

Export Sophistication Effects of Trade Facilitation Reform in Sub-Saharan Africa

Moukaila Mouzamilou Takpara^{1*}, Constant Fouopi Djiogap², Manfred Kouty³,
Bouraïma Sawadogo⁴

Abstract

This paper estimates the effects of trade facilitation reform on export sophistication, measured by the Economic Complexity Index (ECI) in Sub-Saharan Africa (SSA) over the period 2004-2017. It uses four indicators of trade facilitation capturing physical infrastructure, ICT, business, and regulatory environment as well as border, and transport efficiency. The empirical analysis using Ordinary Least Square, Two-Stage Least Square and system Generalized Method of Moment shows that effective trade facilitation reform targeted particularly at improving information and communication technology as well as border, and transport efficiency contributes to promoting the export of sophisticated goods in SSA. These findings suggest that reforms aimed at simplifying border procedures should be implemented and accelerated in SSA countries. Hence, the acceleration of the implementation of the World Trade Organization Trade Facilitation Agreement will be an essential step toward achieving this goal.

Keywords: Trade facilitation; Export sophistication; Sub-Saharan Africa.

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¹ PhD, Pan-African University - African Union Commission, Yaoundé – Cameroon, E-mail: takpara2025@gmail.com,

*Corresponding author

² Associate Professor in Economics, University of Yaoundé II, Cameroon, Department of Economics, CEREG, E-mail: constantfouopi@yahoo.fr,

³ Assistant Professor in Economics, University of Yaoundé II International Relations Institute of Cameroon, WTO-Co Chair, Yaoundé – Cameroon, E-mail: koutymanfred@yahoo.fr,

⁴ PhD Candidate, Pan-African University - African Union Commission, Yaoundé – Cameroon, E-mail: bouraimasaw@gmail.com.

1- Introduction

Recent studies on international trade explain economic development and growth as a process of developing information and learning to produce and export more sophisticated products ([Hidalgo et al. 2007](#); [Saviotti and Frenken, 2008](#); [Abdon and Felipe, 2011](#); [Felipe, 2012](#); [Cristelli et al. 2013](#); [Hausmann et al. 2014](#); [Albeaik et al. 2017](#)). Indeed, since the 2000s, export sophistication⁵ has become a condition for countries, particularly low-income countries to make their exports competitive. The first theories on economic sophistication stem from the works on product classification ([Lall et al. 2006](#); [Hausmann et al. 2007](#)). [Hausmann et al. \(2007\)](#) show that all types of products do not have the same impact on economic development. These authors measure economic sophistication by the level of productivity associated with a country's exports and show that developing countries that manage to export products like those produced and exported by high-income countries generate higher growth.

Increasing productivity is an issue of great importance to developing countries. They have more difficulties improving their export basket ([Harding and Javorcik, 2012](#)). Therefore, it becomes very important to understand the factors that determine a developing country's economic sophistication, since the latter is considered as an important determinant of structural transformation. According to [Lectard and Rougier \(2018\)](#), the sophistication and diversification signal the emergence of new industries that are more capital-intensive and competitive enough to become exporters.

Since the seminal work of [Hausmann et al. \(2007\)](#) on export sophistication, many studies have examined the determinants of countries' export sophistication, showing positive effects of income level, human capital, productive investment, and foreign direct investment ([Cabral and Veiga, 2010](#); [Spatafora et al. 2012](#); [Weldemicael, 2012](#); [Zhu and Fu, 2013](#); [Saadi, 2020](#)). More recent works have provided evidence that it also provides a substantial benefit to developing countries in terms of production stability ([da Costa Neto and Romeu, 2011](#)). However, those studies on the determinants of export sophistication are still limited, particularly for developing countries, especially those in SSA ([Zhu and Fu, 2013](#)). According to [Kamguia \(2021\)](#), over the period 2000-2010, Africa recorded the lowest level of export sophistication compared to Asian and European countries, which are the most sophisticated ones. [Jouini et al. \(2016\)](#) argue that African countries seem to suffer from a double handicap regarding their productive and export structure: insufficient diversification coupled with low sophistication. If export sophistication determines a country's growth and development model, an interesting question arises: what contribution could trade policies, particularly trade facilitation, make to export sophistication?

Trade Facilitation (TF) has become an important part of the current debate on trade liberalization policy. It was at the heart of the World Trade Organization (WTO) negotiating agenda since 2004. The ninth WTO Ministerial Conference held in Bali in December 2013 led

⁵ It is the export of new products and better-quality varieties of existing or new products ([Lectard and Rougier, 2018](#)). It is also referred to the export of complex goods, i.e., goods of high value added, that cannot be easily produced by other countries ([Gnangnon, 2021](#)).

to the adoption of the Trade Facilitation Agreement (TFA), which entered into force on 22 February 2017 following its ratification by two-thirds of the WTO membership. The TFA contains obligations and disciplines that address many of the issues related to barriers to global trade and trade costs (WTO, 2015). In a narrow sense, it is limited to the logistics of moving goods through ports or the more efficient flow of documentation associated with cross-border trade. But its broader definition includes infrastructural aspects (Portugal-Perez and Wilson, 2012).

Most of the empirical studies on the effectiveness of TF reforms have generally focused on countries' export performance in terms of export volumes (Wilson et al., 2003; Motsé and Sorescu, 2013; de Melo and Wagner, 2018) or sometimes, in terms of export diversity (Lee and Kim, 2012; Persson, 2013; Feenstra and Ma, 2014; Beverelli et al. 2015). It has been found that TF has contributed significantly to the increase in exports at the intensive and extensive margins of countries (Beverelli et al. 2015). While such an increase in exports can contribute to economic growth, recent studies on trade and economic development point to the more critical role played by the composition of a country's export basket in its economic performance (Hausmann et al., 2007; Minondo, 2010; Jarreau and Poncet, 2012; Grancay et al. 2015). For these authors, countries whose export basket contains more sophisticated products enjoy higher economic growth. In other words, countries that are specialized in products with high productivity, and sophisticated products will have greater export sophistication and will tend to have higher and faster growth.

In this study, we contribute to the empirical literature on TF by assessing its contribution to export sophistication in SSA countries. This paper is closed to that of Spence and Karingi (2014) who analyzed the effects of TF on SSA countries' export sophistication using the EXPY index of Hausmann et al. (2007). However, the value added of our study compared to their work is threefold. First, unlike their study, our paper uses the Economic Complexity Index (ECI). To the best of our knowledge, this paper presents the first analysis of trade facilitation—export sophistication nexus for Sub-Saharan African countries using the Economic Complexity Index. The ECI gives a holistic measure of knowledge accumulation and sophistication in an economy, by combining information on both the diversity of a country and the ubiquity of its products (Hidalgo and Hausmann, 2009; Hartmann et al., 2017). Also, the focus on ECI which captures economic sophistication⁶ as a potential outcome of fostering trade facilitation is dictated by the fact that, it is an important driver of current economic growth as well as a good predictor of countries' future economic growth and economic development patterns (Albeaik et al. 2017; Gnanon; 2021). Second, our study covers a more recent period (2004-2017), unlike the study by Spence and Karingi (2014) which covered only 2004-2007. The need to actualize the work is particularly important due to the fact that, despite the enormous benefits that may be derived from the effective implementation of trade facilitation reform, Africa's level of trade facilitation remains low compared to other regions of the world (Sakyi

⁶ Some authors like Gnanon (2021) refers “economic sophistication” to the concept of economic complexity. According to Atasoy (2021), ECI shows the overall sophistication of the economy since it incorporates all manufactured goods including exported goods.

et al., 2018). Third, in our study, we test some theoretical channels through which trade facilitation can affect export sophistication namely the intermediates imports and the foreign direct investment channels.⁷

The analysis uses four comprehensive trade facilitation indicators (physical infrastructure, ICT, business environment, border efficiency). Our results show that trade facilitation indicators affect positively and significantly export sophistication in SSA. TF induces greater export sophistication in countries that attract foreign direct investment flows, the greater the level of FDI, the higher is the magnitude of the positive effect of trade facilitation on export sophistication. Trade facilitation always exerts a positive effect on export sophistication, but the magnitude of this positive effect decreases as countries experience higher intermediates imports.

The remainder of the study is organized as follows. Section 2 provides a literature review on the subject matter. Section 3 is devoted to data and stylized facts. Section 4 presents the econometric approach used in the study, and Section 5 analyzes and discusses the results. Section 6 concludes with some policy implications.

2- Related literature review

While trade facilitation directly affects trade flows, the channel through which it affects export sophistication remains ambiguous. Therefore, researchers have conducted extensive research on the link between trade facilitation and export sophistication in order to find the theoretical mechanism linking both of them (Bas and Strauss-Kahn, 2015; Hu, 2020). According to these authors, there are two potential channels for the impact of trade facilitation on export sophistication, one is intermediate goods imported from developed countries, and the other is foreign direct investment (Hu, 2020). For the intermediate goods imported from developed countries, trade facilitation can lead to the "technology spillover" effect of imported intermediates, improve trade efficiency, make it easier for exporting firms to obtain many imported advanced technology intermediates, and help them accelerate their R&D and innovation capabilities. According to Blalock and Veloso, (2007), when enterprises have technical "bottlenecks" in product quality improvement, high-quality imports are an effective way to promote product quality improvement. In the same vein, facilitating trade can also generate "learning" and "sharing" effects by combining the externalities of industrial agglomeration, then making the "spillover" effect an essential mechanism for export sophistication (Duranton and Puga, 2004). Ultimately, export sophistication will increase, and the structure of trade will shift from "quantity orientation to quality orientation. Bas and Strauss-Kahn (2015) have examined the effect of import trade facilitation on the prices of imported inputs and export products, and observed that TF measures will reduce the cost of high-quality intermediate products imported from developed countries, and import equipment for domestic exports. Intermediate products will promote quality improvement.

Concerning the foreign direct investment channel, TF reduces transaction costs, import and export times as well as improving the access of advanced foreign products to

⁷ See the discussions on both channels in the next section.

the domestic market, and increases the level of competition in the domestic market. Consequently, trade facilitation leads to the elimination of low-productivity firms for the benefit of high-productivity firms, which will at the end increase the productivity of the country as a whole (Baumol and Lee, 1991) cited by Hu et al. (2022). Also, FDI uses the learning-by-doing effect produced by the implementation of trade facilitation, which can shorten the negotiation time between export enterprises and foreign partners. This can reduce investment costs, and improve local business models for enterprises located in export regions; fully utilizes the comparative advantages of related industries and absorb advanced technologies from FDI, thereby increasing the productivity and sophistication level of exports. Dunning (2000) confirms this theoretical prediction. For this author, foreign producers could bring their own technology and know-how to produce sophisticated goods that the host country could not produce due to inadequate labor, capital, and technology. The quality of the goods produced will be impacted directly. FDI could also promote export sophistication by taking advantage of knowledge spillovers from foreign firms to locals (Leshner and Miroudot, 2008). According to Hausmann and Rodrik (2003), this indirect effect, that causes the surge in efficiency and productivity, is called “cost discovery”. In the same vein, for Gnangnon (2021), FDI inflows positively influence economic complexity since they are fundamental for the acquisition and transfer of knowledge⁸. Trade facilitation can reduce the fixed costs of firms engaged in trade activities and lower the productivity threshold that meets export standards, thereby promoting export diversification and export sophistication (Hu, 2020).

Few studies have also highlighted the role of trade facilitation on export sophistication. (Felipe, 2012; Weldemicael, 2012; Spence and Karingi, 2014; Chakraborty and Mukherjee, 2016; Nguyen, 2016; Lapatinas, 2019; Atasoy, 2021; Hu, 2020; Hu et al., 2022). For example, Lapatinas (2019) has studied the effect of the internet on economic sophistication. The author has found a positive effect of the internet on economic sophistication measured by the economic complexity index. The results of Atasoy (2021) confirm those of (Lapatinas, 2019). Indeed, in his study on the role of digitalization captured by the use of ICT in export sophistication in 61 countries including 33 emerging countries and 28 developed countries during the period 1995-2017, Atasoy (2021) has found that exports become more sophisticated as digitization progresses. In another dynamic, Hu (2020) has examined the impact of trade facilitation and R&D innovation on the sophistication of manufacturing exports of Russia and Central and Eastern European countries over the period 2003-2017. The author has found that trade facilitation and R&D innovation contributed significantly to export sophistication of Russia and Central and Eastern European countries, especially manufacturing after the 2009 financial crisis. For Central European countries and EU member states, the impact of trade facilitation and R&D innovation on export sophistication is significantly higher than for Eastern European countries and non-EU states. The study of Hu et al. (2022) confirms the finding in European countries. In fact, Hu et al. (2022) have examined the impact of trade facilitation on

⁸ See empirical study for more details about the relationship between FDI and export sophistication (Spatafora et al. 2012; Zhu and Fu, 2013; Cabral and Veiga, 2010).

the export technological sophistication of the European transition economies from 2004 to 2020. With doing business data, they found that trade facilitation significantly impacts the export technological sophistication of transition economies in general.

In the case of Africa, using the 'EXPY' index, [Spence and Karingi \(2014\)](#) have observed that in Sub-Saharan Africa, physical infrastructure and border and transport efficiency promote export sophistication. Analyzing the effect of TF on export sophistication, they found that a 1% improvement in physical infrastructure increases export sophistication by 0.69%, while a 1% improvement in border efficiency increases export sophistication by 0.29%.

Finally, there is a literature also on aid for trade and export sophistication ([Gnangnon 2021](#); [Luu Hai; 2021](#)). Indeed, aid for trade flows for economic infrastructure for example which can be associated with the hard aspect of TF could reduce trade costs and hence, promote the export of complex products. For these authors, developing roads and port infrastructure reduces trade costs and improves trading firms' competitiveness, as well as incentivizes them to invest in R&D that is aimed at identifying new export and complex products. Additionally, an improvement in people's access to ICT tools reduces costs and supports knowledge and innovation improvement.

Summing up, from the existing literature, most of the above studies linking trade facilitation with export sophistication have focused on some selected countries and other regions in the world. Studies on Africa are scarce, (e.g., [Spence and Karingi; 2014](#)). However, [Spence and Karingi \(2014\)](#) have used the EXPY index which has some shortcomings. Our study aims to fill these gaps.

In light of the foregoing, we hypothesize that as FDI inflows are essential for export sophistication, countries that attract more FDI are likely also those that export sophistication products. Therefore, we expect greater FDI to be associated with greater export sophistication. Overall, trade facilitation will likely lead to export sophistication in countries that attract more FDI (theoretical channel 1). Also, countries that import intermediates products are likely also those that export sophisticated products. We expect trade facilitation to result in greater export sophistication in countries that import intermediates products (theoretical channel 2).

3- Data and stylized facts

In this section, we present the data and analyze the facts between TF and export sophistication.

3-1 Data

The export sophistication effects of trade facilitation reform are analyzed using international institutions' databases. The study focuses on 22 Sub-Saharan African countries and covers the period 2004-2017. The sample and period are justified by the availability of data on trade facilitation⁹ and those on the Economic Complexity Index.

⁹ Many studies using trade facilitation variables have encountered this challenge (see for example [Portugal-Perez and Wilson \(2012\)](#); [Sakyi et al. \(2018\)](#)).

The definition of variables is provided in appendix 3.

Export sophistication: It is our dependent variable and captures the level of sophistication of an economy. To measure the export sophistication, authors use various indexes (for example the product classification of Lall et al. (2006), the EXPY index of Hausmann et al. (2007), etc.). The EXPY measure of Hausmann et al. (2007) aims to capture the level of productivity associated with a country's exports. However, this measure of export sophistication has been criticized because its computed using the income level of countries (Hidalgo and Hausmann, 2009; Andreoni, 2011). For Hidalgo and Hausmann (2009), it mechanically raises a problem of circularity, according to which "rich countries export products from rich countries". To address this shortcoming of the EXPY measure of export sophistication, another variable used in the literature is the Economic Complexity Index (ECI) from the Atlas of Economic Complexity of Harvard University. First introduced by Hausmann et al. (2014), ECI is a holistic measure of knowledge accumulation and sophistication in an economy. The ECI measures the sophistication of a country's productive structure by combining information on both the diversity of a country (the number of products it exports) and the ubiquity of its products (the number of countries that export these products) (Hidalgo and Hausmann, 2009). The idea behind ECI is that sophisticated economies are diverse and export products that, on average have low ubiquity because only a few different countries can produce these sophisticated products. Similarly, less sophisticated economies are expected to produce a few ubiquitous products (exported by several countries). ECI exploits this variation in a country's product diversity and ubiquity to create a measure of the country's productive structure that incorporates information on product sophistication (Hartmann et al., 2017). In view of its holistic nature, we use the ECI in this study. ECI takes higher values when the economy becomes more sophisticated¹⁰. In 2017 for example, Japan leads the index with an ECI score of 2.18 and South Sudan is the worst performer with its ECI score of -2.14¹¹.

Trade facilitation: This is our variable of interest. It should be noted that the literature has proposed various indicators that make it possible to understand trade facilitation reforms. These measures bring together different elements that determine the extent to which the environment is conducive to economic and business performance (Wilson et al. 2003; Francois and Manchin, 2013; Portugal-Perez and Wilson, 2012 etc.). The four indicators used in this study are categorized in two groups (hard and soft infrastructure¹²) including:

- i) *Physical infrastructure* which measures the level of development and quality of roads, ports, airports, and rail infrastructure. It is made up of four sub-indicators: quality of the road network infrastructure, quality of the railway infrastructure, quality of the port infrastructure, and quality of the air transport infrastructure (airport connectivity).

¹⁰ Note that, ECI is consistent with the existence of income differentials between countries (Minondo and Requena-Silvente, 2013).

¹¹ <https://oec.world/en/rankings/eci/hs6/hs96?tab=rank>, consulted on 14/09/2022.

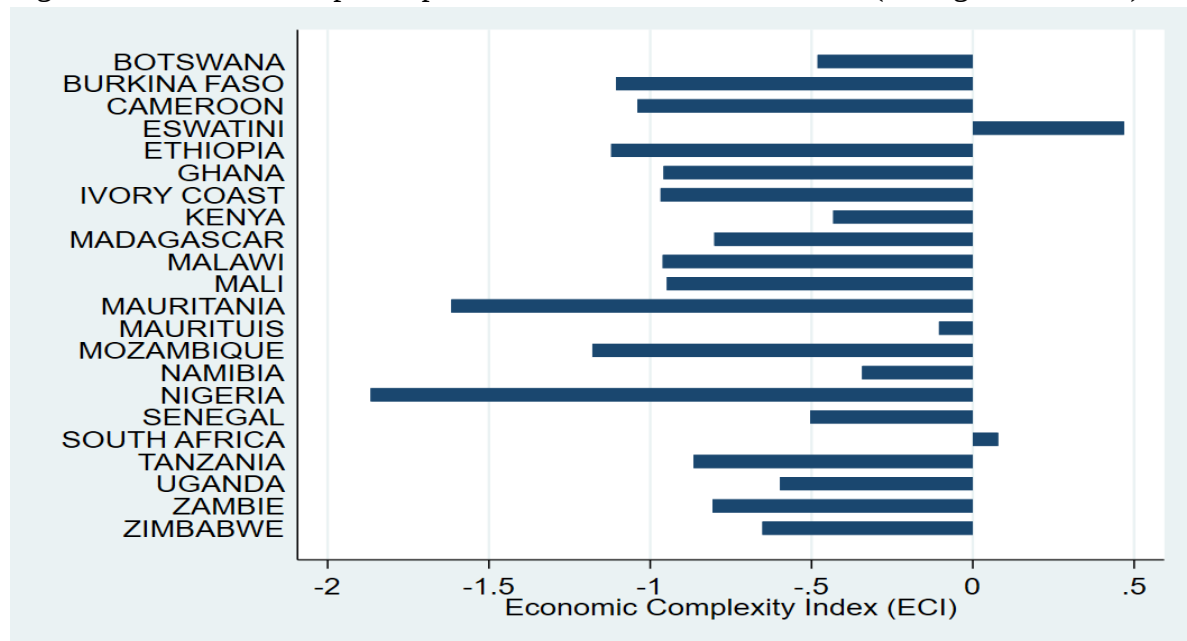
¹² See Portugal and Wilson (2012) for details.

- ii) *Information and Communication Technology* is interpreted as the extent to which an economy uses ICT to improve efficiency and productivity, as well as to reduce transaction costs. It contains indicators on the availability, use, absorption, and priority given by the government to ICT;
- iii) *Business and regulatory environment* measures the level of development of regulations and transparency. It is based on indicators of irregular payments, government transparency, and anti-corruption measures;
- iv) *Border and transport efficiency* aims to quantify the level of customs and inland transport efficiency which is reflected in the time, cost, and the number of documents required for export and import procedures.¹³

Following previous studies, we use GDP/per capita, human capital, FDI, intermediates imports, financial development, the average tariff, and natural resources as other explanatory variables¹⁴.

3-2 Stylized facts

Figure 1: Evolution of export sophistication in Sub-Saharan Africa (average 2004-2017)



Source: Authors based on the Atlas of Economics Complexity data.

Figure 1 above shows the evolution of export sophistication for SSA countries during the period 2004-2017. The analysis in this figure shows that most countries in SSA (90% of the sample) have negative ECI indexes (ranging between -2 and 0). This reflects the fact that most SSA countries in the sample export less sophisticated goods. Among those countries, Nigeria, Mauritania, Mozambique, Ethiopia, Burkina Faso, and Cameroon are the worst performer with scores ranging between -2 and -1. The two countries that perform relatively well with positive ECI index among SSA countries are Eswatini (0.468) and South Africa (0.078). These two countries seem to export relatively sophisticated goods compared with

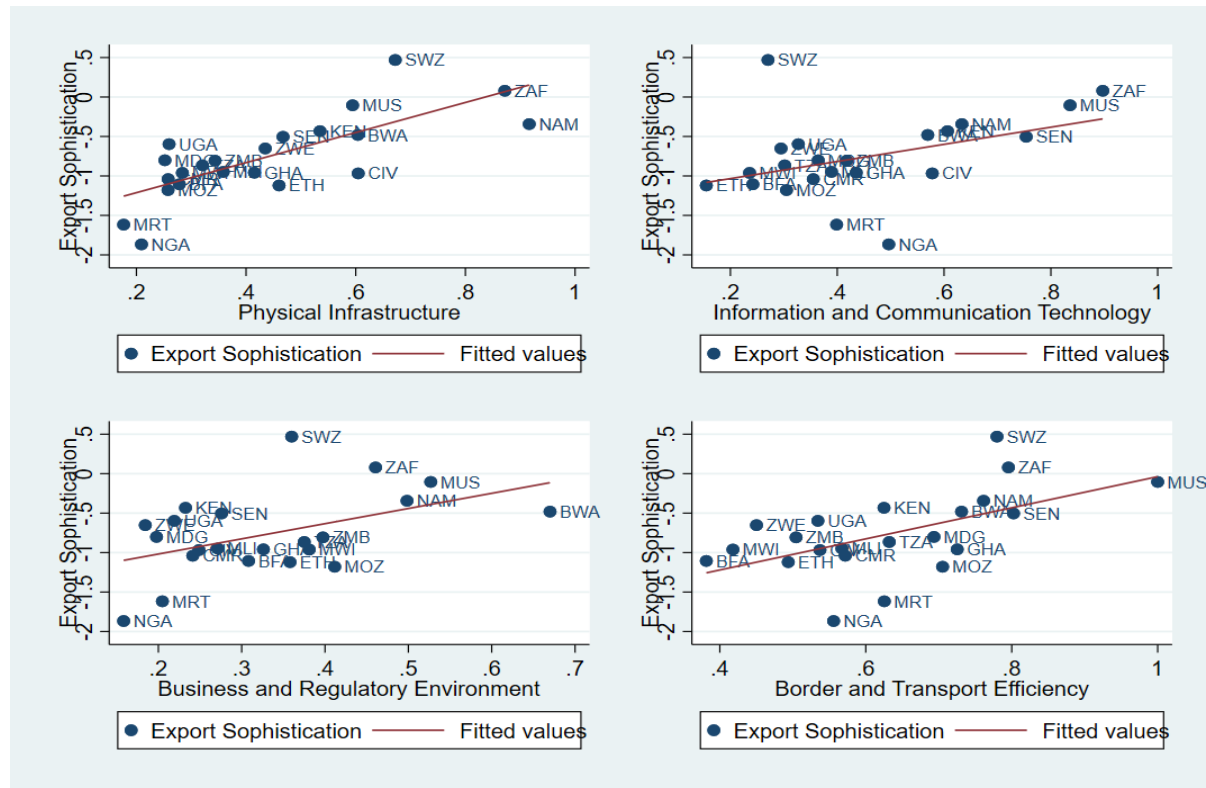
¹³ See details about the four TF indicators in appendix 2.

¹⁴ See the discussion on their expected effects in the empirical specification sub section.

other SSA countries in the sample. It should be noted that, over the period, the values of ECI range between -2.424 and 1.220, while the average ECI index of the SSA zone over the study period is (-0.764) (see appendix 2).

Figure 2 analyzes the correlation between the four trade facilitation indicators and export sophistication. It can be observed that there is a positive and statistically significant correlation between trade facilitation indicators and export sophistication, which suggests that they are moving positively in the same direction. This is confirmed by the positive and statistically significant correlation between trade facilitation indicators and export sophistication at the 1% level (see the correlation coefficients in appendix 1). There is a disparity between countries. Indeed, countries with a high trade facilitation score, seem to favor export sophistication in SSA and vice versa. For example, countries (Eswatini and South Africa) with a high physical infrastructure score have a high index of export sophistication. Conversely, countries such as Mauritania and Nigeria have low average physical infrastructure scores and negative average export complexity indices close to -2 (low complexity goods). Thus, it can be said that an improvement in physical infrastructure contributes to the improvement in export sophistication. Also, having efficient borders with simplified procedures in terms of time and documents for export/import operations seems to favor export sophistication in SSA countries because countries like Mauritius, Eswatini, Namibia, Botswana, and South Africa, which have efficient borders, have also a relatively high economic complexity index.

Figure 2: Correlation between trade facilitation and export sophistication (average 2004-2017)



Source: Authors based on WEF data and Atlas of Economics Complexity data.

4- Econometric approach

In this section, we present the empirical specification (4-1); next, we present the estimation technique (4-2).

4-1 Empirical specification

To study the effects of trade facilitation on export sophistication, we focus on the Economic Complexity Index (ECI) as the main measure of export sophistication but repeat the analysis using the EXPY measure of Hausmann et al. (2007) for the robustness checks. We follow Lapatinas (2019); Atasoy (2021) and Luu Hai (2021), and estimate the baseline Equation (1) below:

$$ECI_{it} = \beta_1 GDPpc_{it} + \beta_2 Edu_{it} + \beta_3 FDI_{it} + \beta_4 IntM_{it} + \beta_5 FinDev_{it} + \beta_6 Inst_{it} + \beta_7 Tariff_{it} + \beta_8 NatRes_{it} + \beta_9 TFI_{it} + \eta_t + \mu_i + \varepsilon_{it} \quad (1)$$

Where ECI_{it} represents the Economic Complexity Index, which measures the sophistication of exports of country i at period t . It is computed using the methodology described in Hidalgo and Hausmann (2009). We include in the model a set of control variables that are deemed to influence export sophistication. These variables include GDP per capita (denoted $GDPpc$); the level of education (denoted Edu), the net foreign direct investment inflows (denoted "FDI"); the intermediates imports (denoted "IntM"); the financial development (denoted "FinDev"), the institutional quality (denoted "Inst"); the tariff applied (denoted "Tariff"), the natural resources dependence (denoted "NatRes"); TFI ; represents the vector of trade facilitation indicators (physical infrastructure, ICT, trade and regulatory environment, border efficiency); η_t are the time-fixed effects; μ_i is a vector representing country fixed effects; ε_{it} is the error term.

GDP per capita: It is a determinant of export sophistication suggested in the literature. According to the supply and demand theories, when GDP per capita increases, consumption preferences change (Aghion and Howitt, 1990; Fiorillo, 2001). The potential risks of diversification decrease with increasing income, and export diversification increases with increasing GDP per capita (Imbs and Wacziarg, 2003). By construction, the measurement of export sophistication is strongly correlated with the income level of exporting countries. We, therefore, expect a positive effect of per capita GDP on export sophistication.

Foreign direct investment: it is captured by the ratio of net foreign direct investment inflows to GDP, and measures knowledge and technology spillovers. By facilitating the transfer of knowledge, technology, and managerial skills, FDI can promote the production and export of more complex goods by destination countries (Hausmann, 2016).

Intermediates imports: It includes all parts and accessories, as well as industrial primary and processed intermediate products. We retain the narrow definition of intermediates imports adopted by the WTO¹⁵, which includes the HS subheadings corresponding to codes 42, 53, 111, 121, 21, and 22 of the Broad Economic Categories (BEC) classification. Since the import of intermediate products can contribute to production, we, expect that it would promote exports of goods, including sophisticated ones.

¹⁵ See the WTO report 2015 titled: International Trade Statistics 2015; www.wto.org/statistics.

Human capital: It refers to all the capacities learned by individuals which increase their productive efficiency. Education level is generally positively associated with productivity and export sophistication in the literature ([Hidalgo and Hausmann, 2009](#); [Faruq, 2011](#)). Indeed, investment in education and health improves the quality of the labor force, increases productivity, and thus promotes export sophistication. In this study, we use the enrollment rate as a human capital index and expect a positive effect.

Quality of institutions: The literature recognizes institutional factors as one of the most important determinants of export sophistication. Among the set of quality of institutions indicators reported by [Kaufmann et al. \(2010\)](#), we choose the control of corruption indicator as a proxy for the quality of institutions. Indeed, reducing corruption within a government can reduce uncertainty and increase producers' incentives to invest and innovate; which improves export diversification and sophistication. It should be noted that corruption within the bureaucracy in countries hinders their trade. We expect it to affect positively export sophistication.

Access to credit: Access to credit is an important component of financial development that facilitates technological innovations through its intermediary role. The literature postulates that as firms' access to credit improves, their chances of diversifying and upgrading their exports increase. Thus, there is a positive correlation between financial development and the sophistication of economies ([Fang et al. 2015](#); [Saadi, 2020](#)). The ratio of private sector credit to GDP, which refers to the financial resources provided to the private sector by financial firms, is used in this study.

The average applied tariff: this is the average of the tariff rates actually applied, weighted by the import shares of products corresponding to each partner country. It is a proxy for trade policy and higher tariffs are likely associated with low levels of export sophistication.

Natural resources: The existence of natural resources in a country is often seen as a constraint on a country's export diversification and sophistication. A country's production and export of natural resources benefit relatively little from innovation and productivity gains, so an economy highly specialized in these sectors would generally experience only fairly slow productivity improvements and consequently very slow diversification and sophistication processes. It is also argued that the effect of natural resources on export sophistication could depend on whether countries rely on these resources or not ([Gnangnon, 2021](#)). Total natural resource rents as a percentage of GDP is used as a proxy for natural resources dependence in this study like [Luu Hai \(2021\)](#).

4-2 Estimation technique

To examine the contribution of trade facilitation to export sophistication, it is important to choose an estimation strategy that addresses challenges due to the heterogeneity of African countries: cross-sectional dependence, heteroscedasticity, and serial correlation. It is argued that these challenges are an important problem in panel data, and ignoring them in the estimation may provide invalid test statistics. For example, in the modern economy, cross-sectional dependence cannot be denied

due to higher economic, financial, and trade integration. For [Khan et al. \(2020\)](#), it cannot be ignored also in the backdrop of shared global shocks and shared global spillover impacts among countries. We first estimate the equation (1) with Ordinary Least Squares (OLS), and we take into account these issues raised above by using the country-year cluster in the regression¹⁶.

It is possible also that model 1 could suffer from the reverse causality between export sophistication and trade facilitation indicators. Reverse causality bias can occur when better infrastructure (hard and soft) influences export at an extensive margin including the export of sophisticated products, the return gained from exports can also be used to invest in hard and soft infrastructure development. In addition, the inclusion of institutional and economic variables in the same equation raises a reverse causality ([Faruq, 2011](#)). In other words, institutions may affect economic outcomes including export sophistication, while economic outcomes may also affect the quality of institutions. Also, export sophistication is not measured by certainties, which could rise a measurement bias.

To address the endogeneity issues mentioned above, we employ an instrumental variable estimation: a Two-Stage Least Square (2SLS) following [Banerjee et al. \(2022\)](#) who have employed lag one and lag two as instruments and derived the predicted values. Thus, equation (1) can be specified as:

$$ECI_{it} = \beta_1 X_{it-1} + \beta_2 T\hat{F}I_{it} + \eta_t + \mu_i + \varepsilon_{it} \quad (2)$$

$$T\hat{F}I_{it} = \beta_1 X_{it-1} + \beta_2 TFI_{it-1} + \eta_t + \mu_i + \varepsilon_{it} \quad (3)$$

$$T\hat{F}I_{it} = \beta_1 X_{it-1} + \beta_2 TFI_{it-2} + \eta_t + \mu_i + \varepsilon_{it} \quad (4)$$

Where TFI_{it-1} is the one-period lagged value and TFI_{it-2} is the two-period lagged value of TFI in country i and at time t . X_{it-1} are lag-one period of our control variables in order to minimize their potential endogeneity except for variable natural resources that is exogenous. The rest of other variables remain the same as in Equation (1). Equations (3) and (4) are the first stage equations where we isolate the effect of trade facilitation. In the second stage, the fitted values of trade facilitation ($T\hat{F}I_{it}$) derived from Equations (3) and (4) are inserted into Equation (2) to address the endogeneity issue between export sophistication and trade facilitation.

¹⁶ The two-way clusters correct the potential presence of heteroscedasticity and autocorrelation. The diagnostics tests in appendix 4 confirm their presence.

5- Results

This section first presents and interprets the results of our estimations and then performs robustness checks of the findings.

5-1 Presentation and interpretation of results

The results of the effect of trade facilitation reform on export sophistication with OLS and 2SLS are presented in Table 1 and Table 2 respectively. It should be noted that our preferred estimator is two-stage least square. The diagnostic tests that allow for the checking of the consistency of the two-stage least square approach are reported at the bottom of Table 2. First, we note the rejection of the null hypothesis of under-identification since the p-values of Kleibergen and Paap, (2006) are zero for all specifications. Our model is therefore correctly identified. Second, when we compare the Cragg-Donald Wald F statistics values to the critical values of Stock and Yogo, (2005) to determine instrumental variable bias and size bias, we reject the weak instrument null hypothesis since the values of the statistics are greater than the critical values of Stock and Yogo, (2005). The Hansen's p-values also are greater than 10% for all specifications. Based on the above, the two-stage least square estimator is appropriate for conducting the empirical analysis.

Our variables of interest have the expected sign according to economic theory, with varying statistical significances. The trade facilitation index (average) and three out of the four trade facilitation indicators affect positively and significantly export sophistication in SSA. The coefficient of the trade facilitation index is positive and statistically significant at 5% level. Its coefficient is 1.30 (column 1) implying that, a 1 % improvement in the average trade facilitation index is roughly associated with a 1.30-point increase in the export sophistication in SSA. For the specific TF indicators, we note that physical infrastructure positively affects export sophistication in SSA at 1% threshold. Its coefficient is positive and significant and indicates that all else being equal, a 1% improvement in the quality of road, rail, airport, and port infrastructures leads to a 1.14-point increase in the export of sophisticated or complex goods. Indeed, this result suggests that having better physical infrastructure reduces the transport costs associated with inputs, and increases productivity and the production of quality goods, thus encouraging firms to export more sophisticated products. This result is consistent with the finding in the literature ([Spence and Karingi, 2014](#)). These authors found in their work that physical infrastructure positively and significantly affects export sophistication in SSA. The information and communication technology plays an important role on export sophistication in SSA. The coefficient of ICT is positive and statistically significant at the 5% level and reveals that an increase in the availability of technology and its utilization in the production process of 1 % is associated with an increase in export complexity in SSA by 0.73-point, all other things being equal. The use of ICT enables innovation, which favors the introduction of new, more sophisticated production methods. This result supports those found in the literature that ICT promotes export sophistication ([Rodriguez-Crespo and Martinez-Zarzoso, 2019](#); [Lapatinas, 2019](#); [Atasoy, 2021](#)). The border and transport efficiency indicator is found to be an important factor in explaining exports of sophisticated goods in SSA.

Indeed, it has a positive and statistically significant contribution at the 1% level and indicates that a 1 % reduction in border procedures leads to a 1.21-point increase in exports of sophisticated goods, all else being equal. In other words, simplifying border procedures, i.e., reducing the number of days and the number of export/import documents promotes the export of sophisticated goods. This result is consistent with those found by [Spence and Karingi, \(2014\)](#). The business and regulatory environment affects positively but not significantly the export of sophisticated goods. Among the four trade facilitation indicators, it appears that border and transport efficiency, and physical infrastructure are the ones that show the highest positive and significant effect on export sophistication.

With respect to the control variables, the results support mostly the theory and reveal the crucial role of the credit to the private sector in promoting export sophistication. This variable has the expected sign in all specifications (columns 1-5) and is significant at 1% in all specifications (table 2). Theoretically, granting credit to firms makes it possible to finance not only physical capital but also other factors of production with significant fixed costs. For [Fosu and Abass \(2019\)](#), a firm must have sufficient liquidity through credit to sustain itself until future returns are realized, given that returns from fixed costs are not immediate. Human capital captured by the enrollment rate has the expected sign and is significant at 1% level in all specifications (columns 1-4). The result shows that it contributes positively to export sophistication. This result confirms the economic theory that workers are likely to be more productive when they are more educated and skilled ([Faruq, 2011](#)). As a result, countries with a larger stock of human capital specialize in producing and exporting higher-quality products ([Schott, 2004; Hummels and Klenow; 2005](#)). This finding is consistent with that of [Faruq \(2011\)](#), who found that improving human capital through education is associated with better export sophistication. In contrast, GDP per capita contributes negatively to export sophistication. This result contradicts the economic literature. [Hidalgo and Hausmann \(2009\)](#) have shown in their study that countries tend to converge towards the level of income dictated by the complexity of their productive structures. Control of corruption affects positively and significantly export sophistication at 1% level in columns 3 and 4 (Table 2). Thus, controlling corruption increases the ability of producers to improve the quality of their exports. The natural resources variable for its part is negative and significant at 1% level in all specifications. According to economic theory and as shown in the results, natural resources contribute negatively to export sophistication. This finding is consistent with the finding by [Yue and Zhou \(2018\)](#) that abundant natural resources are good predictors of the comparative disadvantage of goods. The outcomes also reveal that FDI inflows contributes to promoting export sophistication. The coefficient of the related variable is positive in all specifications and significant at 10% level in column 1 and at 5% in column 4. The role of intermediate imports, as well as FDI, will be further explored in the analysis using their interactions terms with TF.

Table 1: Export sophistication effects of trade facilitation reform: OLS Results

VARIABLES	Dependent Variable: Economic Complexity Index (ECI)					
	1	2	3	4	5	6
Log (pc GDP)	-0.191 (0.129)	-0.284* (0.140)	-0.104 (0.106)	-0.289* (0.136)	-0.209*** (0.068)	0.063 (0.120)
Secondary enrollment rate	0.011* (0.006)	0.010* (0.006)	0.013** (0.005)	0.012* (0.006)	0.002 (0.004)	0.009 (0.005)
Foreign Direct Investment	0.010* (0.005)	0.009* (0.005)	0.006 (0.004)	0.006 (0.005)	0.010* (0.005)	0.004 (0.003)
Intermediates import	-0.234 (0.701)	0.097 (0.662)	1.468* (0.827)	0.313 (0.614)	0.516 (0.592)	0.526 (0.657)
Private_sector_credit	0.007*** (0.001)	0.006*** (0.001)	0.003 (0.002)	0.007*** (0.001)	0.006*** (0.001)	0.003* (0.002)
Control_Corruption	0.221* (0.120)	0.096 (0.118)	-0.076 (0.106)	0.212** (0.095)	-0.086 (0.065)	-0.036 (0.122)
Log (Tariff)	0.552 (0.726)	0.212 (0.872)	-0.036 (0.755)	0.047 (0.814)	0.796 (0.671)	-0.280 (0.693)
Natural resources	-0.029*** (0.009)	-0.030*** (0.008)	-0.038*** (0.011)	-0.032*** (0.008)	-0.025*** (0.007)	-0.027** (0.010)
Trade Facilitation Index		1.290*** (0.417)				
Physical Infrastructure			1.337* (0.735)			
Technology (ICT)				0.615*** (0.165)		
Business and Regulatory Environment					0.153 (0.250)	
Border and Transport Efficiency						0.945** (0.427)
Constant	-0.320 (0.682)	-0.361 (0.589)	-2.366*** (0.771)	-0.259 (0.573)	0.630 (0.430)	-2.711** (1.106)
Observations	234	234	234	234	234	234
R-squared	0.800	0.821	0.784	0.821	0.883	0.732
Number of countries	22	22	22	22	22	22

Note: Robust (clustered on country-year) standard errors in parentheses *, **, *** represent significance at 10%, 5% and 1% respectively. Regressions always included country and time dummies.

Source: authors.

Table 2: Export sophistication effect of trade facilitation reform: IV-2SLS Results

VARIABLES	Dependent variable: Economic Complexity Index (ECI)				
	1	2	3	4	5
Log (pc GDP)	-0.341*** (0.071)	-0.072 (0.057)	-0.267*** (0.079)	-0.266*** (0.065)	-0.114* (0.060)
Secondary enrolment rate	0.012*** (0.002)	0.015*** (0.002)	0.010*** (0.002)	0.013*** (0.003)	0.012*** (0.002)
Foreign Direct Investment	0.007* (0.003)	0.004 (0.004)	0.004 (0.004)	0.008** (0.004)	0.005 (0.004)
Intermediates import	-0.098 (0.364)	1.332*** (0.488)	0.291 (0.392)	-0.223 (0.358)	0.513 (0.469)
Private_sector_credit	0.006*** (0.001)	0.003*** (0.001)	0.005*** (0.001)	0.008*** (0.001)	0.004*** (0.001)
Control_Corruption	0.115 (0.072)	-0.093 (0.068)	0.175*** (0.061)	0.225*** (0.076)	0.022 (0.074)
Log (Tariff)	-0.144 (0.591)	0.265 (0.733)	0.506 (0.585)	0.159 (0.599)	0.065 (0.814)
Natural resources	-0.032*** (0.005)	-0.034*** (0.006)	-0.028*** (0.005)	-0.035*** (0.006)	-0.036*** (0.006)
Trade Facilitation Index	1.304** (0.517)				
Physical Infrastructure		1.146*** (0.362)			
Technology (ICT)			0.727** (0.350)		
Business and Regulatory Environment				0.162 (0.275)	
Border and Transport Efficiency					1.214*** (0.402)
Constant	-0.012 (0.461)	-2.535*** (0.450)	-0.230 (0.472)	-0.001 (0.398)	-1.715*** (0.487)
Observations	203	203	203	203	203
R-squared	0.813	0.772	0.833	0.800	0.766
Underidentification test	58.38	37.51	40.60	33.94	61.19
Prob>LM	0.000	0.000	0.000	0.000	0.000
Weak Identification Test (Cragg-Donald Wald F stat)	170.551	229.943	62.122	145.990	190.633
Stock-Yogo weak ID test critical values					
10% maximal IV size	19.93	19.93	19.93	19.93	19.93
15% maximal IV size	11.59	11.59	11.59	11.59	11.59
20% maximal IV size	8.75	8.75	8.75	8.75	8.75
25% maximal IV size	7.25	7.25	7.25	7.25	7.25
Hansen_stat (overidentification test)	1.987	2.540	0.992	0.479	0.585
Hansen P_value	0.159	0.111	0.319	0.489	0.444

Note: Robust standard errors in parentheses *, **, *** represent significance at 10%, 5% and 1% respectively.

Regressions always included country and time dummies.

Source: authors.

Turning now to the results in Table 3, we have found across columns 1 that the overall trade facilitation index exerts a positive and significant effect on export sophistication, while the interaction term (associated with the variable capturing the interaction between the overall trade facilitation variable and FDI) is positive and significant at 5%. The positive effect suggests that the overall trade facilitation index induces greater export sophistication in countries that attract foreign direct investment.

Among the four trade facilitation indicators, the ICT indicator has a positive and significant effect on export sophistication at 5% level, while the interaction term between this variable and FDI is also positive and significant at 5% level. Taking together, these two outcomes suggest that ICT induces greater export sophistication in countries that attract FDI. In addition, the greater the level of FDI, the higher is the magnitude of the positive effect of ICT on export sophistication. Similarly, the positive effect of ICT on export sophistication rises as the degree of FDI increases.

Also, the border efficiency indicator has a positive and significant effect on export sophistication at 5% level while the interaction term between this variable and FDI is positive and significant at 10% level. These two outcomes reveals that the reduction of trade cost by simplifying trade procedures induces greater export sophistication in countries that attract FDI.

Results in table 4 show the interaction terms between trade facilitation and the intermediates imports. Column (1) in Table 4 shows that the interaction term associated with the overall trade facilitation index and the intermediates imports (TF*IM) is negative and significant at 10% level, while the coefficient of the overall trade facilitation is positive and significant at 10% level. These results suggest that over the full sample, there may be a level of the intermediates imports above which the effect of the overall trade facilitation changes sign and becomes negative. This level of the intermediate import is 1.820 [= exponential (3.475/5.802)], which is far higher than the maximum value (0.664, see appendix 2) of the intermediate's imports in the full sample. Thus, on average, over the full sample, the overall trade facilitation always exerts a positive effect on export sophistication, but the magnitude of this positive effect decreases as countries experience higher intermediates imports. This result is confirmed when looking at the different trade facilitation indicators, which are positive and significant, while the interactions terms associated with them are negative and significant. In fact, physical infrastructure, border efficiency indicators affect positively export sophistication at 5% and ICT is significant at 1%, while the interactions terms affect negatively the export sophistication at 5% for physical infrastructure and ICT. The level of the intermediate's imports above which the effect of the trade facilitation indicators changes sign and becomes negative is 1.845 [= exponential (2.175/3.552)] for physical infrastructure and 2.237 [=exponential (2.321 / 2.883)] for ICT. With the above, we can say that, trade facilitation exerts greater effect on export sophistication through intermediates imports at a certain level. Thus, we can conclude that both variables are complementary over the full sample.

Table 3: Estimation results: Interaction between Trade facilitation and FDI

VARIABLES	Dependent variable: Economic Complexity Index (ECI)				
	1	2	3	4	5
Log (pc GDP)	-0.179*** (0.051)	-0.094 (0.066)	-0.466*** (0.093)	-0.266*** (0.065)	-0.164** (0.070)
Secondary enrollment rate	0.003** (0.001)	0.016*** (0.002)	0.013*** (0.003)	0.012*** (0.003)	0.018*** (0.003)
Foreign Direct Investment (FDI)	-0.054** (0.025)	0.006 (0.006)	-0.002 (0.006)	0.005 (0.005)	-0.006 (0.007)
Intermediates import	0.206 (0.349)	1.090** (0.535)	-0.219 (0.430)	-0.306 (0.353)	-0.714 (0.442)
Private_sector_credit	0.006*** (0.001)	0.003*** (0.001)	0.009*** (0.001)	0.008*** (0.001)	0.004*** (0.001)
Control_Corruption	0.074 (0.063)	-0.042 (0.080)	0.159** (0.067)	0.214*** (0.078)	0.159* (0.083)
Log (Tariff)	0.816 (0.567)	0.212 (0.746)	0.773 (0.566)	0.110 (0.595)	-0.236 (0.819)
Natural resources	-0.040*** (0.004)	-0.034*** (0.006)	-0.030*** (0.005)	-0.035*** (0.006)	-0.037*** (0.007)
Trade Facilitation Index (TF)	0.902* (0.522)				
Physical Infrastructure (PI)		1.070*** (0.370)			
Technology (ICT)			0.530** (0.249)		
Business and Regulatory Environment (RE)				0.128 (0.277)	
Border and Transport Efficiency (BE)					0.736** (0.327)
TF*FDI	0.129** (0.065)				
PI*FDI		0.005 (0.029)			
ICT*FDI			0.036** (0.017)		
RE*FDI				0.025 (0.021)	
BE*FDI					0.019* (0.011)
Constant	-0.250 (0.387)	-2.559*** (0.582)	1.091* (0.642)	0.083 (0.389)	-1.140* (0.590)
Observations	203	203	203	203	203
R-squared	0.759	0.779	0.808	0.802	0.688
Underidentification test	49.58	35.75	39.15	29.89	65.93
Prob>LM	0.000	0.000	0.000	0.000	0.000
Weak Identification Test (Cragg-Donald Wald F stat)	165.401	207.722	89.968	145.032	265.302
Hansen_stat (overidentification test)	0.391	2.500	0.104	0.0462	0.0506
Hansen P_value	0.532	0.114	0.747	0.830	0.822

Note: Robust standard errors in parentheses *, **, *** represent significance at 10%, 5% and 1% respectively.

Regressions always included country and time dummies.

Source: authors.

Table 4: Estimation results with the interaction term between Trade facilitation and Intermediates imports

VARIABLES	Dependent variable: Economic Complexity Index (ECI)				
	1	2	3	4	5
Log (pc GDP)	0.057 (0.075)	-0.179*** (0.053)	-0.286*** (0.085)	0.041 (0.063)	-0.166** (0.068)
Secondary enrollment rate	0.012*** (0.002)	0.011*** (0.003)	0.014*** (0.003)	0.015*** (0.003)	0.018*** (0.003)
Foreign Direct Investment	0.003 (0.004)	-0.005 (0.004)	-0.002 (0.005)	-0.000 (0.004)	0.002 (0.004)
Intermediates import (IM)	3.974** (1.841)	1.142* (0.691)	1.387** (0.620)	-0.115 (0.637)	0.057 (0.640)
Private_sector_credit	0.003* (0.002)	0.005*** (0.002)	-0.000 (0.004)	0.004*** (0.001)	0.004*** (0.001)
Control_Corruption	-0.146* (0.083)	0.233*** (0.059)	0.176** (0.078)	0.118 (0.113)	0.161* (0.085)
Log (Tariff)	-0.455 (0.799)	0.644 (0.639)	0.961 (0.634)	-0.165 (0.873)	-0.207 (0.835)
Natural resources	-0.039*** (0.005)	-0.039*** (0.005)	-0.035*** (0.005)	-0.031*** (0.006)	-0.034*** (0.006)
Trade Facilitation Index (TF)	3.475* (2.076)				
Physical Infrastructure (PI)		2.175** (0.937)			
Technology (ICT)			2.321*** (0.777)		
Business and Regulatory Environment (RE)				-1.104 (0.981)	
Border and Transport Efficiency (BE)					1.452** (0.649)
TF*IM	-5.802* (3.489)				
P*IM		-3.552** (1.807)			
ICT*IM			-2.883** (1.458)		
RE*IM				1.540 (1.831)	
BE*IM					-1.381 (1.008)
Constant	-4.181*** (1.043)	-1.118* (0.600)	-1.131* (0.670)	-1.965*** (0.617)	-1.588** (0.784)
Observations	203	201	201	201	201
R-squared	0.745	0.768	0.791	0.759	0.698
Underidentification test	17.23	28.85	31.57	26.79	39.36
Prob>LM	0.000	0.000	0.000	0.000	0.000
Weak Identification Test (Cragg-Donald Wald F stat)	12.016	45.147	28.186	27.551	89.205
Hansen_stat (overidentification test)	0.0893	1.809	0.175	0.901	0.0130
Hansen P_value	0.765	0.179	0.675	0.343	0.909

Note: Robust (clustered on country-year) standard errors in parentheses *, **, *** represent significance at 10%, 5% and 1% respectively. Regressions always included country and time dummies.

Source: authors.

5-2 Robustness of the results

We run several robustness tests to gain additional insights into the effects of trade facilitation reform on export sophistication. To do so, we test the robustness by using an alternative measure of export sophistication as well as an alternative estimation method.

5-2-1 Alternative measure of export sophistication

We use the export sophistication (EXPY index) measure of [Hausmann et al. \(2007\)](#) in place of the economic complexity index. All other variables remain the same.

The estimation results are presented in table 5. We can see that with the alternative measure of export sophistication, the average trade facilitation index and two out of four trade facilitation indicators positively and significantly affect export sophistication. Indeed, ICT, border, and transport efficiency contribute positively and significantly to the export of sophisticated goods. Although physical infrastructure as well as the business environment affects positively export sophistication, their coefficients are not significant. Compared with the results in table 2, the coefficients of TF indicators are small in table 5. This can probably be explained by the fact that the ECI index takes into account the differential in income level and give real results than 'EXPY'. Regarding the control variables, gross domestic product per capita positively and significantly affects export sophistication (column 1; 2; 3; 4; 5). This is understandable since 'EXPY' is computed by the income level of countries, and it's in line with [\(Hidalgo and Hausmann, 2009\)](#). The results of other control variables are similar to the results in table 2 with differences in some cases.

Table 5: Export sophistication effects of trade facilitation reform: Alternative measure

VARIABLES	Dependent Variable: log (EXPY)				
	1	2	3	4	5
Log (pc GDP)	0.094** (0.039)	0.157*** (0.054)	0.085*** (0.030)	0.130*** (0.033)	0.080** (0.040)
Secondary enrollment rate	-0.001 (0.002)	0.007*** (0.001)	0.001 (0.002)	-0.000 (0.002)	0.005*** (0.001)
Foreign Direct Investment	0.004* (0.002)	-0.006* (0.004)	-0.006* (0.003)	0.004** (0.002)	-0.006* (0.004)
Intermediates import	-0.876*** (0.238)	-0.140 (0.252)	-0.803*** (0.195)	-0.953*** (0.268)	-0.258 (0.229)
Private_sector_credit	0.000 (0.000)	0.001 (0.001)	0.001*** (0.000)	0.001** (0.000)	0.001* (0.000)
Control_Corruption	-0.060* (0.035)	0.003 (0.036)	0.055** (0.026)	-0.019 (0.064)	0.023 (0.035)
Log (Tariff)	-0.255 (0.389)	0.151 (0.473)	0.114 (0.346)	-0.154 (0.386)	0.048 (0.418)
Natural resources	0.015*** (0.002)	0.004 (0.003)	0.008*** (0.002)	0.014*** (0.002)	0.003 (0.003)
Trade Facilitation Index (TF)	0.608** (0.257)				
Physical Infrastructure		0.121 (0.237)			
Technology (ICT)			0.206** (0.098)		
Business and Regulatory Environment				0.084 (0.313)	
Border and Transport Efficiency					0.614*** (0.178)
Constant	8.725*** (0.266)	7.413*** (0.375)	8.824*** (0.209)	8.653*** (0.291)	7.986*** (0.312)
Observations	203	203	203	203	203
R-squared	0.810	0.796	0.874	0.811	0.807
Underidentification test	50.69	26.25	41.04	33.57	61.19
Prob>LM	0.000	0.000	0.000	0.000	0.000
Weak Identification Test (Cragg-Donald Wald F stat)	165.277	181.817	182.747	142.787	190.633
Hansen_stat (overidentification test)	0.740	1.130	0.170	0.700	1.089
Hansen P_value	0.390	0.288	0.680	0.403	0.297

Note: Robust standard errors in parentheses *, **, *** represent significance at 10%, 5% and 1% respectively.

Regressions always included country and time dummies.

Source: authors.

5-2-2 Alternative estimation method

Our third robustness test is performed using an alternative estimation method. There is a concern with the OLS as well as 2SLS estimations. First, and foremost, it is possible that export sophistication is persistent, which is addressed by including his lagged variable in model 1.

Thus, to take into account the dynamic aspect of the model, we employ the system-Generalized Method of Moment (GMM) ([Blundell and Bond, 1988](#)). We check the relevancy conditions of this estimator with diagnostic tests (Arellano-Bond (AB) test and the Hansen test).

The regression results with the system GMM estimator are globally valid. Our results with the system GMM estimator presented in table 6 satisfy the conditions for the use of GMMs, particularly with respect to the autocorrelation test and the validity of the instruments. Indeed, the Arellano and Bond AR (2) test of no second-order autocorrelation in the residuals is acceptable (the p-value > 0.10 for all estimates). Regarding the validity of the instruments, Hansen's tests in all estimates indicate that the internal instruments used are satisfactory (p-value > 0.10) and the ratio of the number of instruments to the number of countries (N) is less than 1 in all regressions (number of instruments $<$ number of countries). Thus, there is no proliferation of instruments. The results presented in table 6 consolidate the first results we obtained with the static model (table 2). First, we note that in all specifications, the initial export sophistication is positive and significant, suggesting a persistence of the export sophistication process in the long term. The coefficients of our key variables with syst-GMM are in line with the economic theory. The overall trade facilitation index as well as the four TF indicators have a positive effect on export sophistication. In fact, the overall TF index is positive and significant at 1% level. Physical infrastructure and the business environment affect positively but not significantly export sophistication, while the coefficient of ICT as well as the border and transport efficiency indicator are positive and significant at 5% and 1% respectively. Among the four trade facilitation indicators, border and transport efficiency seem to play a key role in exporting sophisticated goods. Indeed, efficiency in border and transport which mean simplification of documents as well as reducing number of days required for export/import by 1% increase export of sophisticated goods by 1.14-point. By controlling for endogeneity issue, our results give more insight and are consistent. The control variables globally are similar to the result in table 2. Although this result gives once again more insight into the effects of TF on export sophistication, it should be noted that we do not have a large sample as required for GMM ([Roodman, 2009](#)).

Table 6: Estimation results correcting for the persistence of export sophistication

VARIABLES	Dependent variable: Economic Complexity Index (ECI)					
	1	2	3	4	5	6
L.ECI_initial	0.444*** (0.080)	0.547*** (0.074)	0.359*** (0.089)	0.488*** (0.135)	0.373*** (0.131)	0.424** (0.156)
Log (pc GDP)	0.059* (0.034)	-0.031 (0.045)	-0.034 (0.046)	-0.122 (0.087)	0.113** (0.053)	-0.048 (0.048)
Secondary enrollment rate	0.002* (0.001)	0.002** (0.001)	0.002* (0.001)	0.004** (0.001)	0.003* (0.001)	0.002 (0.002)
Foreign Direct Investment	0.002 (0.003)	0.006* (0.003)	-0.000 (0.003)	-0.001 (0.003)	0.007 (0.006)	-0.004 (0.004)
Intermediates import	0.208 (0.227)	0.293 (0.346)	0.306 (0.260)	0.392* (0.222)	0.588 (0.480)	0.254 (0.452)
Private_sector_credit	0.002*** (0.000)	0.000 (0.001)	0.003*** (0.001)	-0.001 (0.002)	0.002* (0.001)	0.002** (0.001)
Control_Corruption	0.051 (0.053)	-0.100 (0.065)	0.060 (0.055)	0.094 (0.062)	-0.043 (0.165)	-0.076 (0.048)
Log (Tariff)	-0.073 (0.604)	0.931*** (0.329)	-0.521 (0.497)	-0.509 (0.556)	3.696 (3.339)	-0.243 (0.695)
Natural resources	-0.026*** (0.004)	-0.021*** (0.006)	-0.033*** (0.008)	-0.014 (0.010)	-0.028*** (0.010)	-0.025** (0.009)
Trade Facilitation Index		1.456** (0.579)				
Physical Infrastructure			0.172 (0.236)			
Technology (ICT)				1.316** (0.502)		
Business and Regulatory Environment					0.574 (0.911)	
Border and Transport Efficiency						1.141*** (0.297)
Constant	-0.920** (0.333)	-1.084*** (0.329)	-0.526 (0.339)	-0.505 (0.521)	-2.182** (0.858)	-0.997* (0.519)
Observations	219	219	219	219	219	219
Number of countries	22	22	22	22	22	22
Number of instruments	21	21	19	20	16	18
AR2 p-value	0.189	0.874	0.756	0.321	0.415	0.627
Hansen p-value	0.584	0.499	0.650	0.275	0.431	0.463

Note: Robust (clustered on country-year) standard errors in parentheses *, **, *** represent significance at 10%, 5% and 1% respectively. Regressions always included time dummies.

Source: authors

6- Conclusion and policy recommendations

In this study, we analyze the effect of trade facilitation on export sophistication in Sub-Saharan Africa. We first review the theoretical and empirical links between trade facilitation and export sophistication. Theoretically, we found that trade facilitation can contribute to export sophistication through indirect channels, notably intermediates imports and FDI. Empirically, we found that few studies link trade facilitation and export sophistication and there are almost no studies devoted to the specific case of Sub-Saharan Africa. Next, we reviewed the state of trade facilitation and export sophistication in SSA by analyzing the stylized facts as well as the correlation between the different indicators of trade facilitation and export sophistication. The results from the estimation with 2SLS have mostly met the expectations of the economic and econometric literature. The indicators of physical infrastructure, ICT, and border and transport efficiency contribute favorably to the export of sophisticated products in Sub-Saharan Africa. Given the significance and high coefficient of border and transport efficiency and ICT, they appear to contribute more to export sophistication in SSA among the four TF indicators. Finally, we tested the robustness of our results with an alternative measure of export sophistication as well as an alternative estimator, namely the GMM which allows us to take into account the dynamic nature of the model as well as the endogeneity problem. The results obtained with the GMM confirm those obtained in the static model.

This study shows that trade facilitation affects positively export sophistication in SSA. However, to fully benefit from this positive effect, several challenges need to be addressed. Thus, we formulate some recommendations for policymakers. First, border and transport efficiency play a key role in the export of sophisticated goods. To this end, reforms aimed at simplifying border procedures should be implemented and accelerated in SSA countries. These reforms include the establishment of one-stop borders for export-import operations and the installation of single windows in SSA countries, which will reduce the time that economic operators spend at the borders. In order to attract more foreign direct investment especially in the current context of the African Continental Free Trade Area, countries should develop measures such as the publication of information on trade activities and customs procedures at borders. This will enhance the transparency and predictability of customs administration operations. The acceleration of the implementation of the WTO Trade Facilitation Agreement will be an essential step to achieving these objectives.

Moreover, with the increased use of ICT in the production process, better quality of exports can be expected to grow in digitized economies. This work highlights once again the importance of digitalization in facilitating trade. SSA countries that export less sophisticated products have the opportunity to improve their export baskets if exporters are able to adapt to the new digital age. Governments could support this process by providing the right incentives and implementing effective digitalization strategies.

Finally, physical infrastructure remains an important factor in the export of sophisticated products in SSA. There is a need to invest more in the development of infrastructures. Since building physical infrastructures requires big investments, SSA countries need to explore new financing mechanisms including public-private partnerships. Also, the Aid for Trade initiative launched a few years ago seems to be a good niche that could help SSA countries in building infrastructure with the infrastructure category covered by this initiative.

References

- Abdon, A. and Felipe, J. (2011). The product space: What does it say about the opportunities for growth and structural transformation of sub-Saharan Africa?
- Aghion, P. and Howitt, P. (1990). A model of growth through creative destruction.
- Albeaik, S., Kaltenberg, M., Alsaleh, M., and Hidalgo, C. A. (2017). Improving the economic complexity index. *arXiv preprint arXiv :1707.05826*.
- Andreoni, A. (2011). Productive capabilities indicators for industrial policy design. *UHIDO Working paper series*, (17/11).
- Atasoy, B. S. (2021). The determinants of export sophistication: Does digitalization matter? *International Journal of Finance & Economics*, 26(4) :5135—5159.
- Banerjee, R., Maruta, A. A., & Donato, R. (2022). Does higher financial inclusion lead to better health outcomes? Evidence from developing and transitional economies. *Economics of Transition and Institutional Change*.
- Bas, M. and Strauss-Kahn, V. (2015). Input-trade liberalization, export prices and quality upgrading. *Journal of International Economics*, 95(2) :250—262.
- Baumol, W. J. and Lee, iL S. (1991). Contestable markets, trade, and development. *The World Bank Research Observer*, 6(1) :1—17.
- Beverelli, C., Neumueller, S., and Teh, R. (2015). Export diversification effects of the WTO trade facilitation agreement. *World Development*, 76 :293—310.
- Blalock, G. and Veloso, F. M. (2007). Imports, productivity growth, and supply chain learning. *World Development*, 35(7) :1134—1151.
- Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, 87(1) :115—143.
- Cabral, M. H. and Veiga, P. (2010). Determinants of export diversification and sophistication in sub-Saharan Africa.
- Chakraborty, D. and Mukherjee, S. (2016). How trade facilitation measures influence export orientation? empirical estimates with logistics performance index data. *Journal of Economics Library*, 3(4) :554—569.
- Cristelli, M., Gabrielli, A., Tacchella, A., Caldarelli, G., and Pietronero, L. (2013). Measuring the intangibles: A metrics for the economic complexity of countries and products. *PloS one*, 8(8) : e70726.
- da Costa Neto, M. N. C. and Romeu, R. (2011). *Did export diversification soften the impact of the global financial crisis ?* International Monetary Fund.
- de Melo, J. and Wagner, L. (2018). Les coûts à commercer en uemoa impacts potentiels de la mise en œuvre de l'accord sur la facilitation des échanges (afe).
- Dunning, J. H. (2000). The eclectic paradigm as an envelope for economic and business theories of mne activity. *International Business Review*, 9 :163—190.
- Duranton, G. and Puga, D. (2004). Micro-foundations of urban agglomeration economies. In *Handbook o/ regional and urban economics*, volume 4, pages 2063—2117. Elsevier.
- Fang, Y., Gu, G., and Li, H. (2015). The impact of financial development on the upgrading of China's export technical sophistication. *International Economics and Economic Policy*, 12(2) :257-280.
- Faruq, H. A. (2011). How institutions affect export quality. *Economic systems*, 35(4) :586—606.
- Feenstra, R. C. and Ma, H. (2014). Trade facilitation and the extensive margin of exports. *The Japanese Economic Review*, 65(2) :158—177.
- Felipe, J. (2012). *Inclusive growth, full employment, and structural change: Implications and policies for developing Asia*. Anthem Press.

- Fiorillo, F. (2001). Rate of growth and sector specialization coevolution in a kaldorian export-led growth model. *Structural Change and Economic Dynamics*, 12(1) :91-114.
- Fosu, A. K. and Abass, A. F. (2019). Domestic credit and export diversification: Africa from a global perspective. *Journal of African Business*, 20(2) :160—179.
- Francois, J. and Manchin, M. (2013). Institutions, infrastructure, and trade. *World development*, 46: 165— 175.
- Gnangnon, S. K. (2021). Effect of productive capacities on economic complexity. *Journal of Economic Integration*, 36(4) :626—688.
- Grancay, M., Grancay, N., and Dudas, T. (2015). What you export matters: does it really? *Contemporary Economics*, 9(2) :233—244.
- Harding, T. and Javorcik, B. S. (2012). Foreign direct investment and export upgrading. *Review of Economics and Statistics*, 94(4) :964—980.
- Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristarán, M., and Hidalgo, C. A. (2017). Linking economic complexity, institutions, and income inequality. *World development*, 93 :75—93.
- Hausmann, R. (2016). Economic development and the accumulation of know-how. *Welsh Economic Review*, 24 :13—16.
- Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., and Simoes, A. (2014). *The atlas of economic complexity: Mapping paths of prosperity*. Mit Press.
- Hausmann, R., Hwang, J., and Rodrik, D. (2007). What you export matters. *Journal of economic growth*, 12(1) :1—25.
- Hausmann, R. and Rodrik, D. (2003). Economic development as self-discovery. *Journal of development Economics*, 72(2) :603—633.
- Hidalgo, C. A. and Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the national academy of sciences*, 106(26) :10570—10575.
- Hidalgo, C. A., Klinger, B., Barabasi, A.-L., and Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837) :482—487.
- Hu, Y. (2020). Trade facilitation, R&D innovation, and export sophistication of manufacturing industries Evidence from Russia and central-eastern European countries.
- Hu, Y., Jiang, M., Sun, S., and Dai, Y. (2022). Does trade facilitation promote export technological sophistication? evidence from the european transition countries. *SWGR Open*, 12(2) :21582440221106675.
- Hummels, D. and Klenow, P. J. (2005). The variety and quality of a nation's exports. *American economic review*, 95(3) :704—723.
- Imbs, J. and Wacziarg, R. (2003). Stages of diversification. *American economic review*, 93(1) :63-86.
- Jarreau, J. and Poncet, S. (2012). Export sophistication and economic growth: Evidence from China. *Journal of development Economics*, 97(2) :281—292.
- Jouini, N., Oulmane, N., and Péridy, N. (2016). North African countries' production and export structure towards a diversification and export sophistication strategy. *Canadian Journal of Development Studies Revue canadienne d'études du développement*, 37(2) :217-238.
- Kamguia, B. (2021). Do terms of trade improve export sophistication in Africa? new empirical evidence and transmission channel.
- Kaufmann, Daniel Kraay, Aart, and Massimo Mastruzzi, "The Worldwide Governance Indicators: Methodology and Analytical Issues," *World Bank Policy Research Working Paper No. 5430*, Washington, D.C., 2010.
- Khan, F. N., Sana, A., and Arif, U. (2020). Information and communication technology (ict) and

- environmental sustainability: a panel data analysis. *Environmental Science and Pollution Research*, 27(29) :36718-36731.
- Kleibergen, F., & Paap, R. (2006). Generalized reduced rank tests using the singular value decomposition. *Journal of Econometrics*, 133(1), 97-126.
- Lall, S., Weiss, J., and Zhang, J. (2006). The 'sophistication' of exports: A new trade measure. *World development*, 34(2) :222-237.
- Lapatinas, A. (2019). The effect of the internet on economic sophistication: An empirical analysis. *Economics Letters*, 174 :35-38.
- Lectard, P. and Rougier, E. (2018). Can developing countries gain from defying comparative advantage? distance to comparative advantage, export diversification and sophistication, and the dynamics of specialization. *World Development*, 102 :90-110.
- Lee, H.-y. and Kim, C.-S. (2012). The impact of trade facilitation on the extensive and intensive margins of trade: An application for developing countries. *Journal of East Asian Economic Integration*, 16(1) :67— 96.
- Leshner, M. and Miroudot, S. (2008). Fdi spillovers and their interrelationships with trade.
- Luu Hai, D. (2021). Aid for trade and export sophistication in recipient countries. *The journal of international trade & economic development*, 30(4) :530—548.
- Minondo, A. (2010). Exports' quality-adjusted productivity and economic growth. *The Journal of International Trade & Economic Development*, 19(2) :257-287.
- Minondo, A. and Requena-Silvente, F. (2013). Does complexity explain the structure of trade? *Canadian Journal of Economics /Revue canadienne d'économique*, 46(3) :928-955.
- Moisé, E. and Sorescu, S. (2013). Trade facilitation indicators: The potential impact of trade facilitation on developing countries' trade.
- Nguyen, D. X. (2016). Trade liberalization and export sophistication in vietnam. *The Journal of International Trade & Economic Development*, 25(8) :1071-1089.
- Persson, M. (2013). Trade facilitation and the extensive margin. *The Journal of International Trade & Economic Development*, 22(5) :658—693.
- Portugal-Perez, A. and Wilson, J. S. (2012). Export performance and trade facilitation reform: Hard and soft infrastructure. *World development*, 40(7) :1295-1307.
- Rodriguez-Crespo, E. and Martinez-Zarzoso, I. (2019). The effect of ict on trade: Does product complexity matter? *Telematics and Informatics*, 41 :182—196.
- Rodrik, D. (2006). What's so special about China's exports? *China & World Economy*, 14(5) :1—19.
- Roodman, D. (2009). How to do xtabond2: An introduction to difference and system gmm in stata. *The stata journal*, 9(1) :86—136.
- Saadi, M. (2020). Remittance inflows and export complexity: New evidence from developing and emerging countries. *The Journal of Development Studies*, 56(12) :2266-2292.
- Sakyi, D., Bonuedi, I., and Opoku, E. E. O. (2018). Trade facilitation and social welfare in Africa. *Journal of African Trade*, 5(1-2) :35-53.
- Saviotti, P. P. and Frenken, IL (2008). Export variety and the economic performance of countries. *Journal of Evolutionary Economics*, 18(2) :201-218.
- Schott, P. IL (2004). Across-product versus within-product specialization in international trade. *The Quarterly Journal of Economics*, 119(2) :647-678.
- Spatafora, M. N., Anand, R., and Mishra, M. S. (2012). *Structural transformation and the sophistication of production*. International Monetary Fund.
- Spence, M. and Karinigi, S. (2014). Impact of trade facilitation mechanisms on export competitiveness in Africa.
- Srholec, M. (2007). High-tech exports from developing countries: A symptom of technology spurts or statistical illusion? *Review of world economics*, 143(2) :227-255.

- Stock, J., & Yogo, M. (2005). *Identification and Inference for Econometric Models*. Cambridge University Press.
- Wagner, J. (2007). Exports and productivity: A survey of the evidence from firm-level data. *World Economy*, 30(1) :60-82.
- Weldemicael, E. (2012). Determinants of export sophistication. The University of Melbourne.
- Wilson, J. S., Mann, C. L., and Otsuki, T. (2003). Trade facilitation and economic development: A new approach to quantifying the impact. *The World Bank Economic Review*, 17(3) :367-389.
- WTO. (2015), *Speeding up trade: benefits and challenges of implementing the WTO Trade Facilitation Agreement*, World Trade Report, 157p.
- Yue, J. and Zhou, S. (2018). Democracy's comparative advantage: Evidence from aggregated trade data, 1962—2010. *World Development*, 111 :27-40.
- Zhu, S. and Fu, X. (2013). Drivers of export upgrading. *World Development*, 51 :221-233.

Appendix

1- Correlation matrix between trade facilitation indicators and export sophistication

	Export Sophistication	Physical Infrastructure	Information and Communication Technology	Business and Regulatory Environment	Border and Transport Efficiency
Export Sophistication	1.0000				
Physical Infrastructure	0.6445***	1.0000			
Information and Communication Technology	0.3437***	0.5686***	1.0000		
Business and Regulatory Environment	0.3545***	0.4932***	0.2549***	1.0000	
Border and Transport Efficiency	0.4562***	0.458***	0.5807***	0.3628***	1.0000

*** significance at 1%.

2- Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Export Sophistication (ECI)	308	-0.76413	0.561458	-2.42371	1.21975
Overall TF indicator	308	0.461768	0.143001	0.236041	0.803065
Physical_Infrastructure	308	0.435155	0.212433	0.099813	0.958784
Technology_ICT	308	0.448351	0.210831	0.059395	1
Business_Environment	308	0.332142	0.154289	0.045806	0.877447
Border_Efficiency	308	0.631423	0.160155	0.309531	1
GDP_pc	308	2141.116	2321.565	136.4663	10484.91
School_Enrollment	272	103.5443	18.06197	53.8744	149.3075
FDI	308	3.909849	4.946428	-1.44269	39.4562
Intermediates Import	299	0.483574	0.085662	0.205295	0.664063
Private_Sector_Credit	270	28.2207	32.82442	3.678724	160.1248
Control_Corruption	308	-0.43142	0.584954	-1.4049	1.159934
Tariffs	308	0.0559031	0.03916	0	0.1535791
Natural_Resources	308	8.128203	5.749212	0.001171	32.79626

3- Summary of model 1 variable

Variables	Definitions	Sources	Expected signs
Export Sophistication (ECI)	It is measured by the Economic Complexity Index (ECI). Higher values of ECI indicate a complex or sophisticated goods while lower values show exports of unsophisticated commodities	Atlas of Economic Complexity	N/A
Physical Infrastructure (PI)	It captures the level and quality of road, port, airport and rail infrastructure (ranges from 1= extremely underdeveloped, to 7 = well developed)	WEF	+
Information and Communication Technology (ICT)	It concerns the use of ICT to improve efficiency and productivity and to reduce transaction costs (ranges from 1 to 7 = best)	WEF	+
Business and Regulatory Environment (RE)	RE measures the level of development of regulations and transparency (range from 1=low to 7=high).	WEF	+
Border and Transport Efficiency (BE)	It captures the customs and inland transport efficiency reflected in the time and number of documents.	DB	+
GDP per capita	Gross domestic product per capita (current \$)	WDI	+
Human Capital	It measured by the enrollment rate	WDI	+
Foreign Direct Investment	Ratio of the net foreign direct investment as a % of GDP	WDI	+
Intermediates Imports	It represents the import of the Broad Economic Categories (BEC) products as a share of total imports	UNCOMTRADE	
Financial development	It is measured by the credit to the private sector, which refers to the financial resources provided to the private sector by financial corporations	WDI	+
Institution	It is captured by the control of corruption which measures how the public power is exercised for private gain, including minor and major forms of corruption. It values range from -2.5 to +2.5	WGI	+
Tariffs	It is a weighted average rate applied to all products	WDI	-
Natural resources	It is the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents and forest rents	WDI	-

Source: Authors

4- Diagnostics tests

Econometric Problem	Tests	F-Stat	P-Value	Null Hypothesis Accepted/Rejected
Serial Correlation	Wooldridge test	15.928	0.0007	Rejected
Heteroscedasticity	Modified Wald test for GroupWise heteroskedasticity	1023.43	0.0007	Rejected
Cross-sectional dependence	Pesaran (2015) test for weak cross-sectional dependence	0.0000	1.000	Accepted

Source: Authors

5- Trade facilitation indicators and the contribution of each variable in (%) using principal component analysis

Aggregate indicators	Variables/indices	F1
PHYSICAL INFRASTRUCTURE (PI)	Quality of port infrastructure	23,896
	Quality of the airport infrastructure	23,542
	Quality of the road infrastructure	29,333
	Quality of the railway infrastructure	23,228
INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)	Availability of ICT	37,776
	Level of ICT absorption	35,393
	Use of ICT	26,831
BUSINESS AND REGULATORY ENVIRONMENT (RE)	Transparency of government policies	21,186
	Public trust in politicians	27,703
	Irregular payments and bribes	24,387
	Government favoritism to business	26,725
	Number of documents to export	19,498
BORDER AND TRANSPORT EFFICIENCY (BE)	Number of documents to import	20,866
	Number of days to export	29,295
	Number of days to import	30,341

Note: Each variable was standardized to values that range from 0 to 1 to facilitate comparison.

F1 represent the weight of each sub-indices.

Source: Authors based on data from WEF and Doing Business.

6- Economic Complexity Index method

ECI is calculated from export data connecting countries to the products in which they have Revealed Comparative Advantages (RCA) ([Hidalgo and Hausmann, 2009](#)).

The Revealed Comparative Advantage (RCA) of a country c in a product p is:

$$RCA_{cp} = \frac{X_{cp} / \sum_p X_{cp}}{\sum_c X_{cp} / \sum_{cp} X_{cp}} \quad (1)$$

where X_{cp} is the total export of country c in product p . RCA is larger than 1 (indicating that a country has comparative advantage in a product), if a country's export of a product is larger than what would be expected from the size of the country's export economy and the product's global market.

RCA are used to define a discrete matrix M_{cp} which is equal to 1 if country c has RCA in product p and 0 otherwise.

$$M_{cp} = 1 \text{ if } RCA_{cp} \geq 1$$

$$M_{cp} = 0 \text{ if } RCA_{cp} < 1$$

The matrix M_{cp} allows to define the diversity of a country and the ubiquity of a product, respectively, as the number of products that are exported by a country with comparative advantage, and the number of countries that export a product with comparative advantage.

$$\text{Diversity} = k_{c,0} = \sum_p M_{cp}$$

$$\text{Ubiquity} = k_{p,0} = \sum_c M_{cp}$$

Next, a matrix can be defined that connects countries exporting similar products, weighted by the inverse of the ubiquity of a product (to discount common products), and normalized by the diversity of a country:

$$M_{cc'} = \frac{1}{k_{c,0}} \sum_p \frac{M_{cp} M_{c'p}}{k_{p,0}} \quad (2)$$

Finally, the Economic Complexity Index (ECI) is defined as:

$$ECI_c = \frac{K_c - (K)}{\text{std}(K)} \quad (3)$$

where K_c is the eigenvector of $M_{cc'}$ associated with the second largest eigenvalue, the vector associated with the largest eigenvalue is a vector of ones ([Hausmann et al. 2014](#); [Hartmann et al., 2017](#)).

Source: Adapt from [Hartmann et al. 2017](#).

7- List of countries included in the sample

South Africa (ZAF), Botswana (BWA), Burkina Faso (BFA), Cameroun (CMR), Cote d'Ivoire (CIV), Eswatini (SWZ), Ethiopia (ETH), Ghana (GHA), Kenya (KEN), Madagascar (MDG), Malawi (MWI), Mali (MLI), Mauritius (MUS), Mozambique (MOZ), Namibia (NAM), Nigeria (NGA), Senegal (SEN), Tanzania (TZA), Uganda (UGA), Zambia (ZMB), Zimbabwe (ZWE), Mauritania (MRT),

Source: Authors.