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An investigation into the technological complexity of exports from Bangladesh, Ethiopia, Ghana, Madagascar, South Africa and Viet Nam

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This paper addresses the question as to whether, and if so to what extent, Bangladesh, Ethiopia, Ghana, Madagascar, South Africa and Viet Nam have upgraded their exports in terms of technological complexity over the past 15 years. The analysis exploits three product classifications to illustrate the importance of technologically complex products in total exports and complements the findings with a quantitative methodology that computes export complexity at the aggregate country as well as disaggregated product level. Further insights are provided through the employment of a shift-share analysis approach which allows identifying the product groups that drive export growth and upgrading.

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South Africa and Viet Nam are found to be the most diversified exporters in terms of both, export destinations and export products. The two countries are also found to be best integrated in international value chains.

South Africa continues to be the most technologically complex exporter within this group of countries. However, the country's exports grew slowest both in terms of absolute export volumes as well as share in world exports. South Africa is also the only country which registered a stagnation, if not a decline, in the complexity of its exports over the past years. The shift-share analysis further suggests that the country's export competitiveness is rather low compared to the group as well as world average.

In contrast, Viet Nam has not only quadrupled its share in world exports but also upgraded the technological complexity of its exports, particularly in the high tech sector which is now the main driver of the country's export competitiveness.

Exports from Bangladesh, Ethiopia, Ghana and Madagascar show a slight upward trend in the technological complexity of exports but their export products continue to be predominately labour and raw material intensive.

While labour intensive products continue to be the main driver of Bangladesh's export competitiveness, the reliance on this product group made the country sensitive to relatively slowly growing world demand between 2009 and 2013.

Ethiopia, with its focus on raw products and commodities, on the other hand, benefited from a strong world demand for these product groups.

Ghana's export competitiveness continues to be driven by raw products; semi-processed and low-tech products do contribute to the performance though.

Madagascar increased the technological complexity of its exports between 2001 and 2007. However, this trend reversed since. Among the six countries, Madagascar is most sensitive to world trade fluctuations.

While the results illustrate an overall pattern of the technological complexity of the six countries' exports, the analysis also shows that the detailed insights differ considerably with the employed product classification. While Hausmann et al.'s (2013) Economic Complexity methodology is a very good starting point, further refinement in the computation of technological complexity of products would add significantly to the understanding and measurement of export upgrading.

1. Introduction

The objective of this paper is to provide an assessment of the technological complexity of exports from Bangladesh, Ethiopia, Ghana, Madagascar, South Africa and Viet Nam.

First, the analysis focuses on the share of (semi-) processed and raw products in the countries' export baskets. A large share of (semi-) processed products in total exports, and subsequently a limited reliability on raw export products, may be a first indication of a technologically complex export basket. However, the classification into processed, semi-processed and raw products is arguably too broad and aggregated to draw a detailed picture of the technological complexity of exports. Furthermore, while it may be safe to argue that (semi-) processed products are more technologically complex than raw products, this is less clear-cut when comparing semi-processed with processed products.

To provide a more detailed insight into the technological complexity of the six countries' export baskets, a second and third product classification are exploited. The second classification allows computing the share of high-, medium- and low technologically intensive products in total exports and comparing it with the share of labour intensive products as well as minerals and commodities in total exports. The third product classification allows zooming in even further and differentiating between medium-high and medium-low tech products.

The analysis shows that the product classifications draw very different pictures of the technological complexity of the six countries' exports. The classifications also share the common drawback of grouping products together without quantifying the technological complexity at the product level. It is reasonable to assume though that one high tech product is more technologically complex than another high tech product and that these differences are present in each product group.

To address these limitations, Hausmann et al.'s (2013) Economic Complexity methodology is employed as it allows computing the complexity of each country's export basket as well as the complexity of each individual product. The computed country and product complexities are found to be largely in line with and complementary to the prior product classification analysis.

Finally, to identify the drivers behind export upgrading and export growth, Piezas-Jerbi and Nee's (2009) shift-share analysis (SSA) approach is adopted.

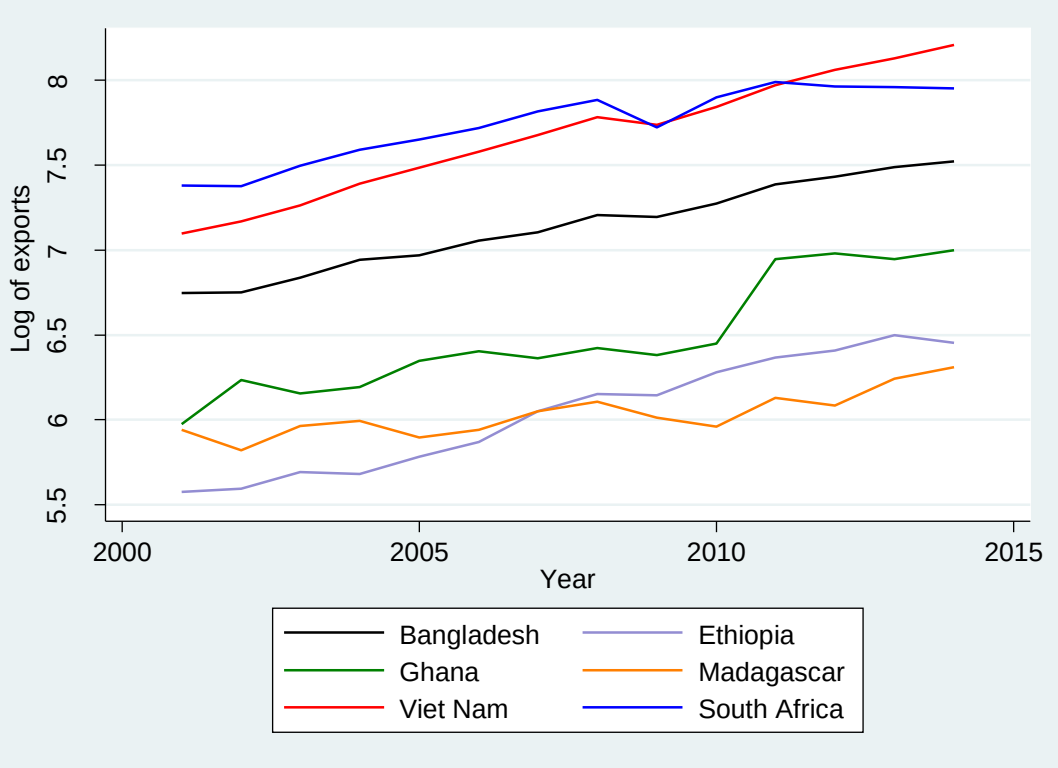
The paper is structured as follows. Section 2 provides an overview of the export performance and international value chain (IVC) participation of the six countries over the past 15 years. Section 3 combines the mentioned product classification analysis with the Economic Complexity methodology to assess the technological complexity of exports and its evolvement over time. Section 4 complements the results with a shift-share analysis approach. Section 5 provides a brief discussion of the main findings and concludes.

2. Export performance and international value chain participation

2.1 Evolution of exports

This section provides an overview of the past and current export performance and international value chain participation of Bangladesh, Ethiopia, Ghana, Madagascar, South Africa and Viet Nam. Figure 1 illustrates the evolution of exports from the six countries since 2001. The export values are transformed to logarithmic values to compare the trends across countries in one figure. Until 2011, South Africa was the largest exporter among the six countries, followed by Viet Nam, Bangladesh, Ghana, Ethiopia and Madagascar. Following a considerable continuous increase in exports, Viet Nam overtook South Africa in the subsequent years. Over the time period of consideration, Ghana (29%) showed the highest average annual growth rate of exports, followed by Viet Nam (22%), Ethiopia (18%), Bangladesh (15%), South Africa (13%) and Madagascar (10%).

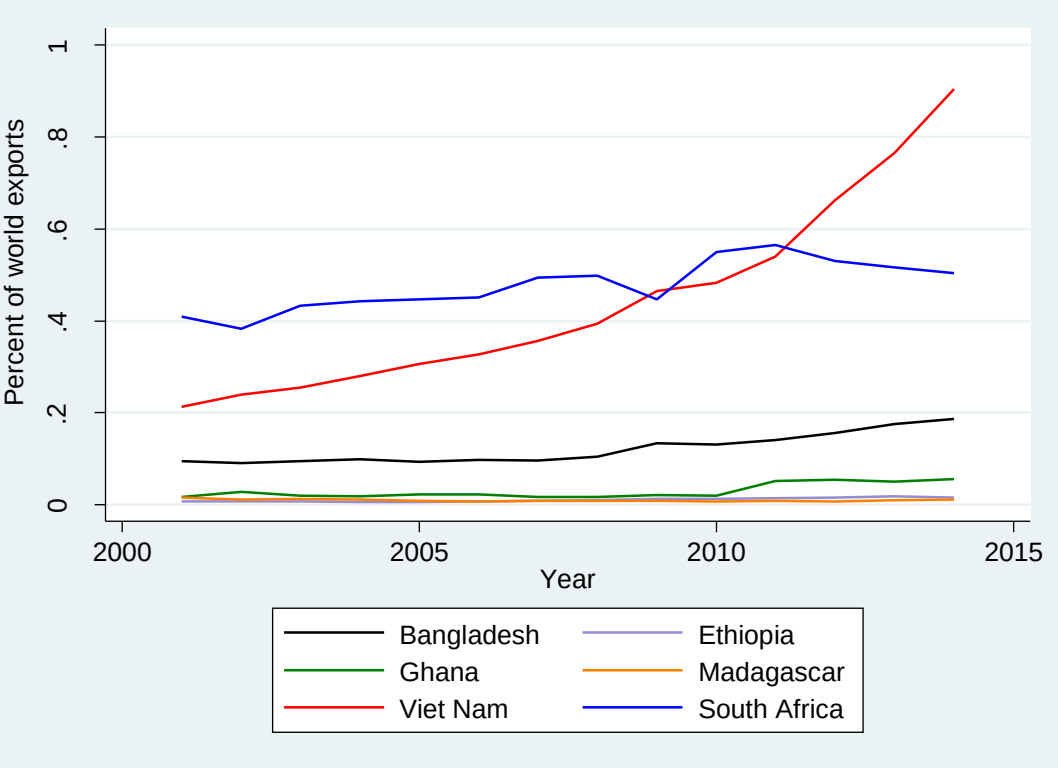
Figure 1: Evolution of exports by country, 2001-2014



The rise of Viet Nam is also evident in Figure 2 which shows the six countries' share of world exports from 2001 to 2014. Viet Nam's share of total world exports grew at an annual average rate of 11%, only surpassed by Ghana (17%). Ethiopia's share of world exports grew at a rate of 8%, followed by Bangladesh (6%), South Africa (2%) and Madagascar (0.2%). At first sight, the reported growth rates of exports and share in world exports may appear strikingly high. However, as will be discussed in the context of Section 3, commodities account for a large share of the six countries' exports and the growth rates are therefore subject to the commodities boom prior to the 2008 financial crisis. To put these growth rates further in context, it should also be pointed out that, in absolute terms, the share of world exports of none of the six countries exceeds one percent.

In terms of export volumes, Viet Nam currently (2014) exports USD 159.5 billion, South Africa USD 90.6 billion, Bangladesh USD 33.5 billion, Ghana USD 11.8 billion and Madagascar USD 2.1 billion per year.

Figure 2: Evolution of the share of world exports by country, 2001-2014



2.2 Export destination concentration

Having discussed the evolution of export volumes, this section provides a first insight into the structure of the six countries' export baskets. Table 1 ranks the six countries' most important export destinations. Given the geographic diversity of the group, the different destination rankings come as no surprise.

Table 1: Top 10 export destinations by country, average 2009-2013

Rank	Bangladesh	Ethiopia	Ghana	Madagascar	South Africa	Viet Nam
1	United States of America	Somalia	South Africa	France	China	United States of America
2	Germany	China	United Arab Emirates	United States of America	United States of America	Japan
3	United Kingdom	Germany	France	China	United Kingdom	China
4	France	Saudi Arabia	Togo	Germany	Japan	Korea, Republic of
5	Netherlands	Netherlands	Netherlands	Canada	India	Germany
6	Spain	United States of America	Italy	Singapore	Germany	Malaysia
7	Canada	Belgium	Switzerland	Netherlands	Botswana	Australia
8	Italy	Sudan (North + South)	China	India	Namibia	Hong Kong, China
9	Turkey	Djibouti	United Kingdom	South Africa	Zimbabwe	United Kingdom
10	Belgium	United Arab Emirates	United States of America	Spain	Netherlands	Singapore

What is interesting to see, however, is the extent to which the six countries concentrate their exports in different destination markets. A commonly applied indicator of export concentration, or diversification, is the Herfindahl-Hirschmann Index (HHI) calculated as

$$HHI = \sum_{j=1}^{N} \left(\frac{x_{ij}}{X_i}\right)^2$$

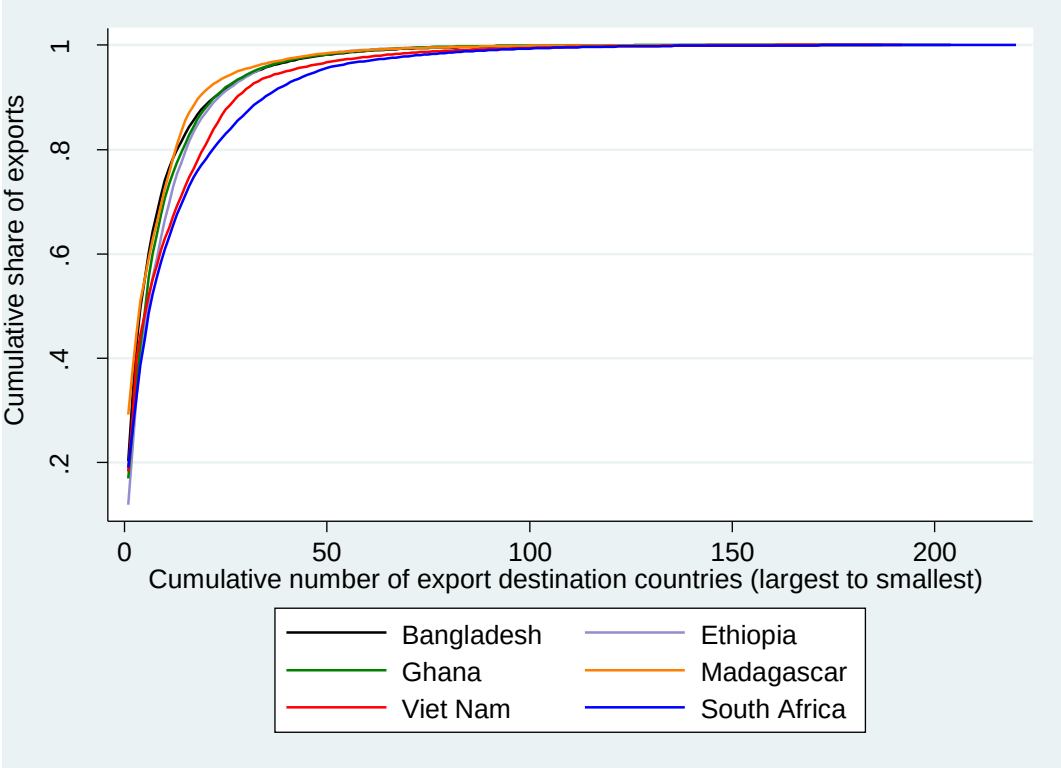
, where x_{ij} is country *i*'s exports to country *j* and X_i is the total exports of country *i*. The index ranges from zero to one, where a low value suggests that a country has a diversified export destination basket and a high value suggests that the country has a concentrated export destination basket. Table 2 suggests that Ethiopia has the most diversified export destination basket in the group, Madagascar the most concentrated. In other words, Ethiopia exports a large share of its total exports to a relatively large number of markets whereas Madagascar sends a large share of its total exports to a relatively small number of countries.

Table 2: Export destination HHI

Country	HHI score
Bangladesh	0.084
Ethiopia	0.058
Ghana	0.068
Madagascar	0.113
South Africa	0.062
Viet Nam	0.069

While the HHI is a good indicator of export diversification, it does give particularly high weight to large market shares. Figure 3 provides a more comprehensive insight into the extent to which countries concentrate their exports on a few destination markets in form of concentration curves. The concentration curves plot the cumulative number of export destination countries on the x-axis and the cumulative share of exports of the respective country on the y-axis. The more concave the curve, the more concentrated the export destination basket. For instance, the 25 most important export destinations receive 80% of South Africa's exports. In Madagascar, the 25 most important export destinations account for more than 90% of the country's exports.

Figure 3: Export destination concentration curves by country, average 2009-2013



2.3 Export product concentration

A similar analysis can be conducted on countries' export product baskets. Table 3 shows the six countries' top export products at the disaggregated Harmonised System (HS) 6 digit level. The nature and technological complexity of these products will be discussed in further detail in Section 3. The Herfindahl-Hirschmann Index of export product diversification is calculated as

$$HHI = \sum_{j=1}^{N} \left(\frac{x_{ik}}{X_i}\right)^2$$

, where x_{ik} is country *i*'s export of product *k* and X_i stands for country *i*'s total exports.

Table 3: Top 10 export products by country, average 2009-2013

Country	Rank	HS6 product label
Bangladesh	1	Jerseys, pullovers, cardigans, etc, knitted or crocheted, of wool or fine animal hair
	2	Mens/boys shirts, of other textile materials, not knitted
	3	Frozen shrimps and prawns
	4	Table linen, of other textile materials, not knitted
	5	Babies garments&clothg accessories of other textile materials,knitted
	6	Raw hides and skins (other than furskins) and leather, of bovine or equine animals
	7	Babies garments&clothg accessories of oth textile materials,not knittd
	8	Other footwear, outer soles of rubber/plastics uppers of leather
	9	Jute and other textile bast fibres, raw or retted
	10	Tents, of other textile materials
Ethiopia	1	Coffee, not roasted, not decaffeinated
	2	Sesamum seeds, whether or not broken
	3	Vegetables nes, fresh or chilled
	4	Cut flowers and flower buds for bouquets, fresh
	5	Live bovine animals
	6	Gold in oth semi-manufactd form n-monetary(inc gold platd w platinum)
	7	Kidney beans&white pea beans drid shelld,whether o not skinnd o split
	8	Skins (in the dry state) and leather of sheep or lamb, without wool on
	9	Goat meat, fresh, chilled or frozen
	10	Other oil seeds
Ghana	1	Gold in oth semi-manufactd form n-monetary(inc gold platd w platinum)
	2	Petroleum oils and oils obtained from bituminous minerals, crude
	3	Cocoa beans, whole or broken, raw or roasted
	4	Gold in unwrought forms non-monetary
	5	Butanes, liquefied
	6	Manganese ores and concentrates etc
	7	Cashew nuts, in shell, fresh or dried
	8	Cocoa paste not defatted
	9	Petroleum oils, not crude
	10	Cocoa butter, fat and oil

Madagascar	**1**	Jerseys, pullovers, cardigans, etc, knitted or crocheted, of wool or fine animal hair
	2	Cloves
	3	Frozen shrimps and prawns
	4	Nickel unwrought, not alloyed
	5	Vanilla
	6	Titanium ores and concentrates
	7	Tunas,skipjack&Atl bonito,prepard/preservd,whole/in pieces,ex mincd
	8	Petroleum oils, not crude
	9	Essential oils, nes
	10	Mens/boys shirts, of other textile materials, not knitted
South Africa	**1**	Platinum unwrought or in powder form
	2	Gold in unwrought forms non-monetary
	3	Bituminous coal, whether or not pulverised but not agglomerated
	4	Iron ores&concentrates,oth than roasted iron pyrites,non-agglomerated
	5	Ferro-chromium containing by weight more than 4% of carbon
	6	Automobiles w reciprocatg piston engine displacg > 1500 cc to 3000 cc
	7	Iron ores & concentrates,other than roasted iron pyrites,agglomerated
	8	Petroleum oils, not crude
	9	Platinum in other semi-manufactured forms
	10	Filtering or purifying machinery and apparatus for gases nes
Viet Nam	**1**	Telephone sets (excl. line telephone sets) and other voice and image transmission apparatus
	2	Petroleum oils and oils obtained from bituminous minerals, crude
	3	Other footwear, outer soles of rubber/plastics uppers of leather
	4	Rice, semi-milled or wholly milled, whether or not polished or glazed
	5	Coffee, not roasted, not decaffeinated
	6	Other printers, copying & facsimile machines; computer input or output units; other office machines
	7	Jerseys, pullovers, cardigans, etc, knitted or crocheted, of wool or fine animal hair
	8	Smart cards; electronic integrated circuits; other electrical machines and parts
	9	Fish fillets, frozen
	10	Anthracite, whether or not pulverised but not agglomerated

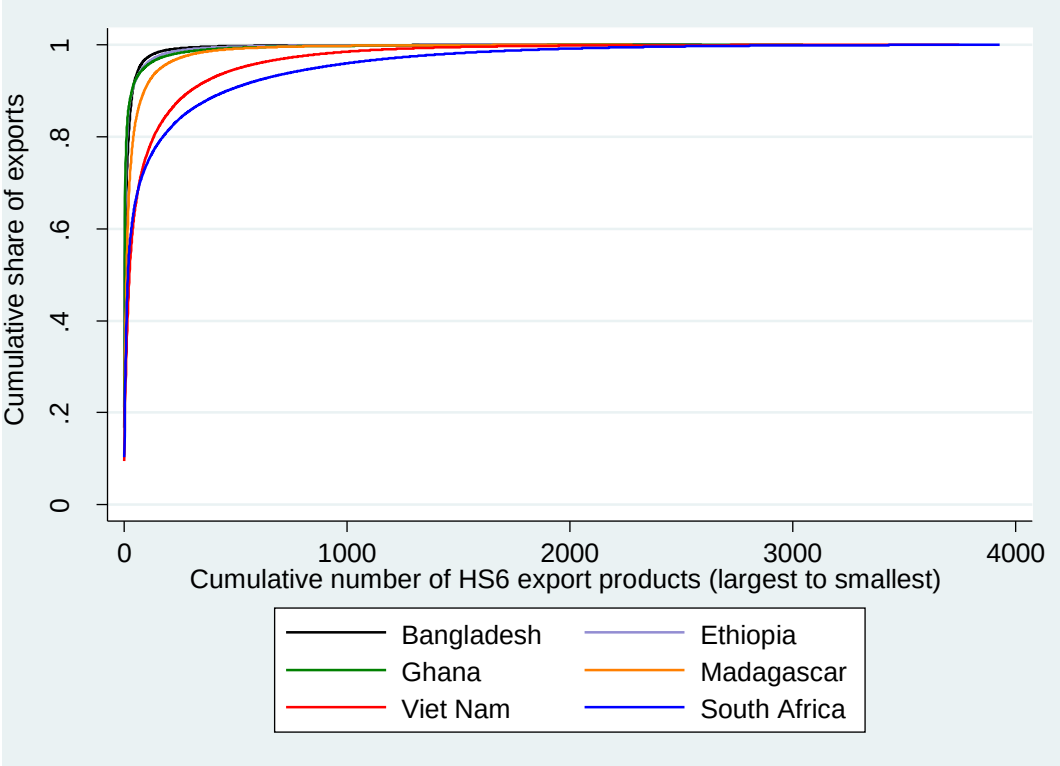
As mentioned previously, the index takes a value from zero to one. A low value indicates that the country has a diversified export product basket while a high value indicates a concentrated export product basket. Put differently, a low value suggests that the country exports large volumes of many products whereas a high value implies that the country exports large volumes of only few products. Table 4 suggests that Viet Nam has the most diversified export product basket while Ghana's export basket is the most concentrated in this country group.

Table 4: Export product HHI

Country	HHI score
Bangladesh	0.083
Ethiopia	0.124
Ghana	0.126
Madagascar	0.037
South Africa	0.024
Viet Nam	0.020

The concentration curves in Figure 4 provide further visual insights about the six countries' export product diversification. The 25 most important export products of South Africa account for around 85% of the country's total exports. In the cases of Bangladesh, Ethiopia and Ghana, in contrast, the top 25 products account for almost 100% of total exports.

Figure 4: Export product concentration curves by country, average 2009-2013



The previous discussion illustrates that South Africa and Viet Nam do not only export the largest volumes in this group but also have the most diversified export baskets, both in terms of export destinations as well as export products. In comparison to the other countries, Madagascar has the

most concentrated export destination basket. However, the country's export product basket is more diversified than Ghana's, Ethiopia's and Bangladesh's. The latter countries' export focus on few products – in Bangladesh's case, textiles – will be discussed further in Section 3. The next section discusses to what extent the six countries are participating in IVCs.

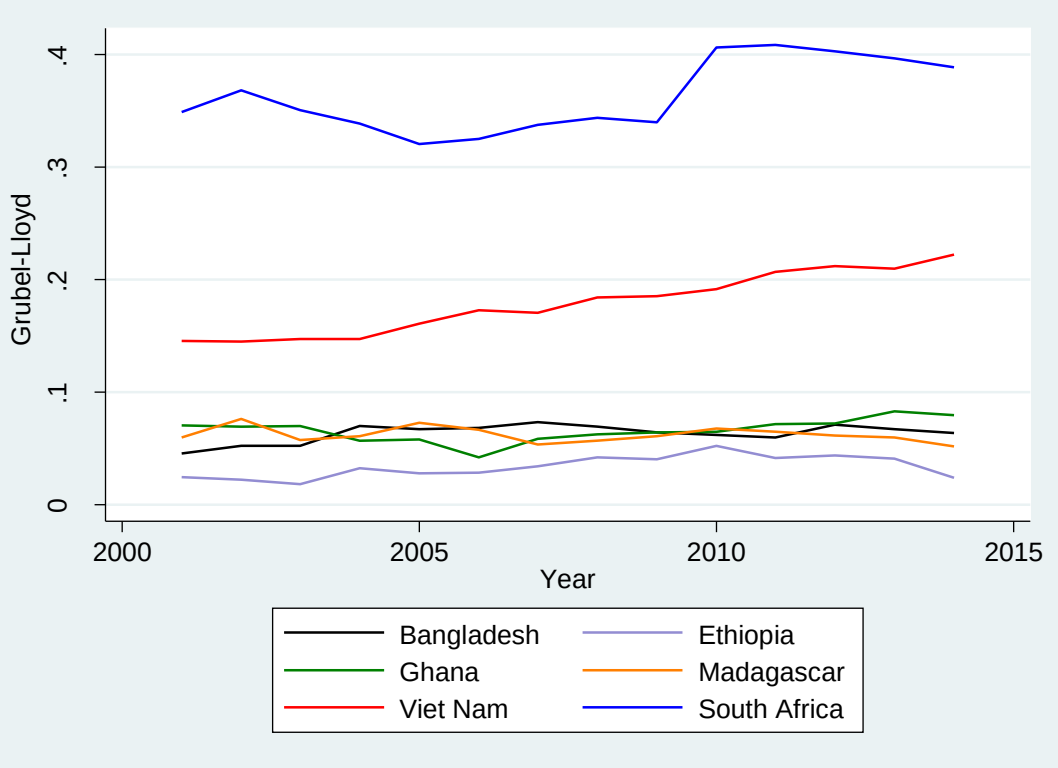
2.4 International value chain participation

This section analyses the importance of intra-industry trade for the six countries as it may present a first approximation of their participation in IVCs (Giovanetti and Marvasi, 2015). A high level of intra-industry trade is regarded as a proxy for extensive IVC participation. The Grubel-Lloyd Index is a straightforward, yet commonly applied indicator to measure the role of intra-industry trade in a country's export basket. The index is computed as

$$GL = \frac{|X_{ik} - M_{ik}|}{X_{ik} + M_{ik}}$$

, where X_{ik} and M_{ik} are country *i*'s exports and imports of product *k*, respectively. The index ranges from zero to one, where zero indicates that there is no intra-industry trade but only inter-industry trade while one suggests the opposite. As illustrated in Figure 5, intra-industry trade is most important for South Africa, followed by Vietnam which has been catching up gradually. For Ghana, Bangladesh, Madagascar and Ethiopia intra-industry trade has remained low in importance over the time period of consideration.

Figure 5: Intra-industry trade by country, 2009-2013



Before examining the technological complexity of the six countries' export baskets, it is worth summarising the findings of this section. Viet Nam has arguably undergone the most significant development. Since 2001, the country has more than quadrupled its share in world exports. In 2011, Viet Nam overtook South Africa and now (2014) exports almost 75% more than South Africa. Viet Nam and South Africa are also found to have the most diversified export product baskets within the group as well as show the most significant participation in IVCs. Bangladesh, Ethiopia, Ghana and Madagascar export considerably less in terms of volume although Bangladesh and Ghana do show gradual growth in their share of total world exports. These four countries are also found to have relatively concentrated export baskets, both in terms of destinations as well as products and participate less in IVCs than South Africa and Viet Nam. The next Section discusses whether South Africa's and Viet Nam's relatively strong performance within this group is also reflected in the technological complexity of their exports.

3. Export complexity

International trade can be an engine for inclusive economic growth and poverty reduction, and contribute to the promotion of sustainable development. To realise these potential gains, firms, and

in particular small- and medium enterprises (SMEs), must not only diversify their exports but also connect to and move up within IVCs. Moving up value chains is inherently related to increasing the technological complexity of products. This section discusses two different approaches to measuring the technological complexity of exports from Bangladesh, Ethiopia, Ghana, Madagascar, Viet Nam and South Africa.

As a starting point, this Section employs three suitable product classifications based on Process Stages (WTO), Skill- and Technology Intensity (UNCTAD) and High-Technology Content (OECD) to provide insights into the technological complexity of the six countries' exports. These findings are then complemented by the quantitative results based on the Economic Complexity methodology developed by Hausmann et al. (2013).

The analysis is based on disaggregated Harmonized System (HS) 6-digit product level data from the International Trade Centre's (2015) Trade Map database. In light of revision changes of the Harmonised System, Decreux and Spies (forthcoming) achieve consistency across years and countries by introducing product groups that encompass all items that have ever fallen under the redefined HS code. As a consequence, the data includes 3,932 HS 6 – based product groups instead of the 5,212 HS 6 products that form the HS 2012 revision. To improve data quality and reliability further, direct data on trade flows are reconciled with mirror data flows (For further detail, see Decreux and Spies (forthcoming)). The next Subsections briefly introduce each product classification before relating these to the exports of Bangladesh, Ethiopia, Ghana, Madagascar, Viet Nam and South Africa. A more detailed assessment on the correspondence between the classifications themselves can be found in Klotz, Kniahin and Jansen (2016).

3.1 Process Stage classification

The World Trade Organisation's (WTO) Process Stage classification (Box 1) provides a good starting point as it differentiates between processed, semi-processed and raw products.

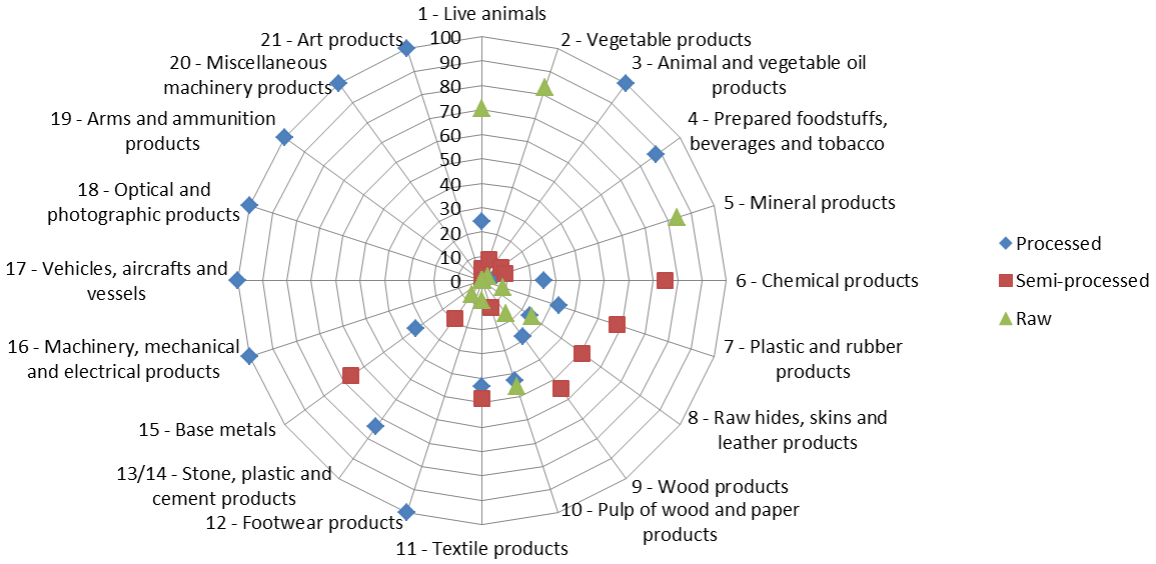
Box 1. Process Stages classification

1 - Processed products
2 - Semi-processed products
3 - Raw products

Source: World Trade Organization (2001). Market Access: Unfinished Business — Post Uruguay Round Inventory. WTO Special Studies, No. 6. Geneva: World Trade Organization. Available from https://www.wto.org/english/res_e/publications_e/special_studies6_e.htm.

To provide an idea of which products are defined as such, Figure 6 relates the classification to the HS sections outlined in Box 2. Unsurprisingly, "1 – Live animals", "2 – Vegetable products" and "5 - Mineral products" are largely composed of raw products. Perhaps more interestingly, Figure 6 shows to which extent certain product groups are composed of processed and semi-processed products. The HS sections in the North-West area of Figure 6 are exclusively composed of processed products. Three quarters of "6 – Chemical products", in contrast, are semi-processed products.

Figure 6: Process Stage classification and HS sections



Note: A point represents the share of products of a specified category in the HS section (0 is 0%, 100 is 100%).

Box 2. HS sections (third revision)

1 - Live animals; Animal products
2 - Vegetable products
3 - Animal or vegetable fats and oils and their cleavage products; Prepared edible fats; Animal or vegetable waxes
4 - Prepared foodstuffs; Beverages, spirits and vinegar; Tobacco and manufactured tobacco substitutes
5 - Mineral products
6 - Products of the chemical or allied industries
7 - Plastics and articles thereof; Rubber and articles thereof
8 - Raw hides and skins, leather, fur skins and articles thereof; Saddlery and harness; Travel goods, handbags and similar containers; Articles of animal gut (other than silk-worm gut)
9 - Wood and articles of wood; Wood charcoal; Cork and articles of cork; Manufactures of straw, of esparto or of other plaiting material; basket ware and wickerwork
10 - Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard; Paper and paperboard and articles thereof
11 - Textiles and textile articles
12 - Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof; Prepared feather and articles made therewith; Artificial flowers; Articles of human hair
13 - Articles of stone, plaster, cement, asbestos, mica or similar materials; Ceramic products; Glass and glassware
14 - Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof; imitation jewelry; Coin
15 - Base metals and articles of base metal
16 - Machinery and mechanical appliances; Electrical equipment; Parts thereof; Sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles
17 - Vehicles, aircraft, vessels and associated transport equipment
18 - Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; Clocks and watches; Musical instruments; Parts and accessories thereof
19 - Arms and ammunition; Parts and accessories thereof
20 - Miscellaneous manufactured articles
21 - Works of art, collectors' pieces and antiques

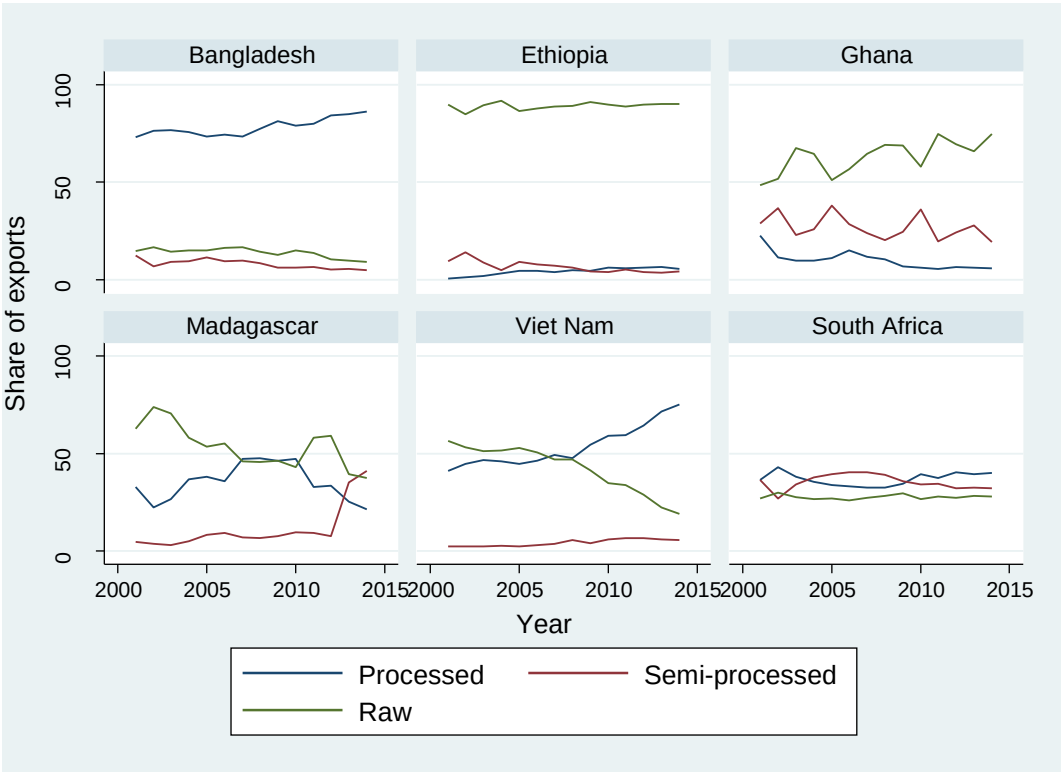
***Source**:* United Nations Statistics Division (2010). HS Classification by Section. Geneva. Available from http://unstats.un.org/unsd/tradekb/Knowledgebase/50043/HS-Classification-by-Section.

Does this indicate that chemical products are less technologically complex than machinery and electrical products? Similarly, are "11 – Textile products" less technologically complex than "12 – Footwear products" because the latter are exclusively composed of processed products while 50% of textiles are semi-processed products?

The answer to both questions is, of course, no. The WTO classification provides only a first idea about the technological complexity of products by differentiating between (semi-) processed and raw products. While it might be safe to argue that (semi-) processed products are technologically more complex than raw products, the same argument may not hold when comparing processed and semi-processed products. The fact that a chemical is rarely a final (processed) product but is most often used as an input (semi-processed) does not reveal much about the technological complexity of the chemical itself. This observation will be discussed in further detail in Subsection 3.5.

Notwithstanding the limitations of the classification as a proxy for technological complexity, it is interesting to see to what extent the six countries' exports are composed of processed, semi-processed and raw products.

Figure 7: Process stage classification and export products by country, 2001-2014



The large majority of Bangladeshi exports are accounted for by processed products. In contrast, raw products present the largest part of exports from Ethiopia, Ghana and Madagascar. Viet Nam has significantly decreased the share of raw products in its exports and moved to processed products. The South African export basket is fairly equally divided into processed, semi-processed and raw products.

3.2 Skill- and Technology Intensity classification

The United Nations Conference on Trade and Development's (UNCTAD) Skill- and Technology Intensity classification (Box 3) overcomes some of the limitations of the WTO classification as it allows zooming in further into the technological complexity of products.

The classification, developed in Basu and Das (2011) and Basu (forthcoming), builds up on UNCTAD (1996, 2002) and Lall (2000, 2005) and groups products into high-, medium-, and low technology, resource-intensive, minerals and commodities.

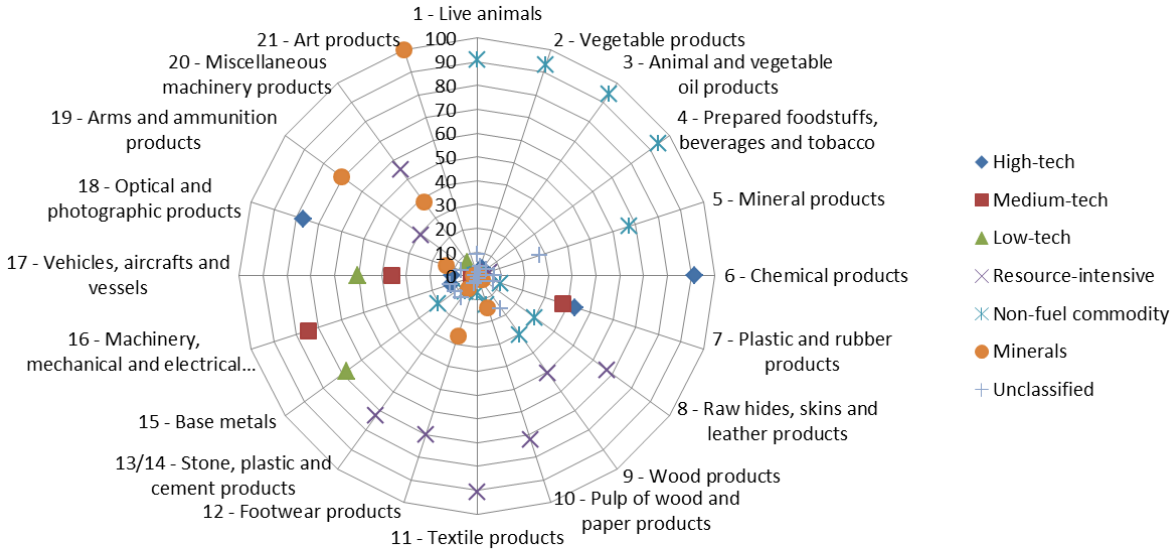
Box 3. Skill- and Technology Intensity classification

1 - High skill- and technology intensive manufactures
2 - Medium skill- and technology intensive manufactures
3 - Low skill- and technology-intensive manufactures
4 - Resource-intensive manufactures
5 - Non-fuel primary commodities
6 - Mineral fuels

***Source**:* Basu, S.R. and Das, M. (2011). Export Structure and Economic Performance in Developing Countries: Evidence from Nonparametric Methodology. Policy Issues in International Trade and Commodities Study Series, No. 48. Geneva: United Nations Conference on Trade and Development. Available from http://unctad.org/en/Docs/itcdtab49_en.pdf.

To do so, the classification takes into account the mix of different skill, technology, capital and scale requirements at the final product stage (UNCTAD, 1996). Figure 8 illustrates how the classification corresponds to the different HS sections. "6 – Chemical products" and "18 – Optical and photographic products" are the most technologically intense product groups. "7 – Plastic and rubber products", "16 – Machinery, mechanical and electrical products" and "17 – Vehicles, aircrafts and vessels" include mainly medium-tech and low-tech products. Resource-intensive products, which to a large extent include labour-intensive products, account for more than 90% of "11 – Textile products".

Figure 8: Skill- and Technology Intensity classification and HS sections



Note: A point represents the share of products of a specified category in the HS section (0 is 0%, 100 is 100%).

Figure 9: Skill- and Technology Intensity classification and exports by country, 2001-2014

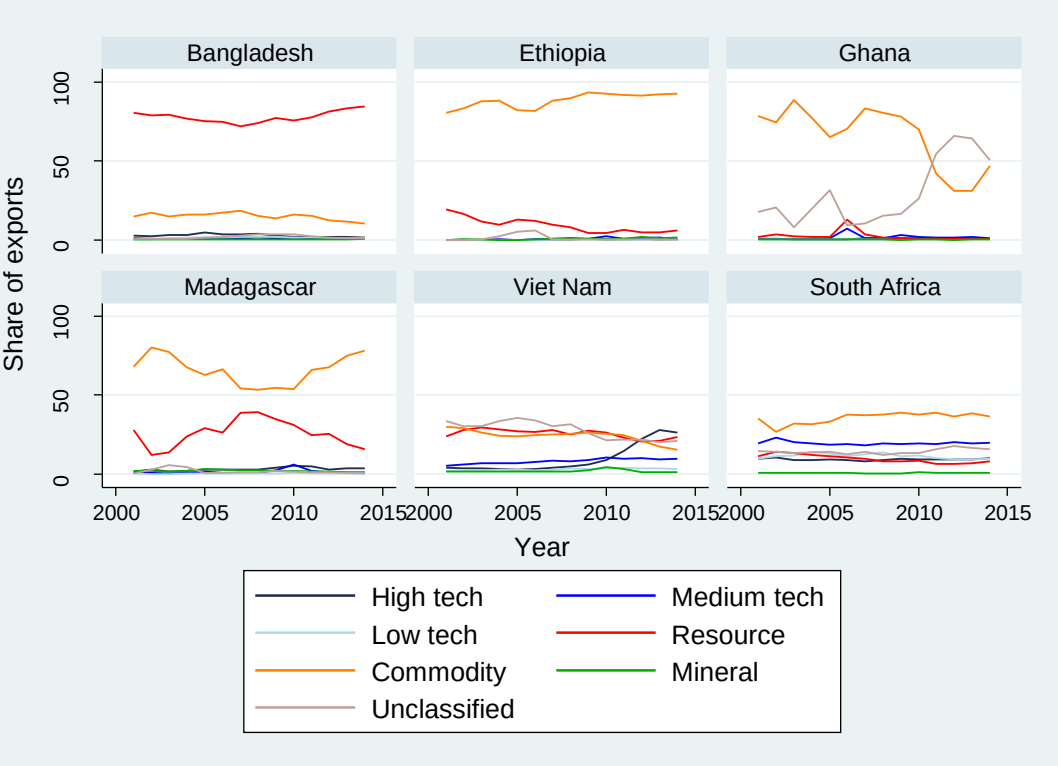


Figure 9 illustrates the composition of exports from Bangladesh, Ethiopia, Ghana, Madagascar, Viet Nam and South Africa according to this classification. Commodities account for large shares of exports from Ethiopia, Ghana and Madagascar. Bangladeshi exports are to a large extent composed of resource-intensive products. Medium tech exports account for fairly constant shares of around 8% and 19% of exports from Viet Nam and South Africa, respectively. Furthermore, Viet Nam has significantly increased the share of high tech products in its exports from 4% in 2001 to 26% in 2013.

3.3 High-Technology Content classification

The OECD High-Technology Content classification goes one step further than the UNCTAD classification as it does not only differentiate between high, medium and low tech products but even between medium-high and medium-low tech products. The origins of the classification date back to 1984, when the OECD developed the initial classification based on direct research and development (R&D) intensity, measured by R&D expenditure in relation to output, weighted by sector and country. The initial classification, based on the second revision of ISIC, differentiated between high, medium and low technology industries.

The classification was refined in 1997 to take the importance of direct and indirect R&D intensity into account and to correspond to the third revision of ISIC. The former captures the extent to which an industry produces technology whereas the latter captures the extent to which an industry uses technology. The direct indicator is obtained by weighing each sector with its share in the production or value added of all OCED countries, taking GDP purchasing power parities as exchange rates. The indirect intensity is based on the R&D expenditure embodied in intermediates and capital goods purchased on the domestic market or imported. (Hatzichronoglou, 1997) Industries classified in a higher category have a higher OECD-average technology intensity than industries in a lower category. The resulting classification is outlined in the Box 4.

Box 4. High- Technology Content classification

1 - High-technology
2 - Medium-high technology
3 - Medium-low technology
4 - Low-technology
5 - Other

***Source**:* Organisation for Economic Co-operation and Development (2011). Technology Intensity Definition. Paris. Available from http://www.oecd.org/sti/ind/48350231.pdf.

Figure 11 illustrates which product groups are identified to be technologically complex. “18 – Optical and photographic products” are by far the most technologically complex products with more than 90% of products in this group being considered as high tech. “6 – Chemical products”, “19 – Arms and ammunition products”, “16 – Machinery, mechanical and electrical products” and “17 – Vehicles, aircrafts and vessels” include mainly medium-high tech products. Low tech products account for more than 90% of “11 – Textile products”.

Figure 10: High-Technology Content classification and HS sections

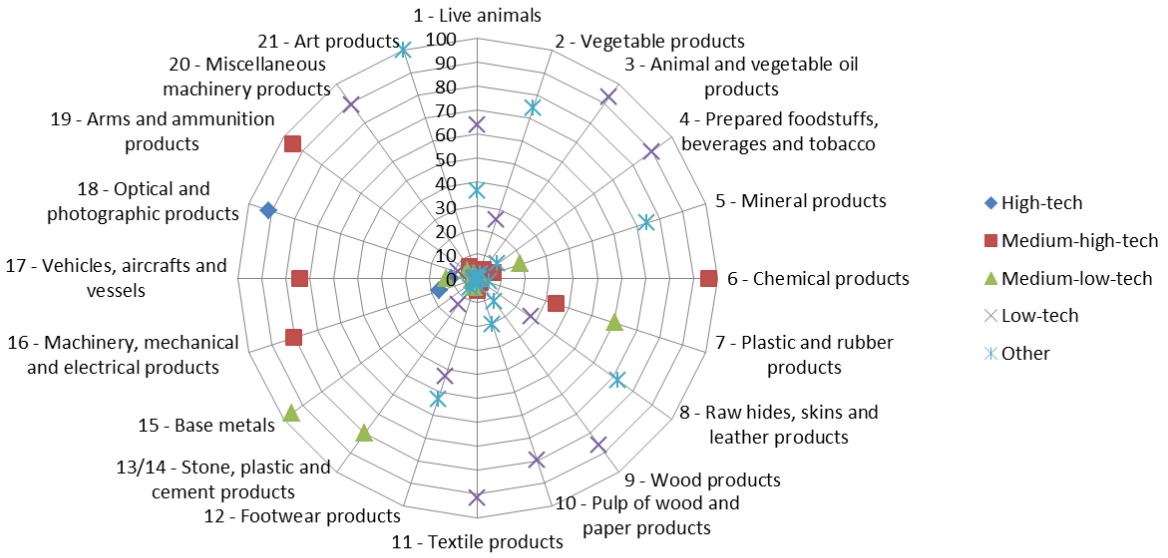
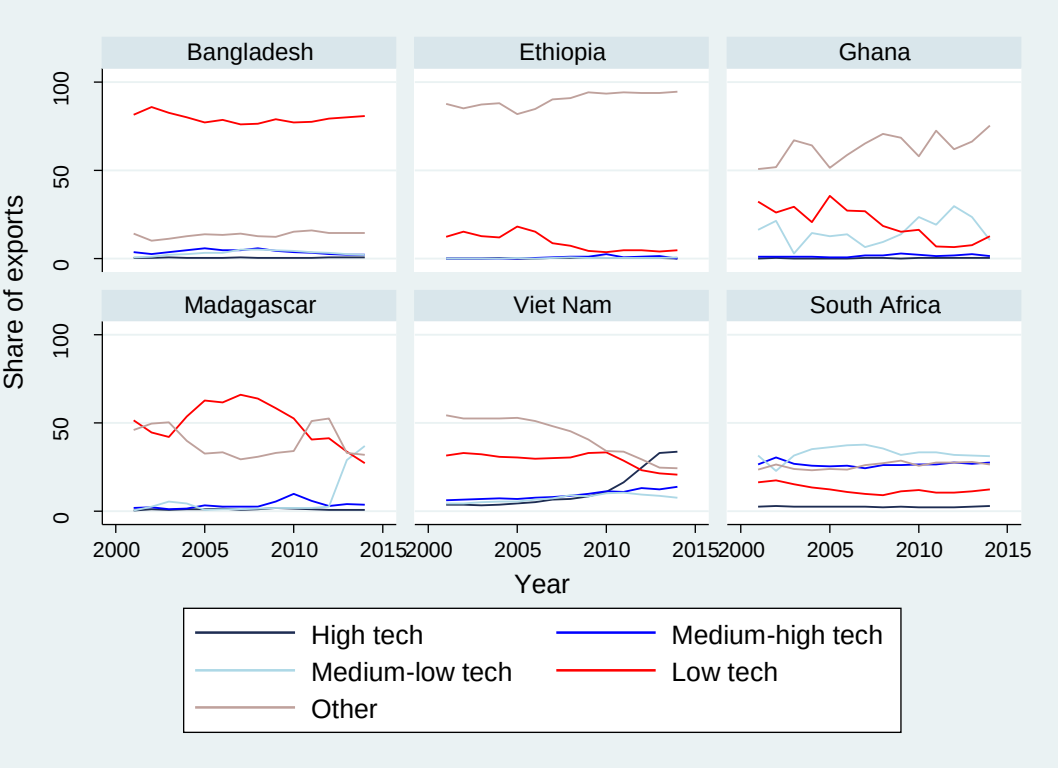


Figure 12 shows to which extent the exports from Bangladesh, Ethiopia, Ghana, Madagascar, Viet Nam and South Africa include technologically complex products.

Figure 11: High-Technology Content classification and exports by country, 2001-2014



Low tech products account for the largest share of Bangladeshi exports. In Ethiopia and Ghana, in contrast, other (non-technology complex) products present the majority of export products. Madagascar increased the share of low tech products in its exports until 2007 but this trend reversed in the following years. 2012 shows a significant increase in the share of medium-low tech products in the country's export basket. Viet Nam has gradually reduced the share of non-technologically complex products. Since 2010, the country has furthermore reduced the share of low tech products in total exports while increasing the share of high tech products. Medium-high and medium-low tech products account for more than half of South Africa's exports. High tech products only account for a limited share of the country's exports, however.

3.4 Summary of product classifications

The three product classifications outlined above provide a good starting point for the assessment of the six countries' export complexity. Of course, there cannot be a perfect correspondence between the classifications since they are designed for different purposes and are based on different methodologies. Consequently, while each classification may provide a valid assessment of the export complexity of the six countries, it is difficult to compare the assessments across the three classifications. For instance, if one accepts the share of processed products in a country's export

basket as a measure of its technological complexity, then Bangladesh outperforms the other five countries of interest. However, the UNCTAD classification suggests that these processed products are actually labour-intensive rather than technologically complex. According to this classification, Bangladesh would be considered one of the less technologically complex countries among the group of six. The third classification, by the OECD, suggests yet something else. According to this classification, Bangladeshi exports technologically complex – even if mainly consisting of low tech.

3.5 Economic and Product Complexity

The three technology classifications outlined above provide a good starting point to assess the technological complexity of the export products from Bangladesh, Ethiopia, Ghana, Madagascar, Viet Nam and South Africa. However, the classifications share some drawbacks. First, the three classifications only allow for grouping products together without quantifying the technological complexity at the product level. Second, the classifications are designed for different purposes and based on different methodologies which makes it difficult to compare the results across the classifications.

To address these limitations, this Subsection employs the Economic and Product Complexity methodology developed by Hausmann et al. (2013). The two complexities are interlinked as the Economic Complexity of a country depends on the complexity of the products it exports, while the complexity of a product depends on the complexity of the country it is exported from. The authors stress that the Complexity methodology does not present an exclusive measure of technological complexity. Instead, "the complexity of an economy is related to the multiplicity of useful [and often tacit] knowledge [and capabilities] embedded in it." (Hausmann et al., 2013, p. 18) The computations therefore do not only measure the amount and diversity of knowledge but also the extent to which an economy is able to combine the resulting capabilities through webs of interactions and produce and export complex products. These capabilities are not only limited to technology but may include design, marketing, financing, human resource management, trade law, etc. Still, in combination with the product classifications outlined before, the calculations provide a useful proxy and very insightful indication of the technological complexity of the six countries' export baskets.

The Product Complexity approach contributes to the analysis in two ways. First, the more rigorous and quantitative methodology adds robustness and allows validating the results outlined above. Secondly, rather than only grouping products according to their technological complexity, the

Product Complexity methodology allows computing the technological complexity at the product level.

The methodology is based primarily on two concepts; diversity and ubiquity. Diversity is the number of products exported by a country with a revealed comparative advantage (RCA). Ubiquity is the number of countries that export a product with a RCA. The two concepts are interlinked in the following way.

A country is considered to be economically complex if it exports a large number of different products (high diversity) that are only exported by a small number of other countries (low ubiquity). This is particularly true if these other countries also export a large number of different products (high diversity) that are only exported by a small number of other countries (low ubiquity), and so on. In other words, a country is economically complex if it exports a large number of products that are only exported by a small number of economically complex countries. By analogy, a product is considered to be economically complex if it is only exported by a small number of countries that export a large number of economically complex products. The concepts of diversity and ubiquity can therefore be used to correct one another in an iterative process which converges after a few iterations and presents the quantitative measurement of Product Complexity.

Since the embodied capabilities cannot be measured explicitly, Hausmann et al. 2013 propose an outcome-based approach of measuring product complexity by looking at the actual country-product specialization matrix M_{cp}. Its element m_{ik} is equal to 1 if country i has export specialization in product k and 0 otherwise. It is assumed that there are in total c countries and p products.

Ubiquity is calculated as:

$$q_{o,k} = Ubiquity_k = \sum_i m_{ik}$$

As mentioned above, ubiquity alone is not sufficient to capture complexity. Consider the case of rare natural resources such as diamonds. The fact that they are found in a few countries only, is not sufficient to argue that diamonds are very complex products. To learn more about the complexity of diamonds, it is necessary to check what other products diamond exporters export. Most diamond exporters only export few other products. In contrast, consider the example of space satellites. These are also only exported by few countries, mainly France and the United States. The important difference is that France and the United States also export a huge variety of other products.

To integrate this formally, the ubiquity score is augmented as:

$$q_{1,k} = \frac{\sum_i m_{ik} d_i}{\sum_i m_{ik}}$$

where $d_{o,i} = \sum_k m_{ik}$ is the diversity score of country i.

To improve this measure further, not only the number of other exported products (diversity) should be incorporated but also their ubiquity. Indeed, a product is complex if it is only exported by few countries which, in turn, export many complex products. This can be implemented by adding weights to the exported products in a country's diversity score where weights should be ideally complexities (q_k) of each product:

$$q_k = \frac{\sum_i m_{ik} \left(\frac{\sum_k m_{ik} \lambda q_k}{\sum_k m_{ik}} \right)}{\sum_i m_{ik}}$$

where λ is a scalar.

Since these complexities are the measure of interest in the first place (q_k), this problem can be rewritten as a classic eigenvector problem in linear algebra:

$$\tilde{\lambda} Q = \tilde{M}_{cp}^T D = \tilde{M}_{cp}^T \tilde{M}_{cp} Q = AQ$$

where $Q = \left(q_1, \dots, q_p\right)^T$ – vector of product complexities q_k, A – linear transformation matrix, $\tilde{\lambda} = \lambda^{-1}$, $\tilde{M}_{cp} = \frac{M_{cp}}{d_o}$, $\tilde{M}_{cp}^T = \frac{M_{cp}^T}{q_o}$.

This matrix formula can be summarized in words as follows: "a product is considered complex if it is exported by countries that export predominantly complex products". Due to mathematical properties of the country-product matrix M_{cp}, the eigenvector associated with the largest eigenvalue is not informative[2]. Thus the eigenvector associated with the second largest eigenvalue is the final product complexity indicator. The results are normalised over the full country sample (222 countries), all products and years to facilitate their illustration.

Figure 12 shows the calculated Complexity scores for the six countries. South Africa continues to be the most technologically complex exporter in this country group. However, the complexity of exports has been slightly falling. Viet Nam, in contrast, upgraded the complexity of its exports from a

[2] For details see Hausmann et al. (2013), Inoua (2016).

normalised score of 0.47 in 2001 to 0.6 in 2014. The complexity of Ghana's export basket fell between 2001 and 2004 from 0.37 to 0.31. Since then, the country increased its export basket complexity again up to 0.4 in 2014. Bangladesh achieved a considerable upgrade from 0.35 in 2002 to 0.42 in 2008. A first glance at the figure suggests that Bangladesh was subsequently hit by the consequences of the financial crisis but the country managed to re-upgrade its export complexity to 0.43 in 2014. The complexity of Ethiopia's and Madagascar's export baskets appears to be rather volatile. However, since 2001 both countries managed to upgrade their export complexity slightly from 0.33 to 0.36 and 0.34 to 0.37, respectively.

Figure 12: Technological complexity of exports by country, 2001-2014

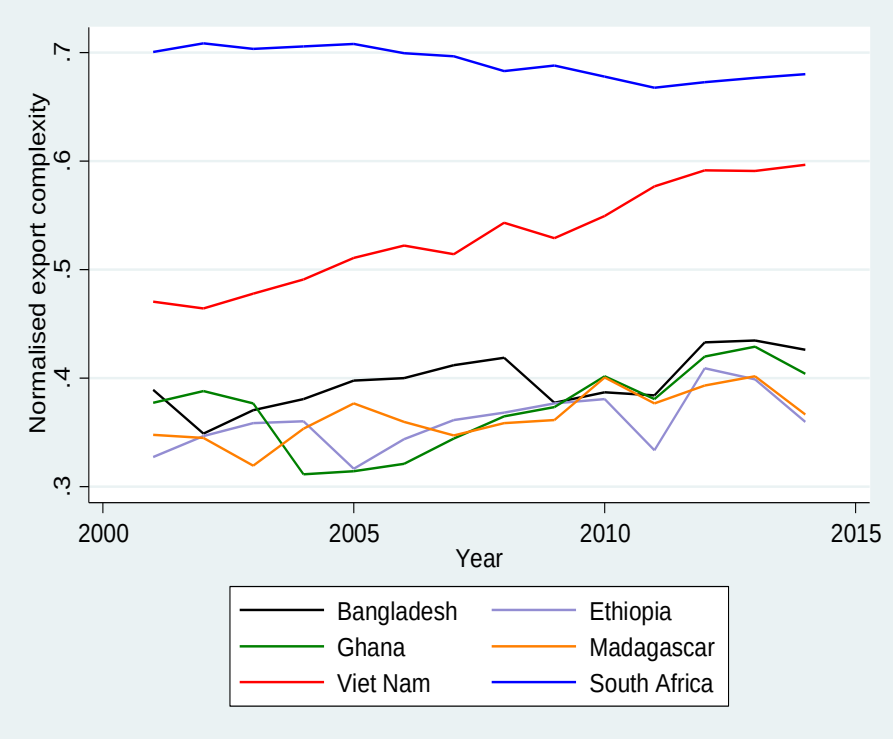


Table 5 replicates Table 3 but adds the product classifications and Product Complexity scores to the corresponding Top 10 export products. With few exceptions, Bangladesh's most important export products include textiles that are classified as processed products. As previously suggested, this does not necessarily mean that they are technologically complex. In fact, Table 5 suggests that these products are rather low tech and labour-intensive. The Product Complexity scores corroborate this observation. Ethiopia's most successful export products mainly include raw products and commodities with rather low Product Complexity scores. Commodities are also very important for Ghana and Madagascar. The respective columns in Table 5 illustrate again the difficulties to compare the results across the classifications. South Africa's Top 10 export products are mainly semi-

processed and processed products with medium technological complexity. Viet Nam performs strongly in exporting high tech information and communications technology (ICT) products.

At a first glance, the Complexity scores appear to correspond fairly well to the product classifications. For instance, Ethiopia's most important export product, coffee, not roasted, not decaffeinated, is classified as raw and commodity and has a computed complexity of 0.4. In contrast, Viet Nam's most important export product, telephone articles, is classified as processed and high-tech and has a computed complexity score of 0.74.

Table 5: Export complexity of the Top 10 products

Country	Rank	HS 6 product label	WTO	UNCTAD	OECD	Product complexity
Bangladesh	1	Jerseys, pullovers, cardigans, etc, knitted or crocheted, of wool or fine animal hair	Processed	Resource	Low tech	0.49
	2	Mens/boys shirts, of other textile materials, not knitted	Processed	Resource	Low tech	0.48
	3	Frozen shrimps and prawns	Raw	Commodity	Low tech	0.44
	4	Table linen, of other textile materials, not knitted	Processed	Resource	Low tech	0.61
	5	Babies garments&clothg accessories of other textile materials,knitted	Processed	Resource	Low tech	0.52
	6	Raw hides and skins (other than furskins) and leather, of bovine or equine animals	Semi-processed	Resource	Other	0.52
	7	Babies garments&clothg accessories of oth textile materials,not knittd	Processed	Resource	Low tech	0.53
	8	Other footwear, outer soles of rubber/plastics uppers of leather	Processed	Resource	Other	0.62
	9	Jute and other textile bast fibres, raw or retted	Raw	Commodity	Other	0.65
	10	Tents, of other textile materials	Processed	Resource	Low tech	0.64
Ethiopia	1	Coffee, not roasted, not decaffeinated	Raw	Commodity	Other	0.40
	2	Sesamum seeds, whether or not broken	Raw	Commodity	Other	0.45
	3	Vegetables nes, fresh or chilled	Raw	Commodity	Other	0.45
	4	Cut flowers and flower buds for bouquets, fresh	Raw	Commodity	Other	0.59
	5	Live bovine animals	Raw	Commodity	Other	0.61
	6	Gold in oth semi-manufactd form n-monetary(inc gold platd w platinum)	Semi-processed	Unclassified	Medium-low tech	0.64
	7	Kidney beans&white pea beans drid shelld,whether o not skinnd o split	Raw	Commodity	Other	0.51
	8	Skins (in the dry state) and leather of sheep or lamb, without wool on	Semi-processed	Resource	Other	0.62
	9	Goat meat, fresh, chilled or frozen	Processed	Commodity	Low tech	0.61
	10	Other oil seeds	Raw	Commodity	Other	0.46

Ghana	**1**	Gold in oth semi-manufactd form n-monetary(inc gold platd w platinum)	Semi-processed	Unclassified	Medium-low tech	0.64
	2	Petroleum oils and oils obtained from bituminous minerals, crude	Raw	Unclassified	Other	0.45
	3	Cocoa beans, whole or broken, raw or roasted	Raw	Commodity	Other	0.47
	4	Gold in unwrought forms non-monetary	Semi-processed	Unclassified	Medium-low tech	0.49
	5	Butanes, liquefied	Raw	Unclassified	Medium-low tech	0.60
	6	Manganese ores and concentrates etc	Raw	Commodity	Other	0.63
	7	Cashew nuts, in shell, fresh or dried	Raw	Unclassified	Other	0.54
	8	Cocoa paste not defatted	Semi-processed	Commodity	Low tech	0.66
	9	Petroleum oils, not crude	Processed	Unclassified	Medium-low tech	0.54
	10	Cocoa butter, fat and oil	Semi-processed	Commodity	Low tech	0.62
Madagascar	**1**	Jerseys, pullovers, cardigans, etc, knitted or crocheted, of wool or fine animal hair	Processed	Resource	Low tech	0.49
	2	Cloves	Raw	Commodity	Other	0.63
	3	Frozen shrimps and prawns	Raw	Commodity	Low tech	0.44
	4	Nickel unwrought, not alloyed	Semi-processed	Commodity	Medium-low tech	0.71
	5	Vanilla	Raw	Commodity	Other	0.59
	6	Titanium ores and concentrates	Raw	Commodity	Other	0.66
	7	Tunas,skipjack&Atl bonito,prepard/preservd,whole/in pieces,ex mincd	Processed	Commodity	Low tech	0.54
	8	Petroleum oils, not crude	Processed	Unclassified	Medium-low tech	0.54
	9	Essential oils, nes	Semi-processed	High tech	Medium-high tech	0.54
	10	Mens/boys shirts, of other textile materials, not knitted	Processed	Resource	Low tech	0.48
South Africa	**1**	Platinum unwrought or in powder form	Semi-processed	Commodity	Medium-low tech	0.72
	2	Gold in unwrought forms non-monetary	Semi-processed	Unclassified	Medium-low tech	0.49
	3	Bituminous coal, whether or not pulverised but not agglomerated	Raw	Unclassified	Other	0.68
	4	Iron ores&concentrates,oth than roasted iron pyrites,non-agglomerated	Raw	Commodity	Other	0.65
	5	Ferro-chromium containing by weight more than 4% of carbon	Semi-processed	Low tech	Medium-low tech	0.69
	6	Automobiles w reciprocatg piston engine displacg > 1500 cc to 3000 cc	Processed	Medium tech	Medium-high tech	0.74
	7	Iron ores & concentrates,other than roasted iron pyrites,agglomerated	Raw	Commodity	Other	0.68
	8	Petroleum oils, not crude	Processed	Unclassified	Medium-low tech	0.54
	9	Platinum in other semi-manufactured forms	Semi-processed	Commodity	Medium-low tech	0.73
	10	Filtering or purifying machinery and apparatus for gases nes	Processed	Medium tech	Medium-high tech	0.74

Viet Nam	**1**	Telephone sets (excl. line telephone sets) and other voice and image transmission apparatus	Processed	High tech	High tech	0.74
	2	Petroleum oils and oils obtained from bituminous minerals, crude	Raw	Unclassified	Other	0.45
	3	Other footwear, outer soles of rubber/plastics uppers of leather	Processed	Resource	Other	0.62
	4	Rice, semi-milled or wholly milled, whether or not polished or glazed	Raw	Commodity	Low tech	0.58
	5	Coffee, not roasted, not decaffeinated	Raw	Commodity	Other	0.40
	6	Other printers, copying & facsimile machines; computer input or output units; other office machines	Processed	Unclassified	High tech	0.71
	7	Jerseys, pullovers, cardigans, etc, knitted or crocheted, of wool or fine animal hair	Processed	Resource	Low tech	0.49
	8	Smart cards; electronic integrated circuits; other electrical machines and parts	Processed	Unclassified	High tech	0.72
	9	Fish fillets, frozen	Raw	Commodity	Low tech	0.51
	10	Anthracite, whether or not pulverised but not agglomerated	Raw	Unclassified	Other	0.69

A comprehensive assessment of the correspondence between the product classifications and the Product Complexity scores can be found in Klotz, Kniahin and Jansen (2016). Preliminary results suggest that there is indeed a positive association between the product classifications and the computed Product Complexity scores. However, while it can be observed that (semi-) processed and technologically intense products have higher average Complexity scores than raw and other (non tech) products, this is less clear-cut when considering the difference in scores among technology intense products. Table 6 shows the summary statistics for Bangladesh, Ghana, Ethiopia, Madagascar, South Africa and Viet Nam and Figure 14 to 36 visualise these. The objective of the next Section is to investigate the drivers behind the six countries' export performance.

Table 6: Product classifications and Complexity, summary statistics, 2014

Country	Product Classification	Level	N	Mean	Std. Dev.	Min	Max
Bangladesh	WTO	Processed	2034	85.75	7.02	34.73	100.00
		Semi-processed	983	85.17	8.94	10.94	96.48
		Raw	393	71.75	15.11	0.00	91.98
	UNCTAD	High tech	879	86.93	4.74	41.10	95.56
		Medium tech	662	88.96	4.57	63.86	100.00
		Low tech	384	87.53	5.47	47.25	99.85
		Resource	367	81.31	9.10	23.76	94.06
		Commodity	721	74.98	13.80	0.00	93.49
		Mineral	143	83.75	7.75	39.90	93.46
		Unclassified	253	84.77	9.72	17.34	95.54
	OECD	High tech	282	88.27	3.28	70.42	95.04
		Medium-high tech	1349	87.72	5.12	17.34	100.00
		Medium-low tech	770	86.57	6.38	31.25	99.85
		Low tech	617	78.18	10.59	14.41	93.42
		Other	392	71.97	15.13	0.00	93.46
Ethiopia	WTO	Processed	2031	85.86	6.87	34.73	100.00
		Semi-processed	918	85.30	8.37	10.94	96.48
		Raw	366	71.74	15.10	0.00	91.98
	UNCTAD	High tech	827	86.84	4.87	41.10	95.56
		Medium tech	674	88.88	4.68	62.77	100.00
		Low tech	383	87.69	5.29	47.25	99.85
		Resource	358	81.17	9.17	23.76	94.06
		Commodity	686	75.58	13.39	0.00	93.49
		Mineral	135	83.53	7.97	39.90	93.46
		Unclassified	251	85.06	9.14	17.34	95.54
	OECD	High tech	277	88.30	3.23	70.42	95.04
		Medium-high tech	1302	87.69	5.28	17.34	100.00
		Medium-low tech	753	86.83	5.60	51.62	99.85
		Low tech	606	78.82	10.08	14.41	93.42
		Other	377	72.05	14.93	0.00	93.46

Ghana	WTO	Processed	2014	85.73	6.99	34.73	100.00
		Semi-processed	826	84.80	9.73	10.94	96.11
		Raw	352	70.67	15.21	0.00	91.87
	UNCTAD	High tech	754	86.89	5.05	41.10	95.56
		Medium tech	656	88.89	4.71	62.77	100.00
		Low tech	374	87.72	4.96	66.96	99.85
		Resource	352	81.44	8.66	31.33	94.06
		Commodity	668	74.38	14.09	0.00	93.49
		Mineral	145	83.54	7.77	39.90	93.46
		Unclassified	242	84.28	10.17	17.34	95.54
	OECD	High tech	270	88.33	3.24	70.42	95.04
		Medium-high tech	1216	87.72	5.40	17.34	100.00
		Medium-low tech	721	86.61	6.36	31.25	99.85
		Low tech	615	78.35	10.44	14.41	93.42
		Other	370	71.46	15.41	0.00	93.46
Madagascar	WTO	Processed	1941	85.70	7.13	34.73	100.00
		Semi-processed	797	85.06	8.93	10.94	96.48
		Raw	365	70.96	14.87	0.00	91.87
	UNCTAD	High tech	713	86.80	5.16	41.10	95.56
		Medium tech	636	88.91	4.77	62.77	100.00
		Low tech	361	87.67	5.44	47.25	99.85
		Resource	357	81.41	8.63	31.33	94.06
		Commodity	670	74.58	13.79	0.00	93.49
		Mineral	141	83.44	7.85	39.90	93.46
		Unclassified	224	85.12	8.62	17.34	95.54
	OECD	High tech	258	88.34	3.29	70.42	95.04
		Medium-high tech	1157	87.72	5.52	17.34	100.00
		Medium-low tech	716	86.87	5.62	51.62	99.85
		Low tech	595	78.04	10.48	14.41	93.42
		Other	377	71.95	14.83	0.00	93.46

South Africa	WTO	Processed	2168	85.68	6.92	34.73	100.00
		Semi-processed	1112	84.99	8.69	10.94	96.48
		Raw	538	73.67	14.23	0.00	91.98
	UNCTAD	High tech	945	86.83	4.67	41.10	95.56
		Medium tech	677	88.88	4.67	62.77	100.00
		Low tech	420	87.38	5.33	47.25	99.85
		Resource	393	81.31	8.93	23.76	94.06
		Commodity	931	76.21	13.10	0.00	93.49
		Mineral	154	83.69	7.60	39.90	93.46
		Unclassified	297	84.49	9.39	17.34	95.54
	OECD	High tech	301	88.18	3.23	70.42	95.04
		Medium-high tech	1439	87.59	5.09	17.34	100.00
		Medium-low tech	841	86.45	6.23	31.25	99.85
		Low tech	727	78.65	10.22	14.41	93.42
		Other	510	73.41	14.40	0.00	93.46
Viet Nam	WTO	Processed	2140	85.70	6.94	34.73	100.00
		Semi-processed	1074	84.99	8.83	10.94	96.48
		Raw	498	72.95	14.49	0.00	91.98
	UNCTAD	High tech	921	86.86	4.71	41.10	95.56
		Medium tech	672	88.90	4.66	62.77	100.00
		Low tech	412	87.41	5.36	47.25	99.85
		Resource	389	81.29	8.97	23.76	94.06
		Commodity	884	75.90	13.32	0.00	93.49
		Mineral	154	83.69	7.60	39.90	93.46
		Unclassified	279	84.44	9.66	17.34	95.54
	OECD	High tech	297	88.24	3.18	70.42	95.04
		Medium-high tech	1404	87.62	5.14	17.34	100.00
		Medium-low tech	825	86.49	6.27	31.25	99.85
		Low tech	708	78.60	10.30	14.41	93.42
		Other	478	72.78	14.62	0.00	93.46

Bangladesh

Figure 13: Product complexity and Process Stage classification, Bangladesh, 2014

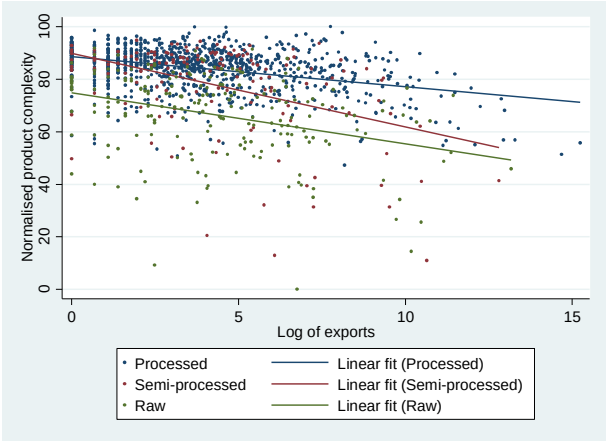


Figure 14: Product complexity and Skill- and Technology classification, Bangladesh, 2014

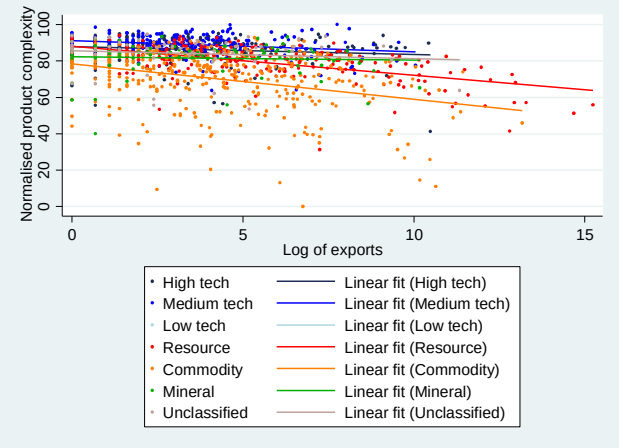
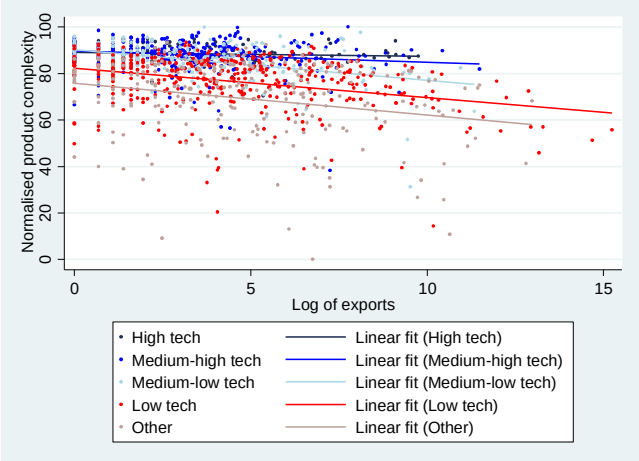


Figure 15: Product complexity and High-technology classification, Bangladesh, 2014



Ghana

Figure 16: Product complexity and Process Stage classification, Ghana, 2014

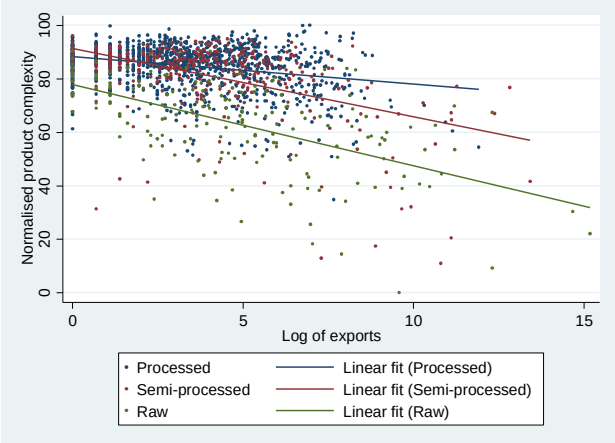


Figure 17: Product complexity and Skill- and Technology classification, Ghana, 2014

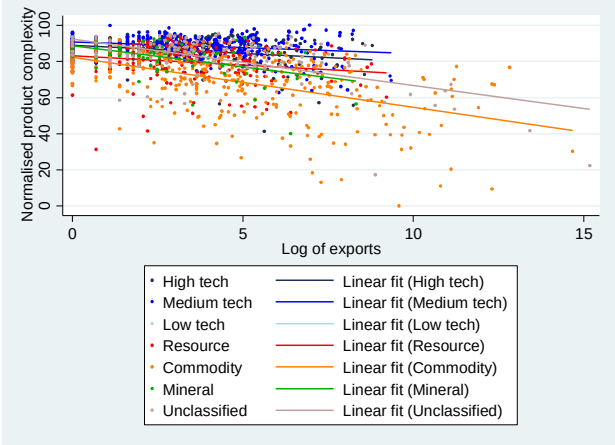
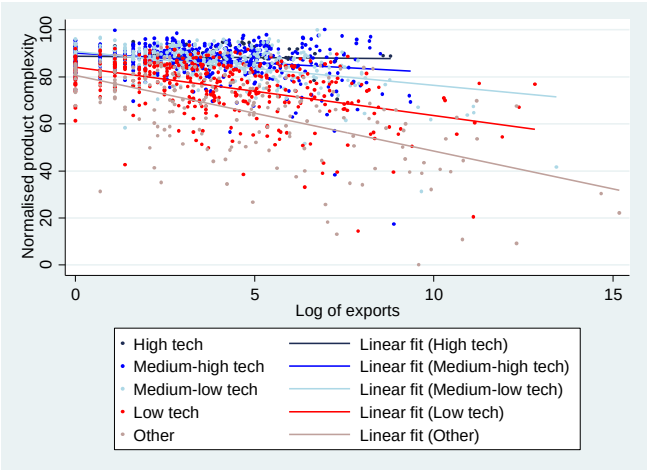


Figure 18: Product complexity and High-technology classification, Ghana, 2014



Ethiopia

Figure 19: Product complexity and Process Stage classification, Ethiopia, 2014

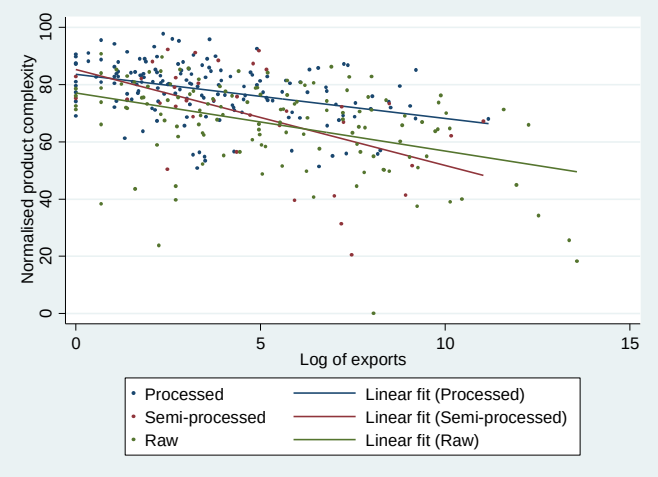


Figure 20: Product complexity and Skill- and Technology classification, Ethiopia, 2014

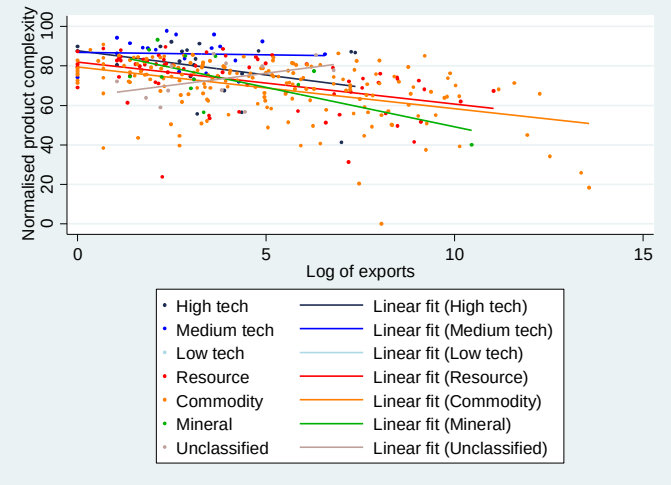
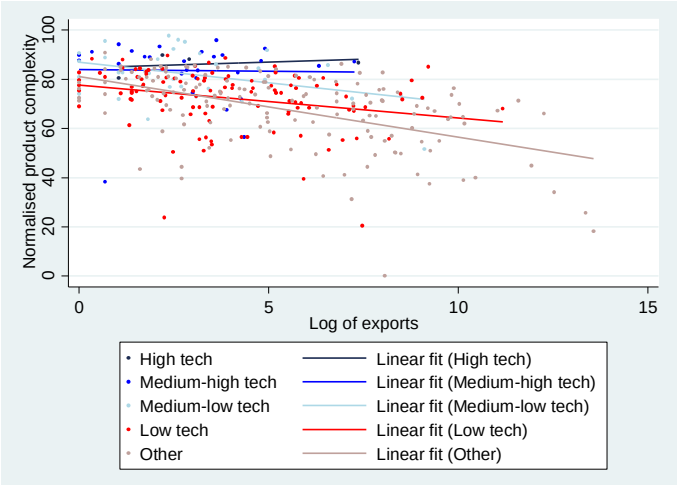


Figure 21: Product complexity and High-technology classification, Ethiopia, 2014



Madagascar

Figure 22: Product complexity and Process Stage classification, Madagascar, 2014

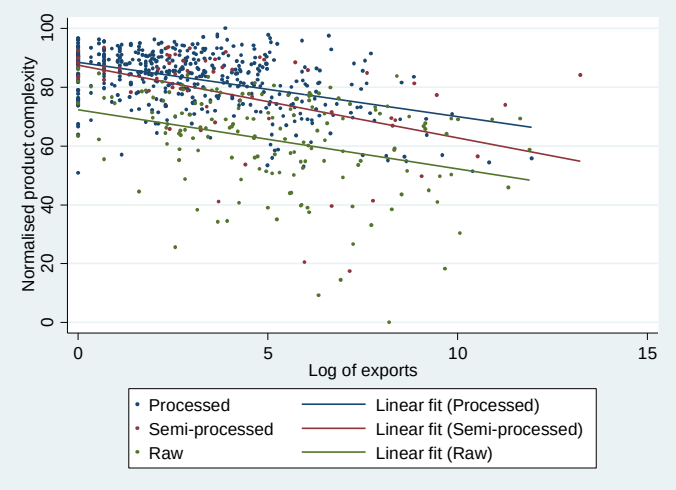


Figure 23: Product complexity and Skill- and Technology classification, Madagascar, 2014

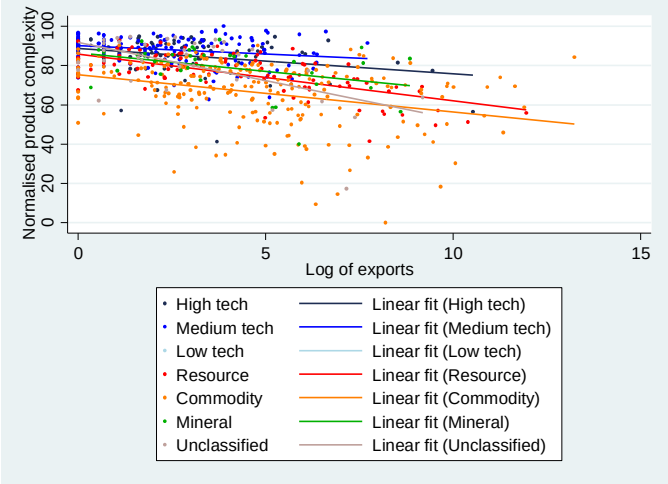
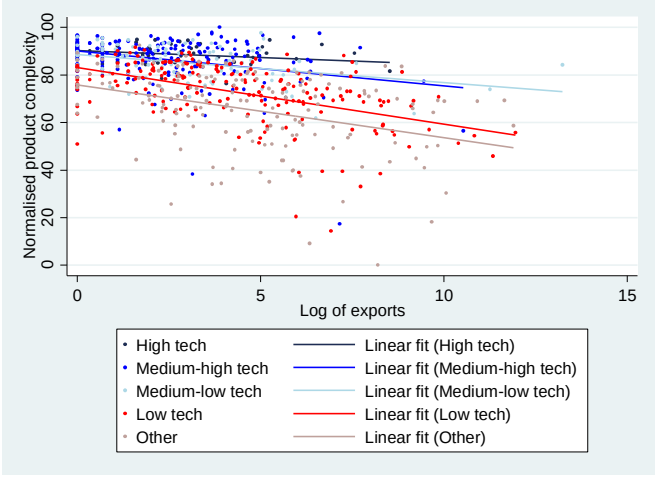


Figure 24: Product complexity and High-technology classification, Madagascar, 2014



South Africa

Figure 25: Product complexity and Process Stage classification, South Africa, 2014

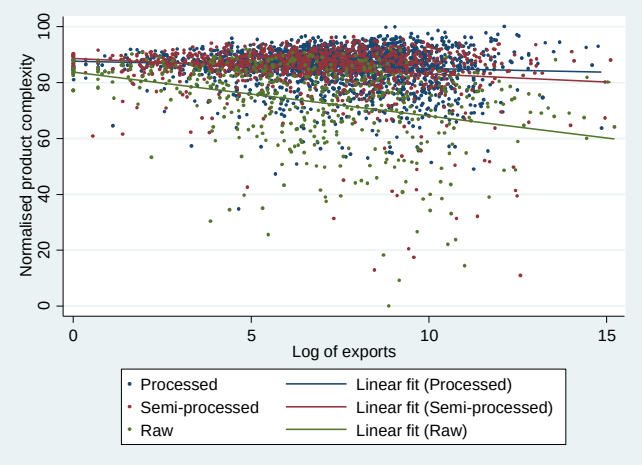


Figure 26: Product complexity and Skill- and Technology classification, South Africa, 2014

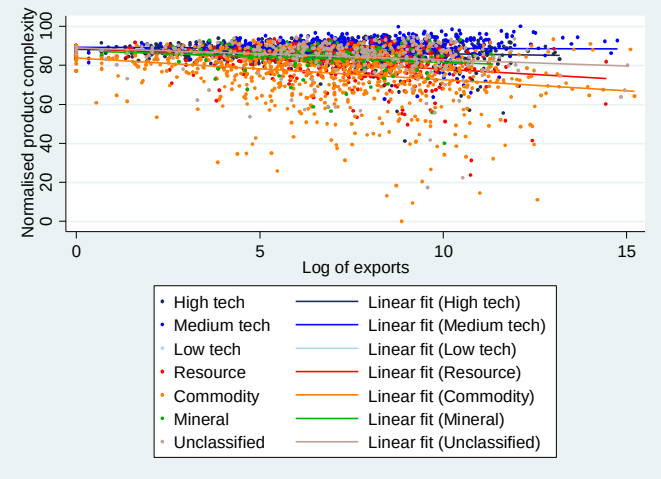
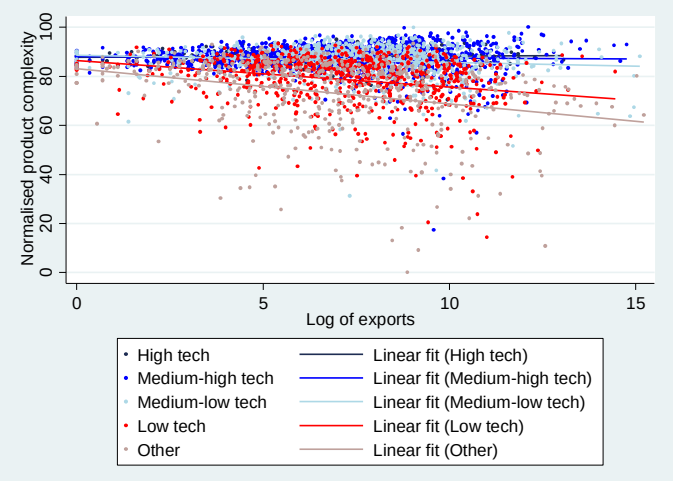


Figure 27: Product complexity and High-technology classification, South Africa, 2014



Viet Nam

Figure 28: Product complexity and Process Stage classification, Viet Nam, 2014

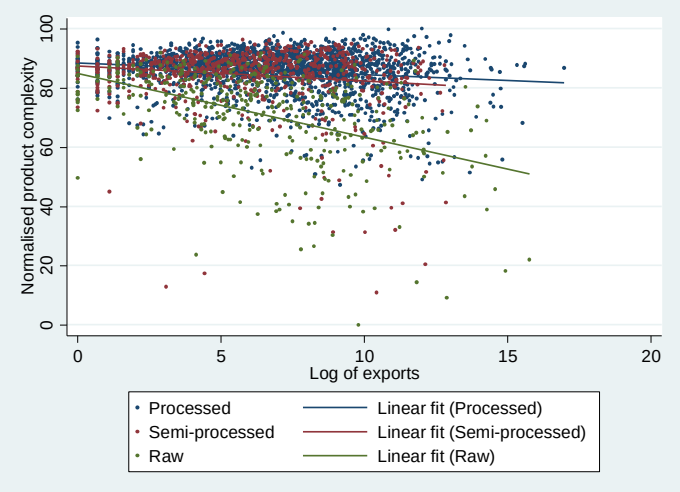


Figure 29: Product complexity and Skill- and Technology classification, Viet Nam, 2014

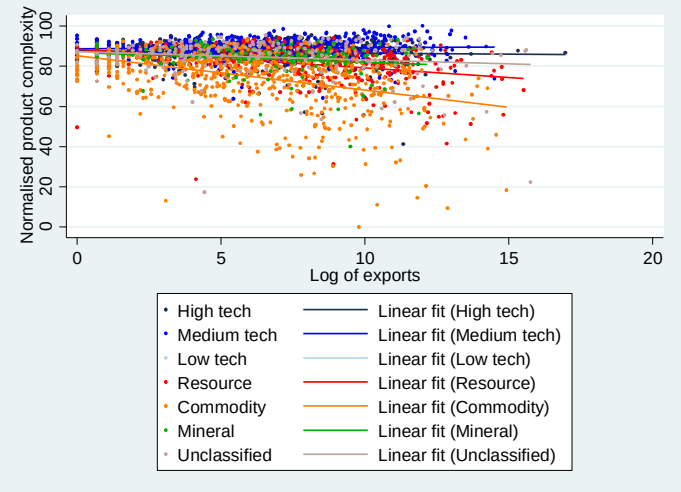
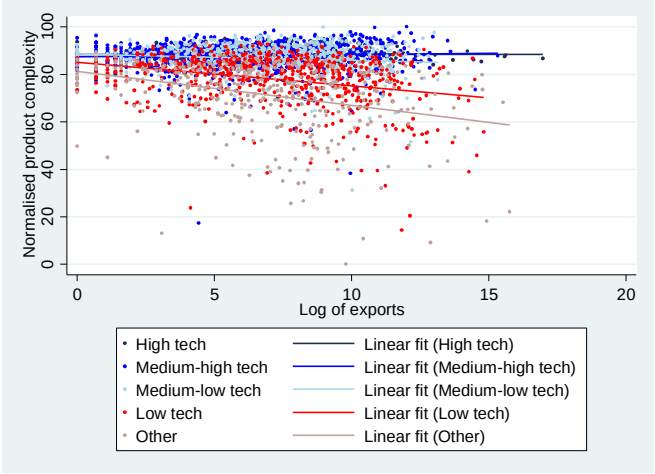


Figure 30: Product complexity and High-technology classification, Viet Nam, 2014



4. Shift-share analysis

This Section employs a shift-share analysis (SSA) approach to decompose the growth of exports of the six countries and identify the main drivers behind it. More precisely, this Section follows Piezas-Jerbi and Nee (2009) in decomposing the growth of exports into four separate components: a global component (GLOBO) indicating changes due to overall growth of world trade, a geographical component (GEO) indicating changes due to the country's distribution of trading partners, a product composition component (COMPO) indicating growth due to the mix of products exported, and a residual term indicating changes in competitiveness, or performance (PERFO).

The derivation of the SSA is out of the scope of this paper but can be found in Piezas-Jerbi and Nee (2009). The SSA essentially boils down to

$$V_{..}' - V_{..} = rV_{..} + \sum_i (r_i - r)\, V_{i.} + \sum_i \sum_j (r_{ij} - r_i) V_{ij} + \sum_i \sum_j (V_{ij}' - V_{ij} - r_{ij} V_{ij})$$

= (1) (2) (3) (4)

, where the left-hand side is the change of a country's exports between 2009 and 2013, (1) is the GLOBO, (2) the COMPO, (3) the GEO and (4) the PERFO indicator and where

$V_{..}'$	= value of total exports of a country in 2013
$V_{..}$	= value of total exports of a country in 2009
r	= percentage change of world exports between 2009 and 2013
r_i	= percentage change in world exports of product i between 2009 and 2013
$V_{i.}$	= value of a country's exports of product i in 2009
r_{ij}	= percentage change in world exports of product i to country j between periods 2009 and 2013
V_{ij}	= value of a country's exports of product i to country j in 2009
V_{ij}'	= value of a country's exports of product i to country j in 2014

The definitions apply to a single exporting country as the analysis is carried out one by one for 222 countries. Since the main destination markets of the six countries of interest vary (See Table 1), the destination markets, *j*, are aggregated to the continents Africa, Asia, Europe, North America, Oceania and South America. Since the UNCTAD and OECD classifications are fairly similar, the following discussion limits itself to two cases: In the first case, product *i* presents the Process Stage classification groups raw, semi-processed and processed. In the second case, product *i* presents the Skill-and Technology Content classification groups resource-intensive, commodities, minerals, unclassified, low-tech, medium-tech and high-tech.

4.1 The GLOBO

The GLOBO indicates changes in a country's exports due to the overall growth of world trade.

By definition, the GLOBO should be identical for both product classifications. As can be seen in Figure 37 and Figure 38 (and Table 7 and 8), this is indeed the case and serves as a robustness check for the calculations.

Table 7: Summary statistics: Process Stages classification

Variable	N	Mean	Std. Dev.	Min	Max
GLOBO	222	57.60139	302.1923	-1789	1807.67
COMPO	222	2.450655	59.19003	-602.598	463.1094
GEO	222	-5.06533	64.59973	-529.937	472.0606
PERFO	222	45.00606	366.7549	-2214.34	3021.53

Table 8: Summary statistics: Skill- and Technology Intensity classification

Variable	N	Mean	Std. Dev.	Min	Max
GLOBO	222	57.60139	302.1923	-1789	1807.67
COMPO	222	-2.24064	65.65944	-736.046	381.1797
GEO	222	-5.63109	75.2003	-645.182	509.9201
PERFO	222	50.26316	351.5114	-1948.6	3270.23

The growth of Bangladeshi exports between 2009 and 2013, for instance, was 56% due to the growth of world exports (Figure 31 and Figure 32). The growth of world exports was particularly important to the growth of Malagasy exports (71%) and least important for Ghanaian exports (26%). A low GLOBO value should be regarded as something positive because it suggests that a country's export performance is determined by its country-specific characteristics rather than global export growth. Table 7 and Table 8 as well as Figure 33 show that the six countries' GLOBO indicator is not far off the full sample average.

Figure 34 decomposes the GLOBO indicator by product classification and largely reflects the countries' composition of exports illustrated in Figure 7 and Figure 9. For instance, the 56% GLOBO contribution to Bangladesh's export growth is mainly driven by the country's processed and resource-intensive products.

Figure 31: Shift-share analysis, Process Stages classification

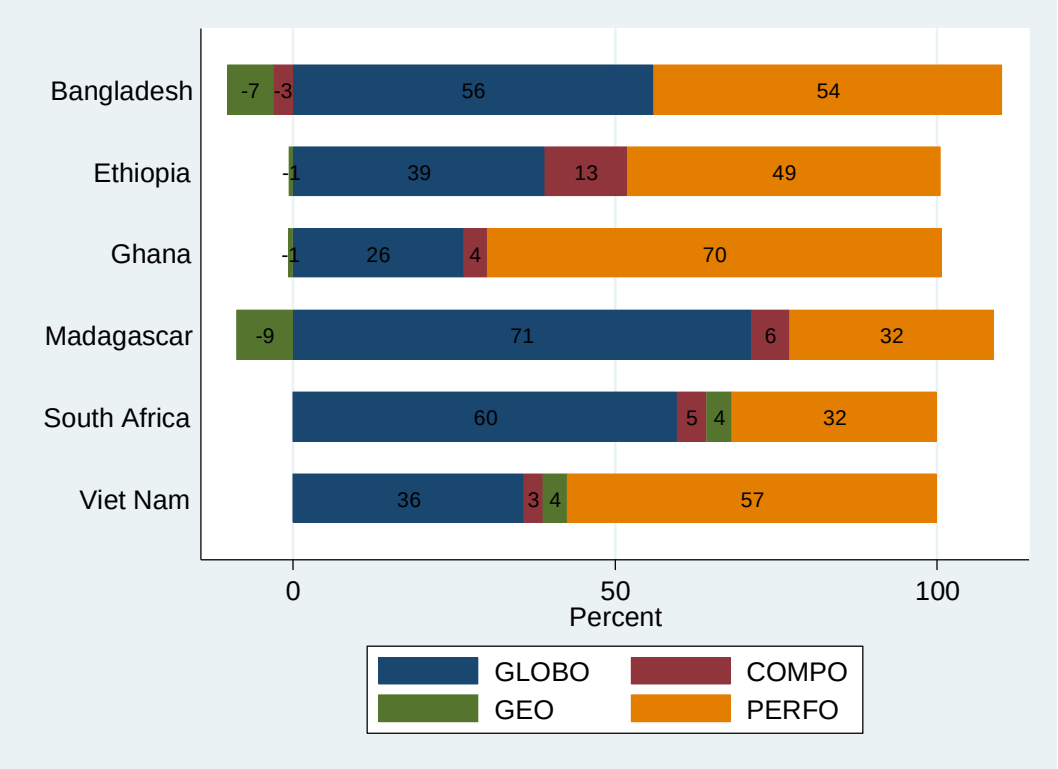


Figure 32: Shift-share analysis, Skill- and Technology intensity classification

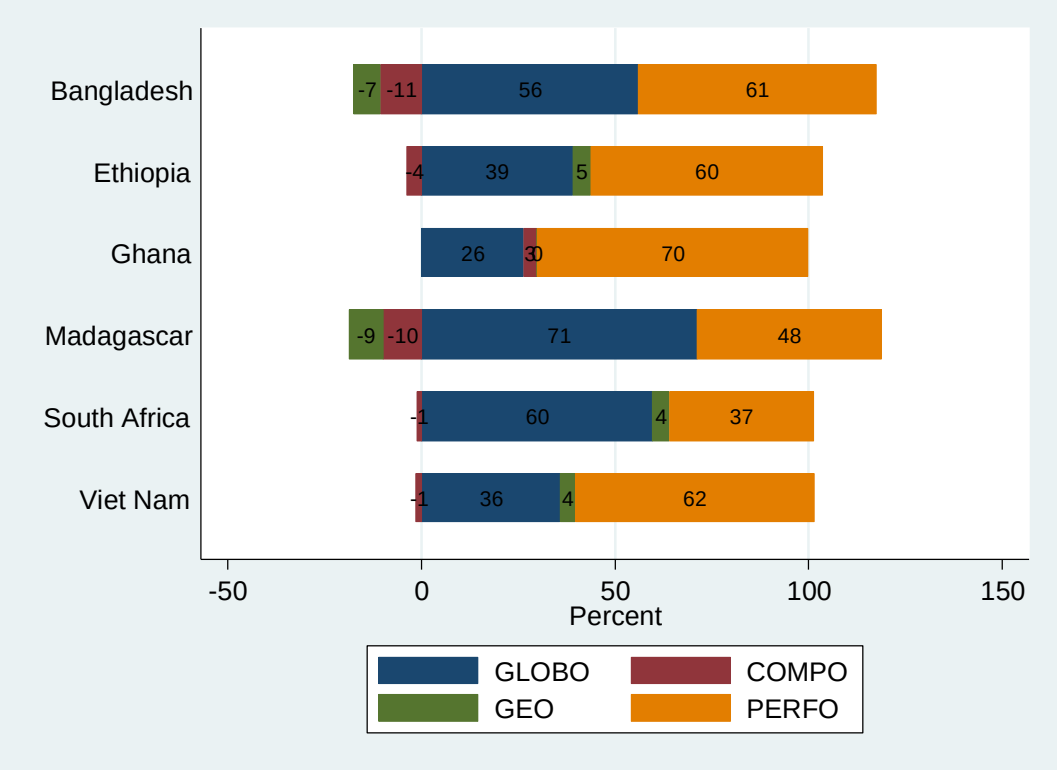
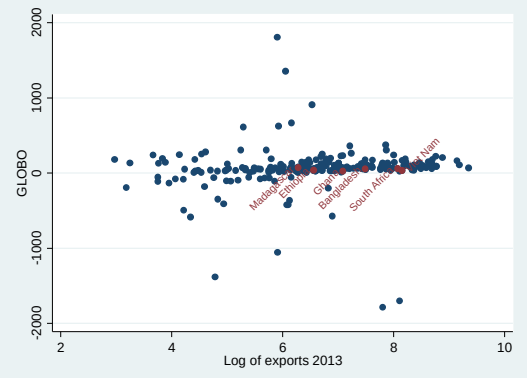


Figure 33: GLOBO



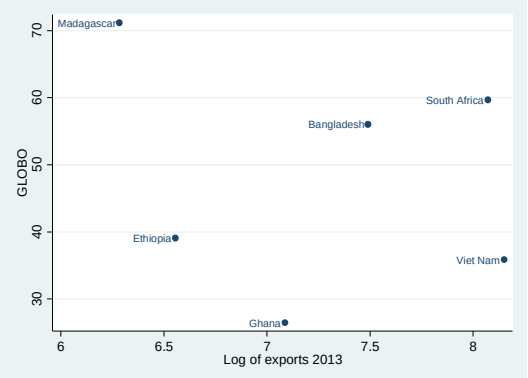
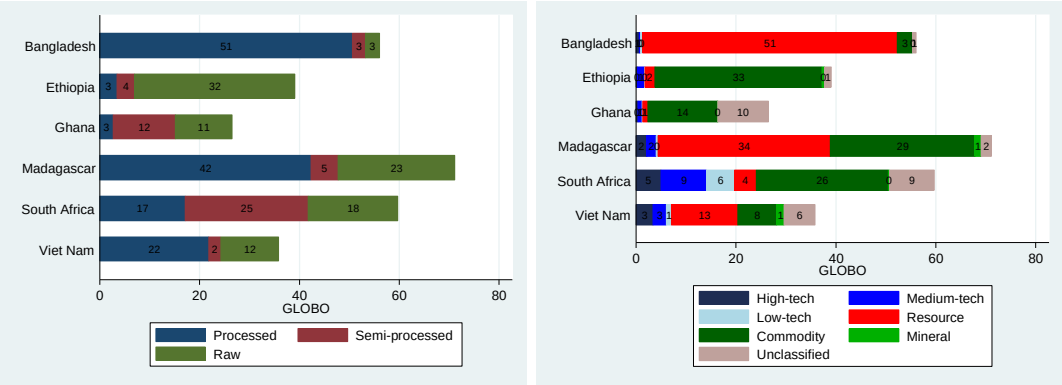


Figure 34: GLOBO decomposition



4.2 The COMPO

The product composition component (COMPO) captures a country's export growth due to the mix of products exported. In other words, the COMPO indicates to which extent a country is able to export products for which world exports grow faster than total world exports. Since exports respond to demand, this suggests that for these very products demand grows faster than average demand. By definition, the results of the COMPO are sensitive to the product classification and its level of disaggregation.

When considering the Process Stage classification, the COMPO is found to be positive for all countries but Bangladesh. In this case, the COMPO suggests that 3% of Bangladeshi export growth is lost due to the country's mix of raw, semi-processed and processed products. The majority of this effect appears to be driven by a loss of exports of processed products – Bangladesh's main export group (Figure 36). In contrast, the composition of raw, semi-processed and processed products accounts for 13% of Ethiopian export growth between 2009 and 2013. The COMPO effect appears to be mainly driven by Ethiopia's main export group - raw products (Figure 36). This pattern can also be observed for the other four countries, even though the importance of the COMPO for their export growth is considerably smaller. While raw product exports contribute positively to the COMPO effect, semi-processed and processed exports appear to drive the COMPO effect negatively. The reason behind this is that between 2009 and 2013 world exports of raw products grew by 69% while semi-processed and processed products grew at a slower rate of 46% and 45%, respectively.

The COMPO results change significantly when considering the Skill- and Technology intensity classification. With the exception of Ghana, all countries lost export growth due to their mix of resource-intensive, commodities, minerals, unclassified, low tech, medium tech and high tech products. While there are cross-country differences, Figure 36 suggests that this negative indicator is

mainly driven by commodities and resource-intensive products. The positive values for unclassified products are not high enough to pull up the COMPO. The unclassified products appear to present a problem in this context because they grew considerably faster (75% from 2009 to 2013) than the other product groups (Resource-intensive: 39%, commodities: 43%, minerals: 36%, low-tech: 38%, medium-tech: 50%, high-tech: 42%).

Figure 35: COMPO

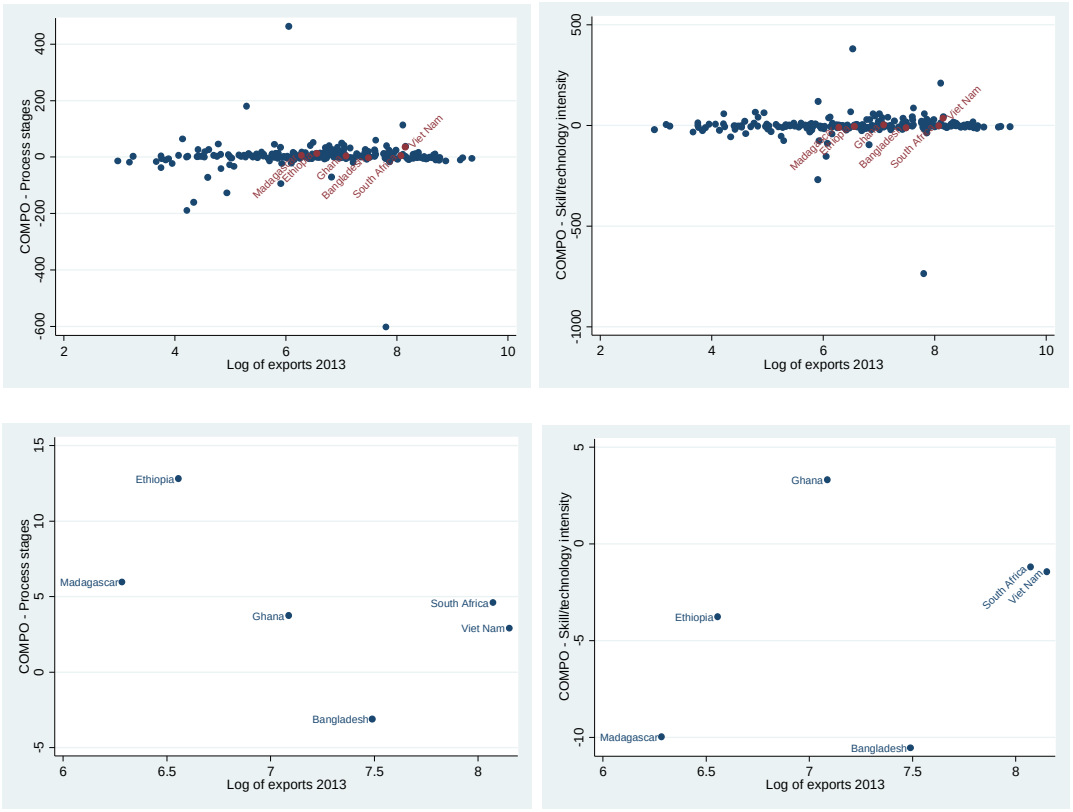
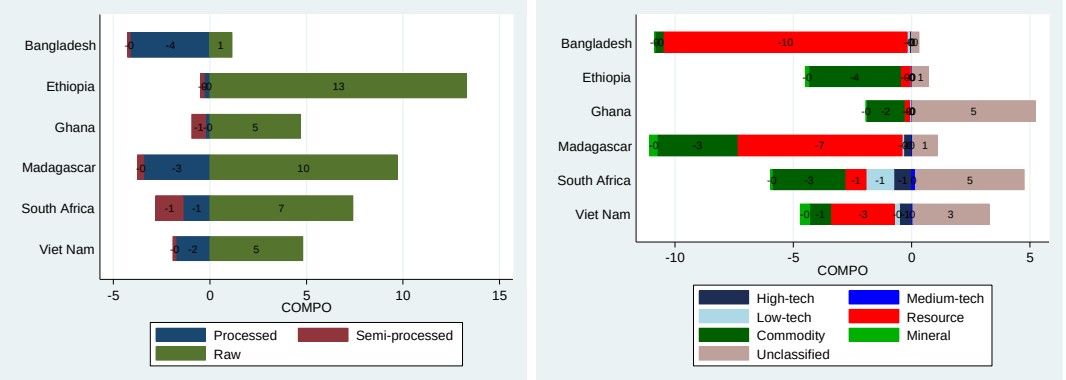


Figure 36: COMPO decomposition



4.3 The GEO

The third, geographical, component (GEO) captures the part of export growth due to a country's distribution of trading partners. In essence, the GEO indicates to which extent a country exports a product to markets in which the demand for this product is higher than the world average demand for this product.

The results are relatively stable across the two different product classifications. Around 4% of Viet Nam's and South Africa's export growth is due to the countries' distribution of trading partners. Viet Nam's GEO is positively driven by Asia, Oceania and South America and negatively driven by Europe, North America and Africa. South Africa's GEO is positively driven by Asia, South America and Africa and pulled down by Europe, North America and Oceania.

In the cases of Bangladesh and Madagascar, the distribution of trading partners is less favourable and causes a loss of export growth between 5% and 8% (Figure 37). The loss for Bangladesh's GEO is driven by Europe and Oceania; for Madagascar it is Europe and North America.

Similarly to the GLOBO, the decomposition of the GEO component by product classification largely reflects countries' export baskets. The GEO indicator affects Bangladeshi and Malagasy exports primarily through processed and resource-intensive products while the (relatively small) GEO effect on South African and Vietnamese exports is driven by a broader variety of products reflecting the countries' more diverse export basket.

Figure 37: GEO

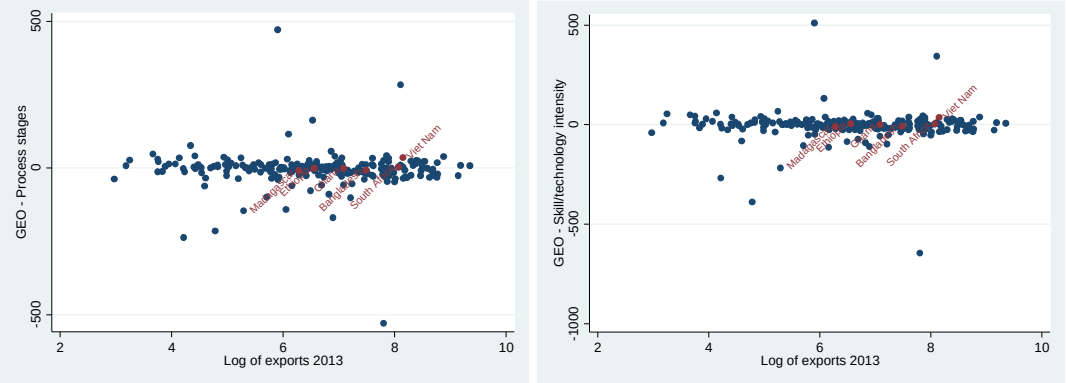
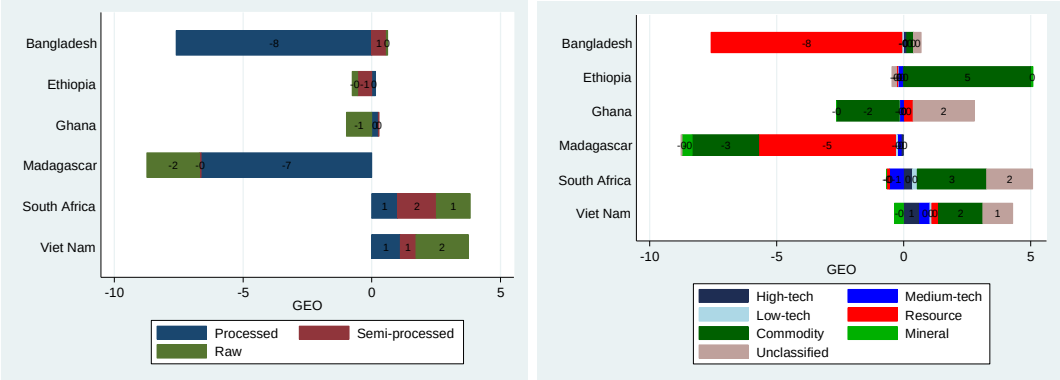


Figure 38: GEO decomposition



4.4 The PERFO

The fourth and last component of export growth is the competitiveness, or performance, indicator PERFO. The PERFO is a residual that should be interpreted carefully as it is not observable but only captures the cumulative effect of all factors other than the GLOBO, GEO and COMPO that may affect countries' exports. In other words, the COMPO may be interpreted as an indicator of competitiveness, but only in a broad sense (Piezas-Jerbi and Coleman, 2009). Figure 39 shows that the PERFO is a strong and positive driver of the six countries' exports. This is true for both product

classifications. Ghana achieves the highest PERFO value of 70%, South Africa the lowest value of 32% and 37% for the respective product classification.

Considering the Process Stage classification (Figure 40), Bangladesh's PERFO is mostly driven by its main export group - processed products. For Ethiopia the main drivers are raw products followed by processed products. Raw products also drive the largest part of Ghana's PERFO followed by semi-processed products. Madagascar appears to be rather competitive in exporting semi-processed products whereas processed products actually pull down the country's PERFO. Semi-processed and processed products contribute the majority of South Africa's and Viet Nam's PERFO. Raw products, in contrast, reduce the indicator slightly. Overall, the PERFO is in line with the countries' export basket composition.

The analysis of the Skill- and Technology Intensity classification, largely confirms this observation. Resource-intensive products – the country's main export group - account for the large majority of Bangladesh's PERFO. Similarly, the majority of Ethiopia's PERFO is accounted for by commodities. The results for Ghana and Madagascar suggest that there might be a correspondence issue for certain products across the two different product classifications. South Africa's PERFO appears to be largely driven by commodities but high- and medium technology products do also contribute to the country's performance. High-tech products are the main driver of Viet Nam's performance, followed by resource-intensive products and medium- and low-tech products.

Figure 39: PERFO

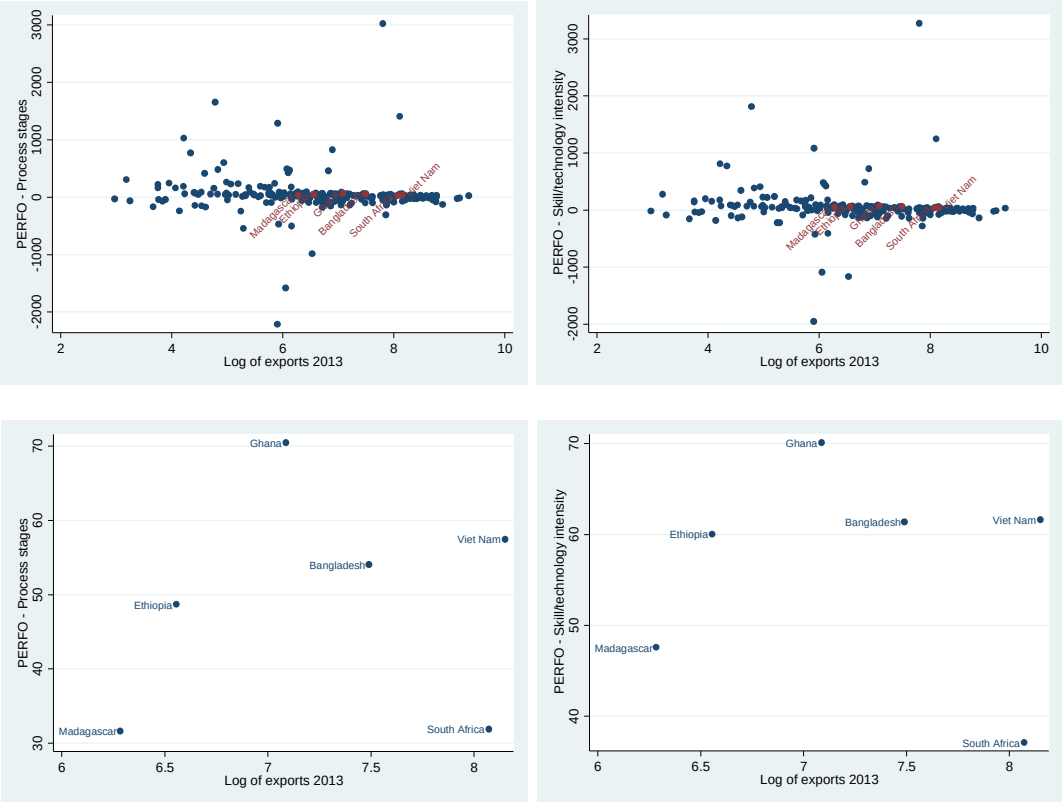
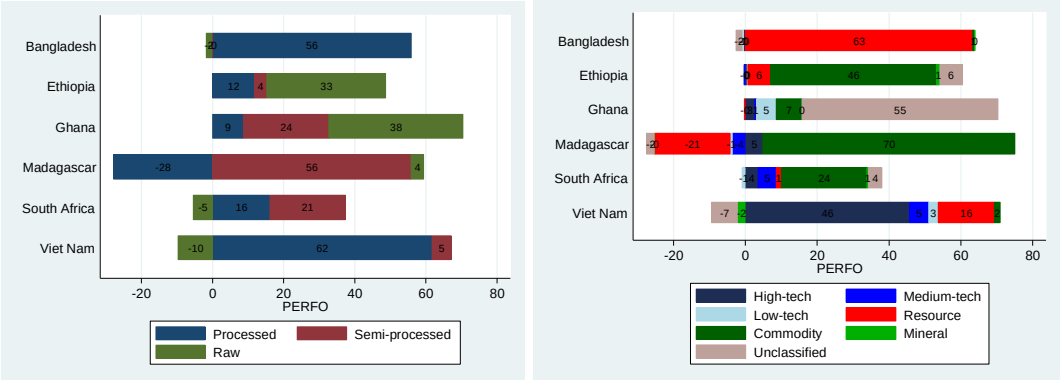


Figure 40: PERFO decomposition



The findings of this section can be summarised as follows. The growth of world exports contributes considerably to the growth of Malagasy, South African and Bangladeshi exports while the export growth of Ethiopia, Viet Nam and Ghana is mainly determined by country-specific factors. At the product level, the GLOBOs are largely in line with the countries' main export groups. Bangladesh's GLOBO indicator, for instance, is driven by world exports of processed and resource-intensive products, while Ethiopia benefits from world export growth of raw products and commodities. The composition of the GLOBO indicator for South Africa and Viet Nam reflects the countries' more diversified export product base.

By definition, the COMPO results are sensitive to the product classification and level of aggregation. When considering the Process Stage classification, the COMPO is found to be positive for all countries but Bangladesh. Bangladesh, which mainly exports processed products, was adversely affected by relatively slowing growing demand for processed products between 2009 and 2013. This also pulls down the COMPO of the other five countries however it is more than compensated by the strongly increasing demand for raw products which contributes largely to the respective countries' COMPO, in particular to Ethiopia – which mainly exports raw products.

The COMPO results change significantly when considering the Skill- and Technology classification. With the exception of Ghana, all countries lost export growth due to their mix of resource-intensive, commodities, minerals, unclassified, low-tech, medium-tech and high-tech. While there are cross-country differences, this negative indicator is mainly driven by commodities and resource-intensive products. The results should be interpreted with care however because the strongly growing unclassified products may distort the picture.

The GEO results are relatively stable across the two different product classifications. Around 4% of Viet Nam's and South Africa's export growth is due to the countries' distribution of trading partners. Viet Nam benefits particularly from demand from Asia, Oceania and South America, while the demand for South Africa's exports appears to be driven by Asia, South America and Africa. In the cases of Bangladesh and Madagascar, the distribution of trading partners is less favourable and causes a loss of export growth between 7% and 9%. Lacking European demand is found to be the main driver of the negative GEO in both cases. The decomposition of the GEO component by product classification largely reflects countries' export baskets. The GEO indicator affects Bangladeshi and Malagasy exports primarily through processed and resource-intensive products while the GEO effect on South African and Vietnamese exports is driven by a broader variety of products reflecting the countries' more diverse export basket.

The PERFO results vary only slightly with the product classification. Ghana has the highest PERFO, followed by Viet Nam, Bangladesh and Ethiopia. Madagascar and South Africa show the lowest PERFO within the group. The results are largely in line with the countries' main export products. The PERFO also confirms the previously discussed successful move of Viet Nam towards high-technology export products.

The SSA is a useful approach to complement the previous analysis of countries' export complexity. However, the SSA also has a number of limitations that are extensively discussed in Piezas-Jerbi and

Nee (2009) and some of these should be mentioned here. First, the methodology is based on changes rather than levels and therefore does not take into account countries' development stages and economy sizes. As a consequence, relative country rankings should be handled with care. Secondly, the present analysis is based on nominal export values which do not account for price fluctuations, notably commodity price fluctuations. Thirdly, the present SSA is a classic approach based on only two years, 2009 and 2013. A dynamic approach which carries out the calculations for each pair of adjacent years would enhance the validity and robustness. Addressing these issues, as well as further concerns presented in Piezas-Jerbi and Nee (2009), is out of the scope of this paper and left for future research.

5. Conclusion

This paper provides an investigation into the technological complexity of exports from Bangladesh, Ethiopia, Ghana, Madagascar, South Africa and Viet Nam.

Within this group, South Africa and Viet Nam have the most diversified export baskets with regards to both, export destinations and export products. Taking intra-industry trade as a proxy, the two countries are also found to be best integrated in international value chains.

South Africa has the most technologically complex export basket in which processed and semi-processed, in particular low- and medium-tech, products account for the majority of exports. However, South Africa is also the only country within the group which registered a stag slight decline in the Product Complexity of exports from 2001 to 2014. The results of the shift-share analysis corroborate this finding as the export performance between 2009 and 2013 is well below the world average and the lowest among the group of the six countries investigated here. While South Africa continues to be the most technologically complex country in this group, these results in combination with the country's relatively slow export growth rate point towards a slight negative trend.

Viet Nam presents the stark contrast. The country has not only quadrupled its share in world exports between 2001 and 2014 but also gradually decreased the share of raw products and commodities in its exports. This development is accompanied by a considerable increase in the share of processed products in total exports, particularly in the high-tech sector. The shift-share analysis confirms that high-tech products are the main driver of Viet Nam's export competitiveness.

Bangladeshi exports are to a large extent composed of processed products. However, these products are found to be labour-intensive rather than technologically complex. Still, the country upgraded the complexity of its exports at a considerable rate until 2008. The shift-share analysis suggests that the country was particularly adversely affected by a slowly growing European demand for processed products between 2009 and 2013. While the country's focus on labour-intensive processed products makes it sensitive to demand fluctuations, these products continue to drive the vast part of the country's export competitiveness.

The large majority of Ethiopia's exports are accounted for by raw products and commodities; the share of more complex products, both technologically as well as resource (labour-) intensive, has been gradually declining. This is also reflected in the relatively small increase in export complexity over the past 15 years. The shift-share analysis suggest however that Ethiopia's export growth between 2009 and 2013 actually benefited from its reliance on raw products as world demand grew faster than for semi-processed and processed goods.

Complex products are also of limited importance in Ghana's export basket in which raw products and commodities continue to account for the vast majority. The complexity of exports fluctuated over the past 15 years but the overall small increase in export complexity appears to mirror the reliance on raw products. The shift-share analysis suggests otherwise, however. Ghana is actually found to be the most competitive exporter within the group of six countries. While this competitiveness is mainly driven by raw products, semi-processed and low-tech products do contribute to the performance.

Madagascar increased the share of processed, mainly resource (labour-) intensive, products between 2001 and 2007. However, this trend reversed since and raw products and commodities have re-gained the largest share of the country's exports. The overall complexity of exports slightly increased since 2001. Within the group, the country is most sensitive to world trade fluctuations and shows the lowest export competitiveness – well below world average. The drivers of this low competitiveness are difficult to identify as the three product classifications used in this paper do not appear to correspond well in the products that Madagascar mainly exports.

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