)
Yf_{t-1}	**0.0062*****		**0.0044***	
	(0.0016)		**(0.0022)**	
$Yf0_{t-1}$		**0.0059*****		**0.0035**
		(0.0016)		**(0.0023)**
$GDPPC_{t-1}$	-0.0099***	-0.0098***	-0.0082***	-0.0079***
	(0.0006)	(0.0006)	(0.0008)	(0.0008)
$YRSCH_{t-1}$	0.0017***	0.0017***	0.0004	0.0004*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$SUM.EFW_{t-1}$	0.0004***	0.0004***	0.0002***	0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$POPL_{t-1}$	0.0017***	0.0017***	0.0011***	0.0011***
	(0.0003)	(0.0003)	(0.0004)	(0.0004)
AREA	-0.0004	-0.0004	-0.0008***	-0.0009***
	(0.0002)	(0.0002)	(0.0003)	(0.0003)
$RESRC_{t-1}$			0.0002**	0.0002**
			(0.0001)	(0.0001)
$MFGSH_{t-1}$			0.0005***	0.0005***
			(0.0001)	(0.0001)
$DISTW_{t-1}$			-0.0004	-0.0004
			(0.0008)	(0.0008)
FTA_{t-1}			-0.00002	-0.00002
			(0.00002)	(0.00002)
$TARIFF_{t-1}$			-0.0002*	-0.0002**
			(0.0001)	(0.0001)
Constant	-0.0168	-0.0155	0.0218	0.0281
	(0.0110)	(0.0112)	(0.0181)	(0.0184)
Observations	1 871	1 871	985	985
R^2	0.2492	0.2486	0.4606	0.4598
Adjusted R^2	0.2411	0.2404	0.4465	0.4457
Year fixed effect	YES	YES	YES	YES
Residual std. error	0.0149	0.0149	0.0103	0.0103
F statistic	30.7096***	30.5977***	32.7547***	32.6480***

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

b) Value-added EXPY and EXPY: basket effect

	Dependent variable			
	GDP per capita growth rate between t+5 and t			
	(1)	(2)	(3)	(4)
$Yf.bkt_{t-1}$	**0.0096^{***}**		**0.0078^{***}**	
	(0.0015)		**(0.0021)**	
$Yf0.bkt_{t-1}$		**0.0088^{***}**		**0.0069^{***}**
		(0.0016)		**(0.0021)**
$GDPPC_{t-1}$	-0.0108^{***}	-0.0105^{***}	-0.0090^{***}	-0.0088^{***}
	(0.0006)	(0.0006)	(0.0008)	(0.0008)
$YRSCH_{t-1}$	0.0016^{***}	0.0016^{***}	0.0003	0.0003
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$SUM.EFW_{t-1}$	0.0004^{***}	0.0004^{***}	0.0003^{***}	0.0003^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$POPL_{t-1}$	0.0015^{***}	0.0016^{***}	0.0010^{***}	0.0011^{***}
	(0.0003)	(0.0003)	(0.0004)	(0.0004)
AREA	-0.0003	-0.0003	-0.0008^{***}	-0.0008^{***}
	(0.0002)	(0.0002)	(0.0003)	(0.0003)
$RESRC_{t-1}$			0.0002^{**}	0.0002^{**}
			(0.0001)	(0.0001)
$MFGSH_{t-1}$			0.0004^{***}	0.0004^{***}
			(0.0001)	(0.0001)
$DISTW_{t-1}$			-0.0001	-0.0002
			(0.0008)	(0.0008)
FTA_{t-1}			-0.00003	-0.00003
			(0.00002)	(0.00002)
$TARIFF_{t-1}$			-0.0002^{*}	-0.0002^{*}
			(0.0001)	(0.0001)
Constant	-0.0386^{***}	-0.0344^{***}	-0.0045	0.0017
	(0.0109)	(0.0111)	(0.0173)	(0.0174)
Observations	1 871	1 871	985	985
R^2	0.2584	0.2558	0.4663	0.4646
Adjusted R^2	0.2503	0.2477	0.4524	0.4507
Year fixed effect	YES	YES	YES	YES
Residual std. error	0.0148	0.0149	0.0102	0.0102
F statistic	32.2240^{***}	31.7925^{***}	33.5112^{***}	33.2920^{***}

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Yf.bkt: basket effect of Yf, calculated using lagged GDP per capita constant (i.e. at time t) to estimate value-added EXPY at t+5.

c) Value-added EXPY and EXPY: basket effect

Before and after GFC

	Dependent variable							
	GDP per capita growth rate between t+5 and t							
	(1) before	(2) before	(3) before	(4) before	(5) after	(6) after	(7) after	(8) after
$Yf.bkt_{t-1}$	**0.0202^{***}**		**0.0093^{*}**		**0.0070^{***}**		**0.0079^{***}**	
	(0.0036)		**(0.0048)**		**(0.0017)**		**(0.0022)**	
$Yf0.bkt_{t-1}$		**0.0195^{***}**		**0.0083^{*}**		**0.0063^{***}**		**0.0069^{***}**
		(0.0037)		**(0.0049)**		**(0.0017)**		**(0.0022)**
$GDPPC_{t-1}$	-0.0160^{***}	-0.0157^{***}	-0.0141^{***}	-0.0139^{***}	-0.0096^{***}	-0.0094^{***}	-0.0076^{***}	-0.0073^{***}
	(0.0015)	(0.0015)	(0.0018)	(0.0018)	(0.0007)	(0.0007)	(0.0008)	(0.0008)
$YRSCH_{t-1}$	0.0031^{***}	0.0032^{***}	0.0029^{***}	0.0029^{***}	0.0012^{***}	0.0012^{***}	-0.0007^{**}	-0.0006^{**}
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0002)	(0.0002)	(0.0003)	(0.0003)
$SUM.EFW_{t-1}$	0.0004^{***}	0.0004^{***}	0.0001	0.0001	0.0004^{***}	0.0004^{***}	0.0004^{***}	0.0004^{***}
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$POPL_{t-1}$	0.0008	0.0009	-0.0003	-0.0002	0.0016^{***}	0.0017^{***}	0.0012^{***}	0.0013^{***}
	(0.0008)	(0.0008)	(0.0009)	(0.0009)	(0.0003)	(0.0003)	(0.0004)	(0.0004)
AREA	-0.0003	-0.0003	0.0002	0.0001	-0.0003	-0.0003	-0.0008^{***}	-0.0009^{***}
	(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$RESRC_{t-1}$			0.0005^{*}	0.0005^{*}			0.0002^{**}	0.0002^{**}
			(0.0003)	(0.0003)			(0.0001)	(0.0001)
$MFGSH_{t-1}$			0.0002	0.0002			0.0005^{***}	0.0005^{***}
			(0.0002)	(0.0002)			(0.0001)	(0.0001)
$DISTW_{t-1}$			-0.0042^{**}	-0.0042^{**}			0.0005	0.0005
			(0.0018)	(0.0018)			(0.0009)	(0.0009)
FTA_{t-1}			-0.00004	-0.00004			-0.00003	-0.00003
			(0.00005)	(0.00005)			(0.00002)	(0.00002)
$TARIFF_{t-1}$			-0.00004	-0.00005			-0.0002	-0.0002
			(0.0002)	(0.0002)			(0.0001)	(0.0001)
Constant	-0.0945^{***}	-0.0909^{***}	0.0644	0.0705^{*}	-0.0305^{**}	-0.0265^{**}	-0.0394^{**}	-0.0320^{*}
	(0.0243)	(0.0250)	(0.0394)	(0.0400)	(0.0122)	(0.0123)	(0.0188)	(0.0188)
Observations	345	345	182	182	1 526	1 526	803	803
R^2	0.3134	0.3061	0.5687	0.5668	0.2269	0.2252	0.4393	0.4372
Adjusted R^2	0.2971	0.2896	0.5353	0.5333	0.2182	0.2165	0.4235	0.4213
Year fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Residual std. error	0.0149	0.0149	0.0103	0.0104	0.0147	0.0147	0.0096	0.0097
F statistic	19.1743^{***}	18.5302^{***}	17.0368^{***}	16.9072^{***}	26.0400^{***}	25.7831^{***}	27.7774^{***}	27.5410^{***}

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Yf.bkt: basket effect of Yf, calculated using lagged GDP per capita constant (i.e. at time t) to estimate value-added EXPY at t+5.

before: before the GFC.

after: after the GFC.

Annex 5: Variance-covariance matrices

Table A5.1 Variance-covariance matrices of export sophistication and their determinants

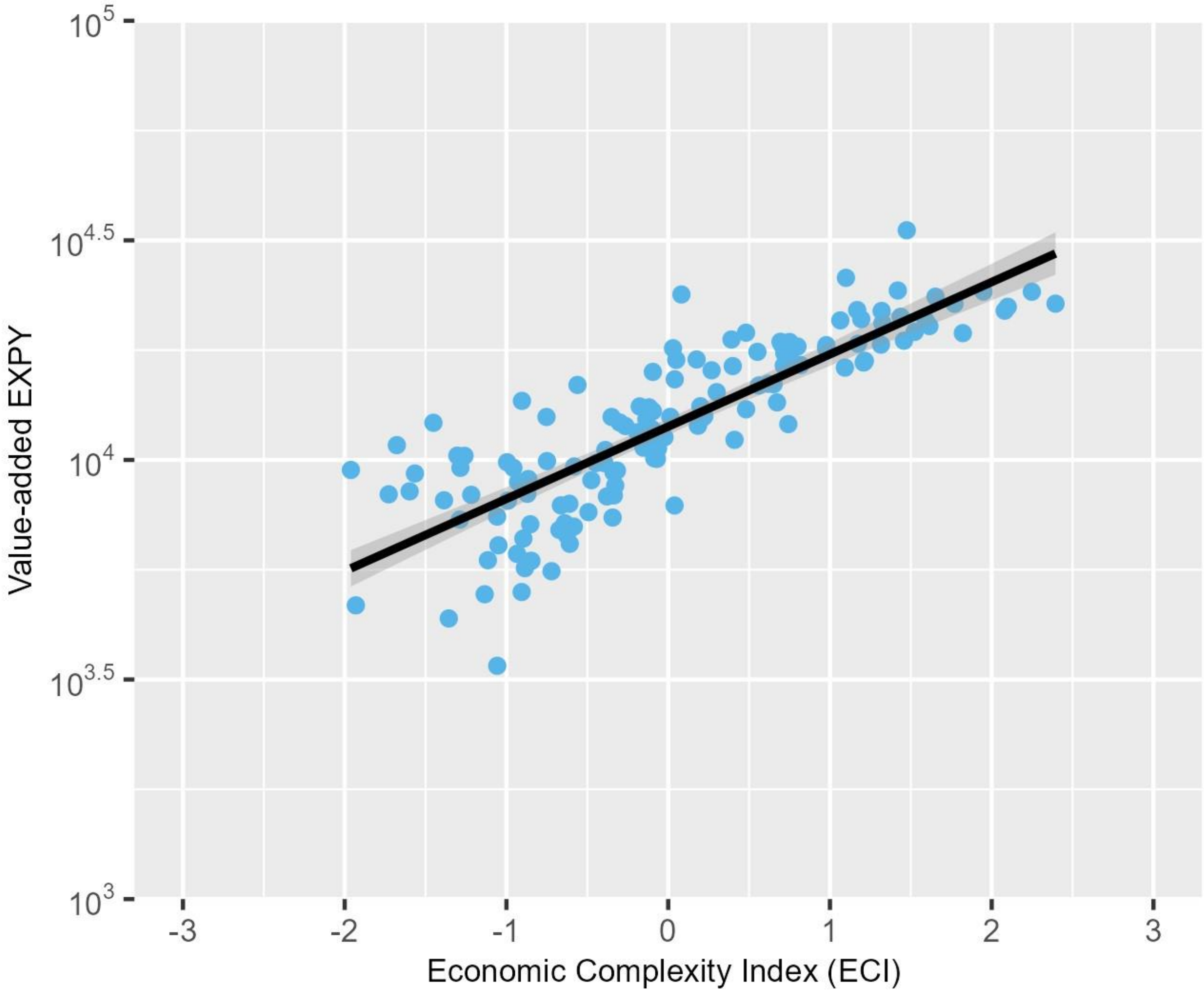
	Yf	ΔYf	Yf.bkt	Yf.bkt/ Yf	GDPPC	YRSCH	SUM.E FS	AREA	POPL	RESRC	MFGSH	DISTW	FTA	TARIFF	BNS.C ST	BNS.D UR	BUR.C US	LPI.AL L	QINFS_ PORT	QINFS_ RAIL	QINFS_ ROAD
Yf	1.00																				
ΔYf	0.41***	1.00																			
Yf.bkt	0.97***	0.40***	1.00																		
Yf.bkt/Yf	0.13***	0.09***	0.36***	1.00																	
GDPPC	0.83***	0.35***	0.80***	0.09***	1.00																
YRSCH	0.71***	0.28***	0.70***	0.19***	0.77***	1.00															
SUM.EFS	0.52***	0.17***	0.52***	0.06***	0.67***	0.55***	1.00														
AREA	-0.08***	0.05**	-0.08***	0.09***	-0.26***	-0.13***	-0.21***	1.00													
POPL	-0.08***	0.05***	-0.08***	0.12***	-0.25***	-0.11***	-0.12***	0.84***	1.00												
RESRC	-0.15***	0.10***	-0.15***	0.05**	-0.18***	-0.29***	-0.34***	0.27***	0.15***	1.00											
MFGSH	-0.03	0.12***	-0.06*	-0.17***	-0.27***	-0.14***	-0.27***	0.10***	0.27***	-0.22***	1.00										
DISTW	-0.31***	-0.10***	-0.30***	-0.01	-0.23***	-0.34***	-0.09***	0.18***	0.16***	0.26***	-0.08***	1.00									
FTA	0.34***	0.14***	0.36***	0.17***	0.27***	0.29***	0.18***	0.20***	0.30***	-0.17***	-0.01	-0.14***	1.00								
TARIFF	-0.24***	-0.12***	-0.22***	-0.07***	-0.26***	-0.32***	-0.25***	-0.05**	-0.08***	0.07***	0.14***	0.31***	-0.13***	1.00							
BNS.CST	-0.37***	-0.12***	-0.39***	-0.21***	-0.42***	-0.40***	-0.38***	0.09***	0.05**	0.19***	0.10***	0.23***	-0.19***	0.16***	1.00						
BNS.DUR	-0.20***	0.03	-0.22***	-0.17***	-0.16***	-0.26***	-0.32***	0.08***	-0.05*	0.19***	0.08**	0.09***	-0.15***	0.08***	0.28***	1.00					
BUR.CUS	0.53***	0.12***	0.52***	0.16***	0.67***	0.48***	0.76***	-0.29***	-0.19***	-0.22***	-0.20***	-0.21***	0.21***	-0.18***	-0.39***	-0.36***	1.00				
LPI.ALL	0.74***	0.24***	0.73***	0.20***	0.80***	0.66***	0.71***	-0.05	0.18***	-0.30***	-0.09	-0.18***	0.46***	-0.54***	-0.35***	-0.33***	0.69***	1.00			
QINFS_PORT	0.54***	0.17***	0.54***	0.21***	0.69***	0.45***	0.64***	-0.25***	-0.11***	-0.19***	-0.23***	-0.07**	0.27***	-0.13***	-0.30***	-0.30***	0.77***	0.74***	1.00		
QINFS_RAIL	0.68***	0.30***	0.67***	0.24***	0.68***	0.60***	0.55***	-0.12***	0.09*	-0.28***	-0.06	-0.28***	0.30***	-0.48***	-0.46***	-0.27***	0.67***	0.76***	0.66***	1.00	
QINFS_ROAD	-0.00	0.00	0.00	0.02	0.01	-0.00	0.01	-0.01	-0.04	0.01	-0.04	-0.01	-0.03	-0.01	-0.01	0.05*	-0.01	-0.03	0.01	-0.01	1.00

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Yf.bkt: basket effect of Yf, calculated using lagged GDP per capita constant (i.e. at time t) to estimate value-added EXPY at t+5.

Annex 6: Value-added EXPY and Economic Complexity Index

Figure A6.1 Correlation between Economic Complexity Index and value-added EXPY, 2020



Note: The ECI is retrieved from the Atlas of Economic Complexity, an online visualisation tool maintained by Harvard University's Growth Lab. https://atlas.cid.harvard.edu/rankings (accessed 21 January 2024)

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