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Université Clermont Auvergne, CNRS, IRD, CERDI, F-63000 Clermont-Ferrand, France

ESSAYS ON THE COMPETITIVENESS AND EXPORT PERFORMANCE OF AFRICAN ECONOMIES

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par

Sano Adéola Camille da Piedade

sous la direction de Patrick Plane

Membres du Jury

Mathilde Maurel	Directrice de recherche au CNRS, Université Paris 1 Panthéon-Sorbonne, CES	Rapporteur
Lionel Fontagné	Professeur, Université Paris 1 Panthéon-Sorbonne, PSE et Banque de France	Rapporteur
Ana Fernandes	Economiste principale, Banque Mondiale	Suffragante
Simone Bertoli	Professeur, Université Clermont Auvergne, CERDI	Suffragant
Michaël Goujon	Professeur, Université Clermont Auvergne, CERDI	Suffragant
Patrick Plane	Directeur de recherche au CNRS, Université Clermont Auvergne, CERDI	Directeur

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Résumé :

Avec une population dépassant les 1,4 milliard d'habitants, faisant ainsi de l'Afrique le deuxième continent le plus peuplé au monde après l'Asie, la contribution de ce continent au commerce mondial demeure modeste. La littérature économique identifie divers facteurs contribuant à la marginalisation des nations africaines dans le commerce mondial, notamment un déficit de compétitivité. S'appuyant sur la littérature existante et reconnaissant l'absence de solution universelle, cette thèse explore, à travers ses trois chapitres, les voies qu'offrent la compétitivité prix et hors prix pour une meilleure intégration des nations africaines au commerce mondial. Le premier chapitre s'intéresse à la mesure de la compétitivité des prix, en examinant spécifiquement la compétitivité du franc CFA à travers le prisme du taux de change d'équilibre comportemental (BEER) et de la parité du pouvoir d'achat (PPA). Une contribution notable réside dans la prise en compte des rentes naturelles, particulièrement importantes dans le contexte des pays africains. Les résultats soulignent des disparités entre les unions monétaires (UEMOA et CEMAC), les sous-périodes et les pays considérés. L'analyse des résultats en fin de la période 2014-2016 n'appelle pas à un réajustement de la parité. Le deuxième chapitre explore l'impact de la sous-évaluation des taux de change sur la survenue d'épisode d'accélérations de croissance des exportations de produits africains. L'analyse englobe une variété de produits d'exportation clés, tant primaires que manufacturés, avec une approche microéconomique unique adaptée à chaque produit. Sur la période 1995-2017, 96 épisodes sont identifiés pour 41 pays africains. Les estimations confirment que la sous-évaluation stimule significativement les poussées de croissance d'exportations des produits africains. Le troisième et dernier chapitre se concentre sur la compétitivité hors prix, en explorant les implications du déploiement rapide des câbles sous-marins le long des côtes africaines pour la sophistication du panier d'exportations des pays africains. A partir d'un échantillon de pays en développement, incluant 23 pays d'Afrique subsaharienne sur la période 1995-2017, les résultats indiquent que l'interconnectivité numérique améliore globalement la complexité des exportations. L'impact positif décroît avec l'accroissement des distances géographiques et maritimes par rapport aux marchés mondiaux, sauf en Afrique subsaharienne, où ces distances amplifient les avantages de l'interconnectivité numérique. Une exploration des mécanismes à l'origine du processus de sophistication des exportations induit par l'interconnectivité numérique a mis en évidence une augmentation des exportations de biens différenciés et une participation accrue aux chaînes de valeur mondiales.

Mots clés : Afrique, poussée des exportations, taux de change, sous-évaluation, compétitivité, exportations, complexité économique ; Internet ; infrastructures de connectivité, diversification des échanges.

Classification *JEL: C23, F15, F31, F41, F45, F63, O11, O47, O55*.

Summary:

With a population of over 1.4 billion, making Africa the world's second most populous continent after Asia, its contribution to world trade remains modest. Economic literature identifies several factors contributing to the marginalization of African nations in world trade, including a lack of competitiveness. Drawing on the existing literature, and recognizing that there is no universal solution, this thesis explores, in three chapters, the ways in which price and non-price competitiveness can help African nations to integrate more fully into world trade. The first chapter looks at the measurement of price competitiveness, specifically examining the competitiveness of the CFA franc through the prism of the behavioral equilibrium exchange rate (BEER) and purchasing power parity (PPP). One notable contribution is the inclusion of natural rents, which are particularly important in African countries. The results highlight disparities between monetary unions (WAEMU and CEMAC), sub-periods and countries considered. Analysis of the results at the end of the 2014-2016 period does not call for a readjustment of parity. The second chapter explores the impact of undervalued exchange rates on the occurrence of episodes of accelerated growth in exports of African products. The analysis encompasses a variety of key export products, both primary and manufactured, with a unique microeconomic approach tailored to each product. Over the period 1995-2017, 96 episodes are identified for 41 African countries. Estimates confirm that undervaluation significantly stimulates growth surges in African export products. The third and final chapter focuses on non-price competitiveness, exploring the implications of the rapid deployment of submarine cables along African coasts for the sophistication of African countries' export baskets. Based on a sample of developing countries, including 23 Sub-Saharan African countries over the period 1995-2017, the results indicate that digital interconnectivity improves export sophistication overall. The positive impact decreases with increasing geographical and maritime distances from world markets, except in sub-Saharan Africa, where these distances amplify the benefits of digital interconnectivity. An exploration of the mechanisms underlying the process of export sophistication induced by digital interconnectivity highlighted an increase in exports of differentiated goods and greater participation in global value chains.

Keywords: Africa, export surge, exchange rate, undervaluation, competitiveness, exports, economic complexity; Internet; connectivity infrastructure, trade diversification.

JEL code : **C23, F15, F31, F41,F45, F63, O11, O47, O55.**

List of Acronyms

2SLS: Two-Stage Least Square

AERC: African Economic Research Consortium

AAE-1: Asia Africa Europe-1

ACE: Africa-Coast-to-Europe

AFD: Agence Française de Development

BEER: Behavioral Equilibrium Exchange Rate

CDP: Committee for Development Policy

CEMAC: Central African Economic and Monetary Community

CEPII : Centre d'Etudes Prospectives et d'Informations Internationales

Cloglog: Complementary log-log

CMG: Cross- section augmented Mean Group

CPMG: Cross- section augmented Pooled Mean Group

DVX: Domestic Value-Added Exports

EASSy: Eastern Africa Submarine System

ECI: Economic Complexity Index

ECOWAS: Economic Community of West African States

EVI: Economic Vulnerability Index

FDI: Foreign Direct Investment

FERDI : Fondation pour les Etudes et Recherches sur le Développement International

FEER: Fundamental Equilibrium Exchange Rate

FVA: Foreign Value-Added

GVCs Global Value Chains

ICTs: Information and Communication Technologies

IMF: International Monetary Fund

IV: Instrumental Variables

LDCs: Least Developed Countries

MENA: Middle East and North Africa

MIT: Massachusetts Institute of Technology

MRIO: Multi-Region Input-Output

OCD : Observatoire de la Compétitivité Durable

OEC: Observatory of Economic Complexity

OECD: Organization for Economic Co-operation and Development

OLS: Ordinary Least Squares

MG: Mean Group

PMG: Pooled Mean Group

PPP: Purchasing Power Parity

QOG: Quality of Government

REER: Real Effective Exchange Rate

RER: Real Exchange Rate

SCI: Shipping Connectivity Index

SCO: Sustainable Competitiveness Observatory

SEAMEWE: Southeast Asia-Middle East-Western Europe

SITC: Standard International Trade Classification

SMC: Submarine Cable

SSA: Sub-Saharan Africa

TEAMS: The East African Marine Systems

UNCTAD: United Nations Conference on Trade and Development

WACS: West Africa Cable System

WAEMU: West African Economic and Monetary Union

WDI: World Bank Development Indicators

WEF: World Economic Forum

WEO: World Economic Outlook

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General introduction:

"All happy families are alike; each unhappy family is unhappy in its own way."

Leo Tolstoy, Anna Karenina

The Anna Karenina principle of development economics

In 1873, as Leo Tolstoy commenced his magnum opus "Anna Karenina" with the assertion, 'All happy families are alike; each unhappy family is unhappy in its own way,' little did he anticipate that this metaphor would transcend the realm of literature and resonate across diverse fields centuries later. The Anna Karenina principle, originating from this seminal statement, unfolds as a metaphorical lens through which success is contemplated as contingent upon the simultaneous fulfillment of a myriad of indispensable conditions, a notion expansively applied in disciplines such as economics.[1] Within the sphere of development economics, the Karenina principle transpose as "all rich economies are alike; each poor economy is poor in its own way" and posits that success in economic development emanates from the meticulous satisfaction of a specific set of criteria, mirroring the concept that contented families (i.e., developed countries) share common attributes. Conversely, failure in this context stems from the deficiency or non-fulfillment of any one of these essential conditions, manifesting in a spectrum of distinct inadequacies. This metaphorical application of the Anna Karenina principle has gained prominence across various academic disciplines, underscoring the imperative of addressing multiple facets to achieve success. It serves as a poignant reminder that the pathways to failure are diverse and intricate, while success often follows a discernibly defined trajectory wherein numerous critical elements harmoniously converge. However, the reverse of the Anna Karenina principle applies differently from one field

[1] See, among others, Diamond (1994; 1997); Bornmann and Marx (2011); Miranda et al. (2021, May 7) and Calvo-Gonzalez, O. (2022, May 19).

to another and is not a panacea.[2] In his bestselling book "Zero to One: Notes on Startups, or How to Build the Future," Peter Thiel offers a contrasting perspective for firms. Indeed, he posits that, unlike the Anna Karenina principle applied to families, "all happy companies are different: each one earns a monopoly by solving a unique problem. All failed companies are the same: they failed to escape competition." Thiel suggests that successful companies distinguish themselves by addressing distinctive challenges and establishing a monopoly in their respective niches. On the other hand, unsuccessful companies share a commonality—they were unable to break free from the constraints of competition.

On the competitiveness debate:

Competition has been a central concept in economics since Adam Smith introduced it as a fundamental force in markets, reinforced by David Ricardo's theory of competitive advantage. This topic attracts significant and hegemonic attention among economists, policymakers, and the media due to its pivotal role in driving economic development, sometimes becoming a 'dangerous obsession.' The extensive interest in the concept of international competitiveness is apparent from the over 6.5 million results generated by a Google search (Olczyk, 2016). The increasing focus on competitiveness rankings, especially at the country level, reinforces this trend (Hassett, 2012). Despite its hegemonic persistence in the debate the concept is not a well-defined in the economic literature. Lachmann (2001) identifies several factors contributing to the lack of a widely accepted definition and theory of international competitiveness, including the broad nature of the concept, misconceptions about the level of analysis, and the absence of a consensus on a theoretical foundation. On a microeconomic perspective, competition creates a dynamic environment where less competitive firms face the risk of losing market share,

[2] Calvo-Gonzalez, O. (2022, May 19) highlights the concept of "isomorphic mimicry," cautioning against blindly adopting institutional best practices from developed nations. The risk of unintended consequences arises when oversimplifying with the Anna Karenina principle. It is important to recognize that assuming all wealthy economies share institutional similarities is misguided; each possesses unique characteristics. This misconception leads to "idiomorphic myopia," hindering the proper acknowledgment of diverse institutional forms.

bankruptcy, or exiting the market, while more competitive firms have the potential to gain market share and experience growth (Hibbs, 1983; Bristow, 2005; Kitson et al, 2004; Porter, 1990 and 1998; Falciola et al. 2020). However, when considering competition at the macroeconomic level, the situation becomes more complex. To paraphrase Krugman (1994), nations - unlike firms - do not have the option to withdraw from the market.[3] Porter (1998), and Krugman as cited in Kurtzman (1998), argues that it is firms, not nations, that compete in international markets. This perspective emphasizes that countries do not participate in the buying and selling of goods overseas; instead, it is individual firms that do so. Put differently, the concept of competitiveness at the national level is not as straightforward as it is for firms. It is rather an evasive concept for which there is no universally agreed-upon theory.[4]

Mulatu (2016), in his typology, categorizes the concept of national competitiveness into three schools of thought, namely the neoclassical economics school, the quasi-competitiveness school, and the competitiveness school. Neoclassical economics school of thought, claim that the concept of competitiveness is well defined at the firm level, where success depends on relative performance. Extending the concept to nations, however, raises questions about dependencies on factors such as cost structure, productivity, and exchange rates. Critics against the neoclassical view, point to inefficiencies in free markets or free trade due to market failures and the non-exogeneity of comparative advantage. They also emphasize the importance of addressing issues such as externalities, economies of scale, imperfect information, and income distribution. Meanwhile, the quasi-competitiveness school, represented by among others Boltho, Fagerberg, and Cantwell, recognizes a limited but meaningful role for competitiveness and emphasizes its use as a measure of national economic performance. Focusing on short-term issues such as real exchange rates and current account deficits,

[3] According to Krugman (1994): "Countries, on the other hand, do not go out of business. They may be happy or unhappy with their economic performance, but they have no well-defined bottom line."

[4] See among others Krugman (1996), Venables (1996), Friedman and Friedman (1997), Boltho (1996), Greene et al. (2007).

competitiveness is viewed as a tool to address specific economic challenges, while advocating a priority for productivity over competitiveness. In contrast, the competitiveness school argues that competitiveness is an integral part of the development strategy for countries, going beyond the efficiency of firms to emphasize commitment and efficiency in high-value sectors. This perspective advocates strategic policies, including subsidies or tariffs, that challenge the complete laissez-faire approach, particularly in high-tech sectors, to promote innovation and increase a nation's overall economic performance and income.

Competitiveness, whether at the national or firm level, encompasses various definitions (see Aiginger et al. 2013; Falciola et al. 2020; Buitrago et al. 2021). Moon et al. (1998) defined firm-level competitiveness as "the capability of firms engaged in value-added activities in a specific industry in a particular country to sustain this value added over extended periods despite international competition." Falciola et al. (2020) contribute to this notion by highlighting that competitive firms must not only fulfill consumers' demands but also do so sustainably, adapting to environmental changes and staying consistently informed about the latest market trends. On a national level, the Organization for Economic Co-operation and Development (OECD, 1992) perceives competitiveness as a country's ability to produce goods and services that meet international market requirements under fair market and free trade conditions, fostering sustainable and increasing earnings for individuals in the long term. The World Economic Forum (WEF), actively assessing competitiveness through the 'Global Competitiveness Index' since the late 1970s, defines it as “the set of institutions, policies and factors that determine the level of productivity of a country”. Within the myriad definitions found in economic literature, this thesis closely aligns with Berger's (2008), which delineates four pivotal theoretical definitions of national competitiveness. The initial definition highlights a nation's trade capacity, covering both price-based and non-price-based competitiveness. The second emphasizes the significance of achieving productivity gains. The third centers on the nation's capacity to adapt to external changes,

involving the fostering of innovation and the maintenance of flexibility. Lastly, the fourth definition relates to the nation's capability to attract capital and labor resources.

The price-based competitiveness

Price competitiveness centers on evaluating the cost position of firms or countries, particularly their capacity to engage in competition through lower costs and favorable home policies (Brander & Spencer, 1985; Krugman, 1986). This is vividly demonstrated by the significant global shift of Western firms to China during the recent wave of globalization, driven by the pursuit of lower production costs.[5] Price competitiveness entails considering the real exchange rate as a crucial variable in assessing a country's macroeconomic position. Rogoff (2005) as quoted in Berger (2008) asserts: "Ask any good international macroeconomist what key variables they most want to know in assessing a country's overall macroeconomic position, and the "real" exchange rate […] will often be near the top of the list". To gauge price competitiveness, a common method involves monitoring changes in unit labor costs, representing the cost of labor per unit of output. Unfortunately, this data is often unavailable for a significant number of developing countries.

Devaluing the currency may be employed to enhance competitiveness and stimulate growth, especially when domestic companies face challenges selling goods abroad (Rodrik, 2008). However, competitive devaluation has drawbacks, leading to potential currency wars, exemplified by China's deliberate undervaluation of the yuan, causing tensions with the US and increased American tariffs. Devaluing a currency may lower export prices, yet it could also lead to higher import prices, potentially impacting the cost of living within a nation (Morvillier, 2020). Furthermore, relying solely on cost reduction, such as lowering wages, for competitiveness may not consistently yield effective results. This approach overlooks factors like export structure and dependence on specific products with limited global competition. Competitiveness enhancement extends

[5] The disruptions in the supply chain caused by the Covid-19 pandemic and the recent geopolitical tensions arising from the Russia-Ukraine conflict have sparked trends in both nearshoring and friendshoring.

beyond cost reduction; productivity levels are equally crucial (Delgado et al., 2012, Krugman, 1990, 1994). While productivity is recognized as the primary driver of prosperity and a key performance indicator, focusing solely on it presents challenges for policymakers, as noted by Falciola et al. (2020). This approach lacks insights into competitiveness determinants, leaving policymakers uncertain about the appropriate tools, and productivity, being a static measure, doesn't reveal the economy's adaptability. Addressing these challenges, Porter's Diamond Model, originating from his work in the 1990s, systematically measures and compares competitiveness determinants, sparking discussions and inspiring key country competitiveness indices such as the World Competitiveness Rankings or the Global Competitiveness Index.

The non-price-based competitiveness

Non-price competitiveness expands the path to success for both companies and nations beyond the traditional focus on cost. Achieving competitive advantage on a global scale depends heavily on differentiating products through superior quality and innovation. This requires developing unique features, incorporating advanced technologies, and staying ahead of industry trends to capture consumer attention and loyalty (Falciola et al., 2020). Diversification, as emphasized by Hummels and Klenow et al. (2005), is also essential. Establishing and maintaining a robust brand image significantly influences consumer perceptions, allowing well-established brands to command higher prices and inspire consumer confidence, irrespective of cost considerations. Human capital plays a central role, as a well-educated and skilled workforce enhances a nation's ability to participate in knowledge-intensive industries, fostering innovation and adaptability. The institutional environment, highlighted by authors such as Douglas North and Daron Acemoglu, emerges as a critical determinant of non-price competitiveness, where effective governance, transparent regulations, and a stable economic and political climate create a conducive business environment for long-term strategic planning. Moreover, the growing importance of environmental and social responsibility, as articulated by Porter

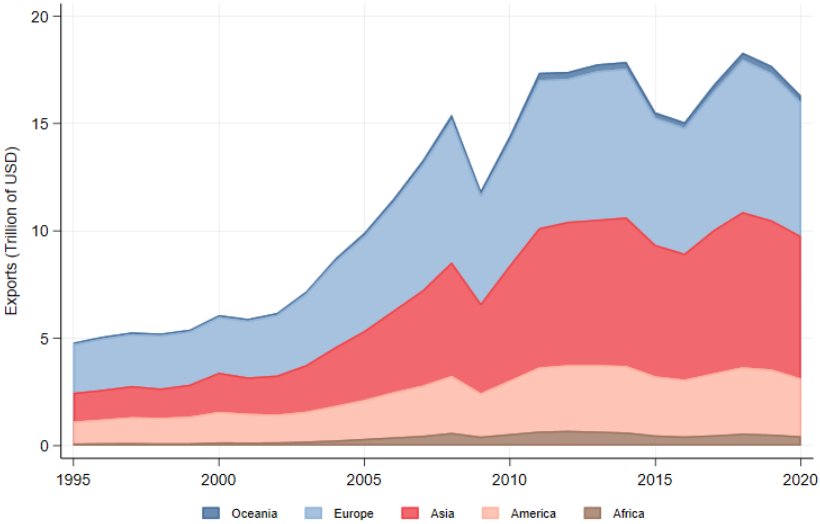
and Kramer (2006) is recognized. Firm and companies that adopt sustainable practices not only contribute to societal well-being, but also enhance their global reputation. This multifaceted and strategic approach to non-price competitiveness includes dimensions such as quality, innovation, technology, market strategies, branding, human capital, institutional factors, and sustainability practices.

Problematic and objective of this thesis:

Despite its population exceeding 1.4 billion, making it the second most populous continent globally after Asia, Africa plays a relatively modest role in the global trade arena, as depicted in Figure 1. The analysis of economic literature on the marginalization of African nations in global trade reveals a complex interplay of factors, including infrastructure challenges, trade barriers and tariffs, limited economic diversification and sophistication of exported goods, institutional weaknesses, lack of access to finance, political instability, skills gap, global trade power imbalances, limited regional integration, and insufficient regional economic cooperation among African nations. These factors - echoing to the Anna Karenina principle - hinder the creation of larger and more attractive markets for international trade, limiting economies of scale. Furthermore, climate change and environmental challenges add to the hurdles.

Drawing insights from existing literature on the challenges hindering the global trade integration of African countries and recognizing the absence of a one-size-fits-all approach due to diverse impediments faced, this thesis explores the potential of both price and non-price competitiveness as avenues for Africa to thrive through enhanced integration into international trade.

Figure 1 : total exports of goods by region over the period 1995-2020



Source: Author using BACI (2022)

Data and time coverage

The empirical analysis in this thesis spans from 1995 to 2017. While the primary focus is on African countries, a broad panel of countries is sometimes required to compute our indicator of interest or to compare African economies with their counterparts worldwide. The analytical work presented in this thesis is grounded on five databases: the World Bank Development Indicators (WDI), the Sustainable Competitiveness Observatory (SCO-Ferdi), BACI database (CEPII), the Observatory of Economic Complexity (MIT), and Telegeography. The trade data and control variables are sourced from the BACI database and WDI, respectively. A substantial portion of the empirical analysis heavily relies on the Sustainable Competitiveness Observatory (SCO) indicators provided by Ferdi. [6] These indicators facilitate an assessment of price competitiveness not only at the macroeconomic level, using Real Effective Exchange Rates data, but also at the sectoral level. This entails a specific focus on the primary export products within both the agri-food and manufacturing sectors of each African country. The SCO offers unprecedented time series datasets, encompassing market shares and unit values, for the top five agricultural and manufactured products exported by each African country.

The MIT project known as the Observatory of Economic Complexity, active from 2011 to 2019, provides access to over 50 years of international trade data through a variety of interactive visualizations.[7] These visualizations are based on an alternative perspective on the development process, derived from a fusion of research in the statistical physics of networks and development economics.[8]

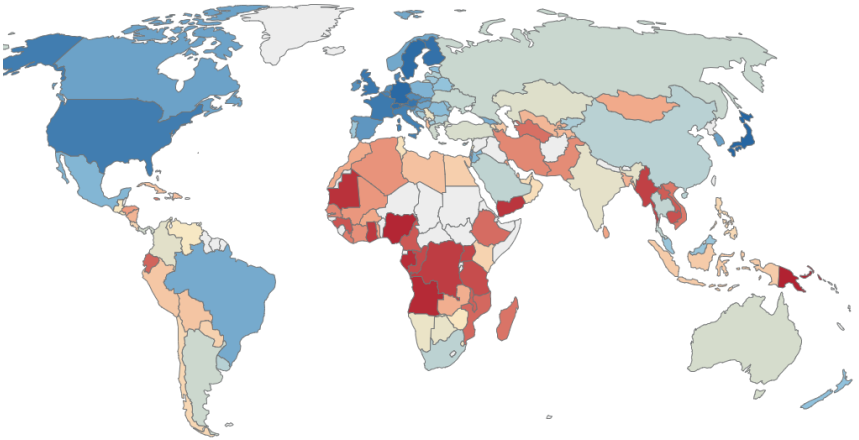
[6] Launched in 2015, the Observatory for Sustainable Competitiveness (OCD) is a statistical tool created by Ferdi with the support of the French Development Agency (AFD). The OCD's ambition is to align the measurement of the ability to produce with the actual performance of Africa in the process of integrating each state into the global economy. To achieve this, the OCD emphasizes the sustainable nature of competitiveness by combining attractiveness, price competitiveness, and vulnerability dimensions.

[7] As of August 2019, OEC has been independent of the MIT Media Lab and is accessible at https://oec.world/. The Harvard Growth Lab also offers comparable data on economic complexity through its Atlas of Economic Complexity (Figure2), accessible at https://atlas.cid.harvard.edu/.

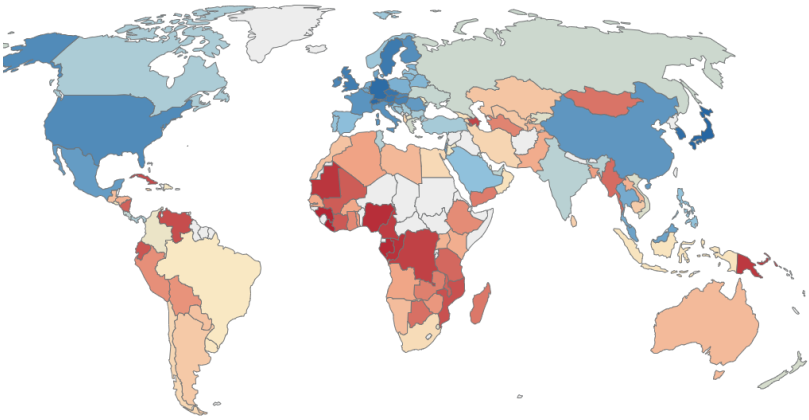
[8] According to Hidalgo (2009), the central insight from this area of research can be summarized as follows: "What matters is not only how much value a country extracts from its products, but more importantly, what the country produces."

Figure 2 : Economic Complexity Index (ECI)

(a) 1995



(b) 2020



Source: Atlas of Economic Complexity – Havard Growth Lab

This interdisciplinary approach has resulted in innovative analytical measures, including the Economic Complexity Index (ECI), the Product Complexity Index (PCI), Product Relatedness, and Country Fitness, which aim to quantify the economic importance of historically overlooked production structures. In the context of this study, we specifically use the Economic Complexity Index (ECI). As defined by Hausmann and Hidalgo (2009), the ECI assesses the sophistication of a country's productive structure by integrating data on the diversity of exported products and the number of countries involved in exporting these products (ubiquity). The underlying concept of the ECI is that advanced economies are diversified and export products with low ubiquity, a characteristic not observed in developing countries that produce less sophisticated goods. The ECI uses country diversity and product ubiquity to construct a measure of a country's production structure that incorporates information about the sophistication of its products. The ECI calculations use export data to link countries to the products in which they have Revealed Comparative Advantages (RCA).

Finally, we utilize Telegeography to access information on the global Submarine Cable (SMC) network (see Figure 3). Telegeography enables us to highlight a new dimension in submarine cable deployment, "digital connectedness," indicating a country's digital closeness to key global markets. This indicator measures the share of the global GDP to which a country is directly connected through submarine cables. The stronger the digital proximity to major production and consumption hubs facilitated by these cables, the higher the level of digital connectedness. This increased digital connectedness streamlines exporters' access to information on buyers, production technologies, pricing, input quality, market regulations, and more. Consequently, this enhances both the incentives and capabilities to enter these markets and export more sophisticated products.

Figure 3 : Submarine Cable Map 2023

Source: [Telegeography]

Methodological choices and approaches used in the thesis

Misalignments in exchange rates, both at the country and sectoral levels, constitute a focal point in this thesis. In theoretical terms, misalignments denote discrepancies between actual real exchange rates and their presumed equilibrium states. Nevertheless, the challenge of practically observing equilibrium exchange rate levels has spurred a comprehensive and controversial body of literature employing varied approaches. These approaches can be broadly classified into two groups: models-based approaches, such as Purchasing Power Parity (PPP), and structural approaches, exemplified by the Behavioral Equilibrium Exchange Rate (BEER).[9] In this thesis, a chosen approach is adopted in each

[9] As well summarized by Grekou (2020), structural approaches include three main categories: macroeconomic (Fundamental Equilibrium Exchange Rate - FEER, Desired Equilibrium Exchange Rate -

of the two groups. The PPP and the BEER approaches were chosen for their simplicity and minimal data requirements.[10] The PPP approach posits that the exchange rate should be set at a value ensuring equality between domestic and foreign price levels when expressed in the same currency. Any deviation of the exchange rate from the level ensuring PPP should naturally self-correct. Consequently, in the long term, the real exchange rate remains constant and equal to unity. The BEER approach evaluates the equilibrium exchange rate by using a reduced equation based on long-term relationships between the real exchange rate and fundamental economic variables. The BEER thus allows for the calculation of a trajectory of the long-term equilibrium real exchange rate, considering factors like relative productivity, terms of trade, and net foreign asset and natural resource rents for the relevant countries.

In line with common practice in the literature, we also assess price competitiveness by examining the ability to increase exports. While the conventional measure of export capacity predominantly involves volumetric analysis, we opt for the export surge methodology, a choice motivated by the relatively limited role of African countries in international trade. Our specific focus is on each country's top 5 primary and manufactured exports, which facilitates the identification of substantial expansions in their traditional export portfolios, thus mitigating the impact of sporadic exports influenced by singular or conjonctural factors. The surge methodology, derived from the seminal work of Hausmann, Pritchett, and Rodrik (2005) and subsequently applied by

DEER), (macro)econometric (Behavioral Equilibrium Exchange Rate - BEER, Permanent Equilibrium Exchange Rate - PEER), and dynamic approaches (Natural Real Exchange Rate - NATREX). In contrast, model-based approaches include Purchasing Power Parity (PPP), Capital Enhanced Equilibrium Exchange Rate (CHEER), and Intermediate-Term Model-based Equilibrium Exchange Rate (ITMEER). See Driver and Westaway (2004) for further discussion.

[10] While both favored approaches possess distinct advantages in their implementation, they nonetheless exhibit certain limitations. Indeed, the Purchasing Power Parity (PPP) approach is inherently a very long-term perspective (Bénassy-Quéré et al., 2010) that overlooks the role of capital flows and determinants of the real exchange rate (MacDonald, 2000). On the other hand, the Behavioral Equilibrium Exchange Rate (BEER) approach has faced criticism for its lack of robust theoretical foundations and the sensitivity of its estimations to the chosen fundamentals (Lopez-Villavicencio et al., 2012).

Freund and Pierola (2012) in assessing national dynamics in total manufactured exports, involves the definition of surges with two breakpoints in the evolution. Export growth in a given period must exceed the previous growth in an equivalent period, and it must also exceed the global growth rate. Thus, a counterfactual is formulated that integrates information on growth and market share. The export surge method parallels the hypothetical-deductive framework of the double-difference method but uses a backward reasoning approach. First, we identify surges, analogous to the treatment, using a counterfactual. We then proceed to explore their determinants.

Value added and main result of the thesis

This thesis is structured around three chapters, primarily focusing on price competitiveness and non-price competitiveness in Africa. In the first chapter, we delve into the question of measuring price competitiveness. To do so, we rekindle the perennial debate on the competitiveness of the CFA franc through the lenses of the Behavioral Equilibrium Exchange Rate (BEER) and Purchasing Power Parity (PPP). To conduct this analysis, we use a panel of 99 countries of various levels of development over the period 1990-2016. Behavioral misalignments (BEER) are estimated using panel cointegration methods (Pool Mean Group - PMG), while PPP misalignments are derived from a standard OLS regression. A significant contribution of this chapter is the consideration of natural rents, which are typically not included in the fundamentals of the equilibrium exchange rate but constitute an important factor in misalignments in African countries predominantly dependent on natural resources. The two adopted analytical criteria revealed disparities across monetary unions, sub-periods, and considered countries. In particular, the BEER model favors WAEMU, while the PPP criterion favors CEMAC. These divergent results persisted, with misalignments proving impervious to variations in productivity measures and sample composition. Toward the conclusion of the period (2014-2016), deviations from the equilibrium rate did not appear to necessitate a parity readjustment. However, within the group of 14 members, the Central African Republic conspicuously exhibited a substantial overvaluation. This circumstance stemmed from

vulnerabilities and political fragility, consequences extending beyond the scope of a mere nominal exchange rate adjustment.

The second chapter examines in detail the impact of exchange rate undervaluation on driving export surges of African products. Building on the foundational research of Freund and Pierola (2012), this chapter extends the analysis to a wide range of key export products, both primary and manufactured. What sets this chapter apart is its innovative approach, which introduces a microeconomic dimension of price competitiveness tailored to each export product, considering the macroeconomic environment of major competitor countries exporting similar goods. Over the period 1995-2017, 96 episodes are identified for 41 African countries, covering 149 products with 4-digit HS codes. The focus of the study is the computation of country and product specific real exchange rate misalignments. Testing a key hypothesis, the study confirms that undervaluation significantly boosts competitiveness and triggers export surges. Using a complementary log-log model, the results remain robust to various considerations, confirming the influence of product-level undervaluation on export surge episodes. In essence, Chapter 2 provides valuable insights into the complex interplay between currency undervaluation, product-level price competitiveness, and the resulting patterns of export surges in African economies. The nuanced analysis of both primary and manufactured goods provides a comprehensive understanding of global market dynamics.

The third chapter focus on non-price competitiveness and delves into the implications of the recent and rapid deployment of submarine cable (SMC) along the African coasts for the sophistication of the African export basket. The contribution of this chapter is threefold. Firstly, this chapter highlight a new dimension of submarine cable deployment termed "digital connectedness," reflecting a country's digital proximity to major global markets and assess its impact on export sophistication. Secondly, sophistication is measured by indicators of the complexity of the export basket, primarily based on the Economic Complexity Index (Hidalgo, 2021). Thirdly, an innovative instrument, the

number of indirect undersea cable connections (second-order connections), is computed to address potential reverse causation between digital connectivity and export complexity. Drawing from a sample of developing countries, including 23 countries in sub-Saharan Africa (SSA), covering the period 1995-2017, the results show that digital connectivity generally enhanced export complexity. However, there exists geographical and temporal heterogeneity. In comparison to the rest of the world, Sub-Saharan Africa (SSA) experienced an additional increase in economic complexity, particularly during the period 2006-2015, indicative of a catching-up phase for the region. The positive impact of digital connectivity diminishes as geographic and maritime distances from global markets increase, except in SSA, where these distances amplify the benefits of digital connectedness. Examining the mechanisms underlying the process of export sophistication through digital connectedness, the results indicate that it enhances the export of differentiated goods—those with higher information search costs—and promotes participation both upstream and downstream in global value chains.

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Chapter 1: Are the CFA francs at their equilibrium level? *

*This chapter is joint work with Patrick Plane (CNRS-CERDI-UCA) and has been published in French in *Revue française d'économie*, 2021, vol. XXXVI, issue 4, 87-127.

Résumé

En Zone franc, la parité fixe des francs CFA fait de nouveau débat alors que l'*éco*, une monnaie de substitution, est annoncée en UEMOA. On s'interroge sur les mésalignements possibles du taux de change dans chacune des deux unions monétaires qui composent cet espace institutionnel de coopération (UEMOA, CEMAC). Le diagnostic est établi par référence à deux théories et un panel de 99 pays couvrant la période 1990-2016 : le taux de change de PPA ajusté de l'effet productivité et le taux de change d'équilibre comportemental (BEER). Ces deux critères donnent des résultats assez différents sur les unions, entre les pays membres et sous périodes considérées. Les résultats sont robustes aussi bien à la définition de la mesure de la productivité qu'à la taille de l'échantillon. Globalement, la fin de période ne suggère pas de mésalignements qui pourraient justifier un changement de parité avec cependant des hétérogénéités nationales.

Keywords: Africa, equilibrium exchange rate, BEER, PPP, misalignments, productivity, Franc Zone.

Classification *JEL: C23, F31, F45, O47, O55*.

Abstract

In the Franc Zone, the fixed parity of the CFA franc is debated again, while the *eco*, a substitute currency, is to be announced in the WAEMU. We investigate the question about potential exchange rate misalignments in the two monetary unions (WAEMU, CEMAC) of this institutional space. The diagnosis is established by reference to two theories and from a panel of 99 countries over the period 1990-2016: the PPP exchange rate level adjusted for the productivity level and the *Behavioural Equilbrium Exchange rate* (BEER). These two theoretical criteria provide different results across unions, and country-members or sub-periods. Results are robust to the definition of the productivity measurement and to the sample size. Overall, the end of the period does not suggest misalignments that could justify a change of the parity although national heterogeneities arise.

Keywords: Africa, equilibrium exchange rate, BEER, PPP, misalignments, productivity, Franc Zone.

Classification *JEL: C23, F31, F45, O47, O55*.

I. Introduction

CFA francs circulate in fifteen African countries. They were pegged to the French franc between 1945 and 1999, then to the euro with an unchanged parity of 655.957 CFA francs since 1994.[11] The fixed or adjustable exchange rate regime is the most common option in Africa. In 2018, 59.2% of states adopted it, compared to 16.7% who preferred floating (IMF, 2019). In an institutional framework of coordinated monetary and fiscal policy, the case of the Franc Zone, a fixed exchange rate ratio has advantages. It contributes to the objective of price stability and reduces the transaction costs and uncertainties that affect international trade and investment. In the Franc Zone, we can add to this the principle of a guarantee of convertibility without a priori limit. In the event that reserves are exhausted within a union, the French Treasury provides a guarantee to the issuing institution of the West African Economic and Monetary Union (WAEMU) or the Economic Community of Central African States (CEMAC).[12]

[11] The franc zone is made up of two unions, the WAEMU composed of eight countries: Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo, and the CEMAC which includes the following countries: Cameroon, Central African Republic, Gabon, Equatorial Guinea, Congo (PR), Chad. Each of the two unions has its own CFA franc, whose parity is the same but can be adjusted separately. In addition to these two unions, there is the Comoros archipelago, which is not discussed in this article. Each union has its own independent central bank: the Central Bank of West African States (BCEAO) for the WAEMU, and the Central Bank of Central African States (BEAC) for the CEMAC. For the institutional arrangements and presentation of the Franc Zone, see S. Guillaumont Jeanneney (2016) and P and S Guillaumont (2017). For an analysis of economic performance in the Franc Zone, see Feindouno et al (2020).

[12] The convertibility of CFA francs is effective only in each of the issuing areas. In other words, the bills and coins of one union are not convertible in the other union, nor are they convertible in the rest of the world. This restriction, dating from 1993, was partly a response to the objective of reducing capital flight, which was reflected in CFA franc redemptions, particularly in Europe. Moreover, the convertibility guarantee from the French Treasury only comes into play after a "sweeping" policy by the Central Bank, which consists of mobilizing for its own benefit the currencies held by the union's public and private organizations. France's solidarity only comes into play as a last resort, after it has been effective in the area of the Union concerned by the exhaustion of reserves. In this context, this solidarity is automatic and without a priori limits, which does not exempt countries from setting up a correction program that very generally involves signing an agreement with the IMF. The Treasury's convertibility guarantee is therefore subtle. It is not an unconditional flow of aid, and a fortiori a donation, since the contribution of foreign currency is repayable.

In an economic environment that is stable or influenced by temporary shocks, exchange rate fixity is a factor of predictability for economic calculations. This advantage is less obvious when there are lasting changes. Since 2008, the slowdown in global growth and changes in relative commodity prices have altered African economic balances. The structure of international trade in the franc zone has also continued to be distorted to the benefit of imports from emerging countries, some of which have used active exchange rate policies. Intra-community trade is also modest because of undiversified production systems. However, WAEMU is more diversified than CEMAC, which is also more involved in regional integration through the Economic Community of West African States (ECOWAS) (see Coulibaly and Gnimassoun, 2013; Gnimassoun ,2019).

Eventually, the 15 ECOWAS states should constitute an effective free trade area with a common currency. Achieving this objective will take time. The exchange rate regime and its implications for monetary and fiscal policy is one of the stumbling blocks. Nigeria, which accounts for two-thirds of ECOWAS GDP and nearly four times that of WAEMU, is in favor of a flexible exchange rate regime. The WAEMU, on the other hand, wants to maintain a fixed parity with the euro. The principle was reiterated with the announcement of the forthcoming creation of the "eco" which should replace the CFA franc. The programming of these institutional changes against the backdrop of continental integration and the need for competitiveness calls for attention to the parity of the CFA franc. Some economies have been severely affected by the end of the commodity super-cycle, and all are awaiting structural transformations. The aim is to cope with the rapid increase in the working population and the rise in living standards. These long-term objectives and the economic and institutional changes underway raise questions about the appropriateness of the CFA franc parity.[13]

The equilibrium exchange rate is not directly observable, hence the ambiguities of definition and the plurality of measures (Hinkle and Montiel ,1999; MacDonald ,2000).

[13] The question of the equilibrium exchange rate is posed outside of the question of the optimality of the monetary zone. For an analysis from this angle, see Coulibaly and Gnimassoun (2013).

The question of the exchange rate is treated here independently of questions about the optimal monetary zone, which the Franc Zone is not because of its limited intra-community trade and the absence of budgetary transfers between countries to deal with asymmetric shocks. The focus is on a single question: is the parity of the francs acceptable for each of the two unions and for each of their member states? Two methods of identification, which are more complementary than competing, are used.

The first is absolute purchasing power parity (PPP). Between two countries at different levels of development, price parity is only effective once the price of non-tradable goods has converged. At any point in time, however, econometrics on an international panel reveals the presence of misalignments through the deviation from the convergence path dictated by productivity on tradable goods. This criterion assumes that productivity is the only factor in the evolution of the equilibrium exchange rate. Through its relationship with unit costs, however, this criterion provides information on the ability of relative prices to contribute to structural transformations. To facilitate these transformations and create a competitive advantage, some authors recommend that the price of non-tradables should evolve below the long-run convergence norm dictated by the productivity of tradables.

The second method is the behavioral equilibrium exchange rate (BEER).[14] It is associated with medium-term internal and external macroeconomic equilibrium. This criterion is preferred to the more normative Fundamental Equilibrium Exchange Rate (FEER) of Williamson (1983). Misalignments are determined from a cointegration analysis by the difference between the observed and estimated real exchange rate. The latter is determined by a small number of factors-i.e., the fundamentals. Franc zone countries are included in a panel of 99 countries considered over the period 1990-2016. In the presence of a limited time dimension, the estimation of a country-specific error correction model is not very robust (Chudik and Mongardini, 2007). A panel restricted to the Franc Zone would lead to ambiguities in interpretation. A monetary zone with a fixed exchange rate

[14] Behavioral Equilibrium Exchange Rate (BEER).

and guaranteed convertibility is a priori compatible with long misalignments. An African panel would not offer a less impeccable analytical framework, especially for the absolute PPP criterion and the positioning of African countries on the long-term price path.

The second section reviews the two equilibrium exchange rate criteria and the measurement of related misalignments. The third section is devoted to empirical applications. Depending on the evaluation method, differences appear both between the two unions and within them. The Central African Republic stands out from the other countries with an overvaluation attributable to political fragility. Overall, between 1994 and 2016, there were exchange rate imbalances within the zone, which varied according to the period, including within each monetary union, while remaining within margins compatible with the uniqueness of the parity. The fourth section focuses on the robustness of the results with respect to the measurement of the productivity effect and the composition of the sample. An innovation of the paper is to propose a correction for the Balassa-Samuelson effect by subtracting commodity rents from the per capita product. For the oil-exporting countries of the CEMAC, this correction has potentially significant effects. In the end, these analyses only marginally modify the results. The last section concludes with the main lessons of this work.

I. Two conceptions of the equilibrium exchange rate and related misalignments

The fundamental equilibrium exchange rate (FEER) is based on a desired and financially sustainable current account balance (external equilibrium) and on the realization of potential output without price pressures (internal equilibrium) (Williamson, 1983, 1994; Edwards, 1988, 1989). The measurement of the FEER is problematic for African economies with structural underemployment and an exorbitantly large informal sector. The uniqueness of the "desired" current account balance is also difficult to assess. While less prescriptive, the combination of our two criteria approaches the analytical content of the FEER.

1. Absolute Purchasing Power Parity corrected for the productivity effect

The equilibrium exchange rate equalizes the international price of the same basket of goods in a common currency. A deviation from this principle results in part from international productivity differentials in the production of tradable goods (the Balassa [1964] - Samuelson [1964] effect). Productivity catching up in this sector triggers wage increases that spread to non-tradable goods where productivity is internationally more homogeneous. Inflation that is somewhat higher than in the developed countries is therefore to be expected. It reflects the long-term trend towards equalization of the price of non-tradable goods that accompanies the convergence of per capita products. The price gap between countries at different levels of development is more important and lasting because labor, an abundant and cheap factor in low-income countries, is largely mobilized for the production of non-tradable services (Kravis and Lisey [1983]; Bhagwati [1984]). Factor endowment and the presence of structural unemployment are therefore factors that slow down international price convergence.[15]

Misalignments can be identified from the purchasing power parity conversion factor (i.e., the exchange rate of the dollar that allows one to buy the same quantity of goods in a country as in the United States). Dividing this conversion factor by the official exchange rate, we obtain a real exchange rate (*RER*) distributed in an interval (0-1). Under the assumption of the uniqueness of the price of tradable goods, a value of less than 1 indicates a purchasing power of the domestic currency greater than that suggested by the official dollar exchange rate. In an international sample covering all levels of development, the regression of RERs on per capita products gives the normal long-run trend of the productivity effect, while deviations from the regression line signal misalignments.

[15] Johnson et al (2004) estimate the time horizon for the convergence of price levels of non-tradable goods to be three or four centuries.

The real exchange rates of countries i $(RER)_{it}$ are therefore regressed on the PPP-expressed GDP per capita $(GDPPC)_{it}$. Time fixed effects, denoted f_t, are incorporated into the specification to capture the impact of shocks common to all countries in the sample, including the productivity of the United States in the tradables sector. The specification is proposed without country fixed effects, following Frankel (2004), Johnson et al (2007), Rodrik (2008), in more recent publications Couharde and Sallenave (2013) or Ribeiro et al (2020). The econometric estimation only aims at subtracting from the RER the long-run impact of productivity on relative prices. The joint introduction of country fixed effects and GDP per capita would pose an identification problem, since the former is often seen as a proxy for productivity (Cornwell, Schmidt, Sickles, 1990). The misalignment of the currency of country i in year t is measured by u_{it}.

$$\log (RER)_{it} = \alpha + \beta \log(GDPPC)_{it} + f_t + u_{it}, \quad (1)$$

$$Misalignments_{it} = log\ (RER)_{it} - \log \widehat{(RER)}_{it}$$

With $u_{it} < 0$, undervaluation and $u_{it} > 0$, overvaluation.

$RER_{it} = \frac{PPP_{it}}{XR_{it}}$ with $PPP_{it}\ and\ XR_{it}$, respectively, the conversion factor that equalizes the purchasing power of the currencies and the official exchange rate against the US dollar.

A well-functioning economy depends on a balanced relative price structure. For developing countries, however, market and organizational inefficiencies blur the message. Because of mass unemployment and the need for structural transformation, some authors advocate not sticking to a PPP target corrected for the productivity effect. For low-income countries, Rodrik (2005; 2008; 2009; 2010; 2015) argues that the production of tradable goods is penalized by the poor quality of public institutions. These failures act as an additional cost for the execution of contracts and the functioning of the economic system. Institutions would therefore be a barrier to development, whereas they should be a "lubricant" for confidence in market mechanisms (see Arrow 1972, 1974). The

transaction costs associated with them are not neutral for the productive structure. They affect the profitability of tradable goods whose price is fixed on the international market. On the other hand, these costs can be passed on to consumers of non-tradable goods depending on the degree of internal competition and the level of price elasticity of demand.

In this strand of literature, sustainable undervaluation of the real exchange rate would be a second-best solution for structural transformation, an option preferable to random and potentially misallocated public subsidies in the productive system (Nouira, et al 2011). Guzman et al (2018) have recently returned to the topic. A Stable and Competitive Real Exchange Rate (SCRER), i.e., an exchange rate that structurally supports the production of tradable goods, would be a key instrument of an industrial policy. It would allow discoveries and learning, which are long and costly, in an uncertain world of fixed or even irrecoverable costs. This instrument of horizontal industrial policy is therefore perceived as an incentive that is both economical in terms of public funds and does not generate distortions between branches and sectors of activity.[16]

2. BEER and the medium-term economic equilibrium

Using the Behavioural Equilibrium Exchange Rate (BEER) method, the equilibrium exchange rate is linked to a vector of fundamentals by an error correction model (Clark and MacDonald,1999; MacDonald,2000; Couharde et al, 2018). In Couharde et al (2018), this vector consists of three variables: the country's productivity relative to that of its trading partners, the net foreign assets position, and the international terms of trade. The equilibrium exchange rate and related misalignments are then calculated for 182 countries, including the 14 in the Franc Zone. The list of fundamentals is extended here

[16] The logic of a vertical industrial policy in which the state invests in the selection of activities and national champions (i.e., cherry-picking strategy) incurs the risk of faulty choices inherent to the weaknesses of the institution.

to include trade openness. The share of investment or public expenditure in GDP are variables that have been tested but found to be relevant.

Productivity reflects the Balassa (1964) - Samuelson (1964) effect. It is measured by the country's GDP per capita in PPP dollars relative to that of the average of its trading partners. The weighting scheme is identical to that used to construct the real effective exchange rate index (REER). Productivity is correlated with several factors, including attractiveness, institutional quality and public governance, which reduce transaction costs. The equilibrium exchange rate is also influenced by changes in relative prices between tradable goods (ToT). An increase in the price of exports relative to imports increases income and domestic demand so that the relative price of non-tradables rises. The income effect generally dominates the substitution effect whereby the price of non-tradables would fall because of a shift in domestic demand to imported goods. Trade openness is added to the previous determinants. It is measured by exports and imports of goods and services relative to GDP. Greater openness requires limiting the distortions in relative prices that affect the profitability of exposed firms. The change in net foreign assets (NFA) is associated with net capital flows. This ignores the compositional effects of these flows (Combes et al ,2012,2019; Stiglitz ,2008).

By estimating a cointegrating relationship, the misalignments are decomposed into cyclical or random deviations and long-term deviations. Given the very restrictive nature of the Dynamic Fixed Effect (DFE), two estimators can be used for the cointegration relationship. With the Mean group (MG), the coefficients are specific to each country so that independent regressions are estimated on the basis of which the mean coefficients are calculated (Pesaran and Shin, 1995). The quality of this estimator depends on the time dimension, which is quite short in our case. With the Pooled Mean Group (PMG), we assume the uniqueness of the long-run coefficients, while the constant, the short-run coefficients and the speed of adjustment are variable from one country to another. The estimator thus allows for different transitory shocks that generate

heterogeneity within the panel (see Pesaran et al.,1998, 1999; Blackburne and Frank,2007; Elbadawi et al.,2012). In the presence of common factors or interindividual dependence, the Cross- section augmented Mean Group (CMG) and Cross- section augmented Pooled Mean Group (CPMG) estimators should be considered (See Pesaran, 2006; De V. Cavalcanti et al., 2015).

The model to be tested can be specified as follows with the real effective exchange rate index (REER) of country *i*, calculated over *t* years as the weighted geometric average of the nominal exchange rate indices (XR) adjusted for relative consumer prices (*CPI*). The weight given to each country is a function of its importance among the top 10 partners j in imports and exports, excluding oil (γ_{ij}), from 2009-2013. These real effective exchange rates are established in the framework of FERDI's Sustainable Competitiveness Observatory (SCO). Descriptive statistics and data sources are provided in Appendices 1-3.

$$REER_{it} = \prod_{j=1}^{10} \left(XR_{ij} . \frac{CPI_{it}}{CPI_{jt}} \right)^{\gamma_{ij}} \qquad (2)$$

$$\log(REER)_{it} = \beta_{0i} + \beta_1 \log(Productivity)_{it} + \beta_{2i} \log(NFA)_{it} + \beta_{3i} \log(ToT)_{it} + \beta_{4i} \log(Openness)_{it} + \varepsilon_{it} \qquad (3)$$

Equation (3) can be written as an ARDL (1,1,1,1,1) model with X = (Productivity, NFA, ToT, Openness) as the vector of explanatory variables.

$$\log(REER)_{it} = \beta_{0i} + \lambda_i \log(REER)_{i,t-1} + \beta'_{io} \log(X)_{it} + \beta'_{i1} \log(X)_{i,t-1+} \varepsilon_{it} \qquad (4)$$

ε_{it} is a random deviation. From Equation (4) and the specification of the Mean Group (MG) estimator that allows for variation in all regression coefficients across country *i*, we can rewrite the Error Correction Model (ECM) as follows:

$$\Delta \log(REER)_{it} = \phi_i [\log(REER)_{i,t-1} - \beta_{0i} - \beta'_i \log(X)_{i,t-1}] + \lambda'_i \Delta \log(X)_{it} + \varepsilon_{it} \qquad (5)$$

ϕ_i is the error correction coefficient (ECC). Negative and less than unity, this coefficient indicates how quickly the endogenous variable returns to long-run equilibrium following shocks to fundamentals. With the Pool Mean Group (PMG) estimator, the short-run regression coefficients are country-specific so that (β_0, β') substitute for (β_{0i}, β'_i) in (5). The misalignment measure comes as follows where log $(REER)_{it}$represents the estimate restricted to the long-run relationship.

$$Misalignements_{it} = log\ (REER)_{it} - \log \widehat{(REER)}_{it} \qquad (6)$$

II. Measurement and interpretation of misalignments

1. Application of the principle of PPP adjusted for the productivity effect

$$\text{Log}\ \widehat{(RER)}_{it} = \underset{(0,01)}{0,264^{***}}\ log(GDPPC)_{it} - \underset{(0,12)}{2,946^{***}} \qquad (7)$$

$$R^2 = 0,449\ et\ \ n = 693$$

The relationship between the real exchange rate (RER) and the GDP per capita in PPP dollars (GDPPC) is estimated on 693 observations. The 99 countries are observed over 27 years divided into four-year sub-periods, which have the advantage of filtering out random shocks.[17] The GDPPC coefficient is of the same order as that proposed in the empirical literature (Rodrik, 2008). The percentages of misalignment in the Franc Zone are reported in Table 1 for the main subperiods. The pre-devaluation period (1990-1993) shows that the need for parity adjustment was more pronounced in the WAEMU than in the CAEMC. This is borne out by both the simple and weighted averages of misalignments. Giving equal weight to each member state is in keeping with the institutional logic of the two unions. Legally, a parity adjustment must receive the consent of all member countries of a union. However, Côte d'Ivoire and Senegal contribute nearly 60% of the WAEMU's GDP, and Cameroon 46% of that of the CEMAC.

[17] This approach is consistent with the estimation of the BEER, where the filtering is carried out through the cointegration relation that separates the short- and long-term effects.

If need be, these countries can therefore win membership, if necessary, by financially compensating those that would not have agreed to the parity adjustment, hence the interest in also reasoning on the weighted average.

The 1994 devaluation had a lasting effect on the competitiveness of the franc zone. Although the percentage adjustment of the parity was significant (50%), the pass-through of this nominal change to consumer prices was quite low. Several reasons contributed to the limitation of a generalized pass through. The reduction of tariffs and non-tariff barriers has squeezed trade margins and increased local competition. At the same time, the monetary policy of the two central banks has been prudent and public wages have changed little, so that domestic demand has helped to moderate the rise in prices of non-tradables. All other things being equal, the RER was therefore favorable to tradable goods. These competitive advantages were slowly eroded, particularly in WAEMU, where the early 2000s saw a return to overvaluation, i.e., an RER above the long-term international standard set by the PPP adjusted for the productivity effect. While the situation subsequently improved between 2014 and 2016, the misalignment remains significant in Niger and Togo.

Table 1. Productivity-adjusted PPPs and Misalignments in the Franc Zone (in %)

	1990-1993	1994-1997	2010-2013	2014-2016
WAEMU (simple average)	**24**	**-1**	**18**	**16**
WAEMU (weighted average)	**26**	**3**	**15**	**12**
Benin	15	0	14	10
Burkina-Faso	56	20	17	10
Côte d'Ivoire	5	-9	10	9
Guinea-Bissau	-44	-59	17	20
Mali	12	-13	9	10
Niger	48	23	37	33
Senegal	55	23	17	8
Togo	43	10	23	24
CEMAC (simple average)	**15**	**-19**	**7**	**-5**
CEMAC (weighted average)	**9**	**-21**	**0**	**-15**
Cameroon	39	22	6	2
Central African Republic	102	60	53	76
Chad	20	-7	23	8
Congo	-42	-60	10	-31
Equatorial Guinea	18	-59	-35	-53
Gabon	-45	-68	-12	-32

N.B. The misalignments are derived from the regression estimate on 99 countries and over 1990-2016. Only the most interesting four-year subperiods are shown here. For more information, see Tables A.1 and A.2 in the Appendix. Positive numbers reflect overestimates.

In CEMAC, the overvaluation of 2006-2013 faded at the end of the period. The average exchange rate for the union is close to equilibrium, although there are disparities between member countries. In Equatorial Guinea, the price of non-tradables is lower than the norm for a per capita GDP that is strongly influenced by the oil sector. In 2008, depending on whether one reasons in current dollars prices or international dollars using purchasing power parity (PPP) rates, GDP per capita was $22,742 and $38,441 respectively, close to Portugal's levels! In 2017, the decline was significant: 9,850 and 24,917 dollars. The undervaluation of 53% over 2014-2016 thus bears the mark of the oil economy, its influence in terms of prices and exported volumes.

With a 76% overvaluation between 2014 and 2016, the Central African Republic is at the other end of the CEMAC spectrum. The misalignment is largely a consequence of internal political convulsions. The civil war (2012-2016) was a violent productivity shock. It

resulted in a contraction of GDP per capita from $566 to $402, a 29% decline. In this context of vulnerability, adjusting the nominal exchange rate would have little effect on the production of tradables. In addition to the drop in GDP, which is partly a consequence of the contraction of food crops and the displacement of populations, there is a lack of fluidity in transportation and logistics. This has led to higher risk premiums on the international corridor between Bangui, the capital, and Douala, the main Cameroonian port of entry to this landlocked country (see Plane,2021). The decline in production and the rise in prices are thus the ingredients of the overvaluation highlighted by the criterion of absolute PPP adjusted for the normal effect of productivity.

2. Estimating the behavioral exchange rate (BEER)

The cross-sectional dimension of the sample, 99 countries observed over the period 1990-2016, largely dominates the temporal depth (N>T). A problem of cross-section dependence (CD) may arise and bias the results of standard stationarity and cointegration tests. The Pesaran test [2004] allows us to identify this problem. Under the null hypothesis of cross-section independence, the CD statistic tends towards N (0,1).

Table 2. Test of cross-section dependence (Pesaran, 2004)

H0: No cross-sectional dependence					
Variables	***REER***	***Productivity***	***NFA***	***TOT***	***Openness***
Pesaran (CD- test)	15.20	72.18	26.45	9.11	-1.93
P-Value	(0.00)	(0.00)	(0.00)	(0.00)	(0.05)

Cross-sectional independence is systematically rejected (Table 2). The implementation of the second generation CIPS (Cross-Sectionally Augmented IPS) stationarity test of Pesaran (2007) highlights the non-stationarity of the fundamentals in level and the stationarity in first difference (Table 3).

Table 3. Test de stationnarité de Pesaran (2007) - CIPS

H0 : les séries sont intégrées I (1)		
Variables	Level	First-difference
REER	1.238 (0.892)	-7.394 (0.000)
Productivity	4.687 (1.000)	-7.120 (0.000)
NFA	-3.439 (1.000)	-4.823 (0.000)
TOT	-7.711 (0.990)	-5.707 (0.000)
Openness	2.581 (0.995)	-8.960 (0.000)

N.B. P-values are expressed in brackets. The specifications incorporate a maximum of two lags.

Table 4. Test de cointégration

Pedroni's cointegration test (2004)						
Tests				Statistics		P-value
Phillips-Perron Modified				4.64		0.00
Phillips-Perron				-4.96		0.00
Augmented Dickey-Fuller				-3.88		0.00
Westerlund cointegration test (2007)						
Tests	with constant			with constant and trend		
	Statistics	P-value	Robust P-value	Statistics	P-value	Robust P-value
Gt	-2.640	0.000	0.000	-3.089	0.000	0.060
Ga	-9.374	0.000	0.080	-14.574	0.000	0.570
Pt	-28.886	0.000	0.010	-34.677	0.000	0.000
Pa	-11.559	0.000	0.000	-17.485	0.000	0.000

Note: H0: no cointegration. The specification of the model is one in which the real effective exchange rate is explained by productivity, NFA, ToT and openness. The optimal number of lags and leads is determined by the Akaike information criterion. Robust p-values are obtained by bootstrapping at 100 iterations.

Table 4 presents the Pedroni (2004) and Westerlund (2007) cointegration tests, first and second-generation tests, respectively. The test statistics of Pedroni (2004) are obtained after correcting for interindividual dependence according to the procedure of Levin, Lin, and Chu (2002).[18] The test of Westerlund (2007) evaluates cointegration

[18] Implemented in Stata 15 software.

through four statistical tests: group-mean tests (Ga, Gt) and panel tests (Pa, Pt). The application of these tests rejects the null hypothesis of no cointegration.

Regressions with the CMG and CPMG estimators are proposed with the short-run dynamics and error correction coefficient on the sample of 99 countries over the period 1990-2016 (Table 5). The empirical choice between CPMG and CMG is mediated by the Hausman test, which does not reject, at 91% confidence, the null hypothesis of difference in long-run coefficients across countries $[(\chi^2(4) = 1{,}01)]$.

The long-run coefficients have the expected signs. Since the variables are expressed in logarithm, these coefficients are elasticities. For a 1% increase in the relative productivity index, column 2 suggests that the Balassa-Samuelson effect translates into a 0.156% increase in the real exchange rate. The use of relative productivity is justified by the country-specific weighting scheme of the REER partners. For the PPP criterion, the country's productivity approximated by GDP per capita was sufficient insofar as the United States was the common reference for the entire sample. The impact of the terms of trade is somewhat weak with an elasticity of 0.10%. In generally smaller samples, the range is more like 0.15% - 0.25% (see Elbadawi et al, 2012).

Table 5. BEER model
(sample of 99 countries over the period 1990-2016)

	(1) *CMG*	(2) *CPMG*
	Long-term coefficients	
Productivity	0.609*	0.156***
	(0.356)	(0.0232)
NFA	0.601	0.615***
	(1.756)	(0.0746)
ToT	0.162	0.0960***
	(0.200)	(0.0237)
Openness	-0.195	-0.226***
	(0.186)	(0.0262)
	Short-term coefficients	
ECC = (ϕ_i)	**-0.461*** **	**-0.172*** **
	(0.0288)	**(0.0174)**
Productivity	-0.0751	0.0768
	(0.0837)	(0.0782)
NFA	0.223	0.523***
	(0.150)	(0.145)
ToT	0.0130	-0.0144
	(0.0260)	(0.0285)
Openness	-0.254***	-0.320***
	(0.0331)	(0.0374)
Constant	-6.65e-05	-0.00120
	(0.0202)	(0.00451)
Observations	2 574	2 574
CD P-Value	0.390	0.884
Hausman test (1) vs (2)	1.01 (P-value: 0.909)	

Nota bene. Standard deviation in parentheses; *** p<0,01, ** p<0,05, * p<0,1. CD P-value refer to the Pesaran (2004) cross-sectional dependence test with a normally distributed statistic under the null hypothesis of no cross-sectional dependence. The variables are expressed in logarithm except for net foreign assets. CCE: error-correction coefficient that we noted ϕ_i in the theoretical specification (5).

For the trade openness rate, the elasticity is in common order of magnitude. A 1% increase results in a 0.2% decrease in REER. The coefficient on NFA is also at the expected level. Negative, the error-corrected coefficient suggests an adjustment speed of 17.2% per year. Thus, it takes 3.9 years for a halving of the gap to equilibrium. This percentage is in the

range of what is found elsewhere with variations in methodological options (see Elbadawi et al, 2012; Edwards,1989; Owoundi, 2016; Abdih and Tsangarides, 2008).

The results with the behavioral model only partially confirm the application of the PPP criterion. The 1994 parity adjustment is once again justified with initial misalignments (1990-1993) that are larger in CEMAC than in WAEMU (Table 7). Moreover, the CFA franc, which was heavily undervalued on a PPP basis at the end of the period, is now moderately overvalued in Equatorial Guinea. The sub-period (1990-1993) was a turning point. Oil exploitation and the good terms of trade situation led to a rebalancing that resulted in a shift from significant overvaluation to undervaluation in the second half of the decade.

For both unions, after 1994, the CFA franc fluctuated around the value of the behavioral equilibrium exchange rate (BEER), within acceptable margins of fluctuation with respect to the fixed exchange rate regime and the institutional arrangements for cooperation with France. The situation has never been comparable to the deterioration in the economic and financial situation of 1985-1993, which motivated the 1994 devaluation (Collange and Plane, 1994). The most recent sub-period therefore does not raise questions about the adequacy of the parity. However, the Central African Republic continues to stand out, but we know both the origin and the solutions, which are above all political and institutional.

The results obtained are in line with those of the IMF (2018a, 2018b). The institution refers to a misalignment in CEMAC of between -5% and +16.6%, while the WAEMU would be close to the equilibrium exchange rate. The comparison can also be made with the CEPII's BEER model, which covers a different period than ours: 1973-2016 versus 1990-2016. The model has only three fundamentals (Productivity, NFA, TOT) and the weighting scheme is based on 30 partner countries according to the relative weight of exports and imports. Ten partners are retained in our approach, which also excludes oil trade. Over 2014-2016, Figure 1 proposes three calculation methods for each union. On the left, the CEPII distribution, then our two with the variant on fundamentals,

respectively three (CEPII) and four. For the WAEMU, the distributions are comparable, with less deviation with our approach, and a median that highlights the same level of undervaluation. For the CEMAC, the median is also close to the equilibrium exchange rate, but with a more dispersed distribution.

Figure 1 : Comparative analysis of misalignments (2014-2016)

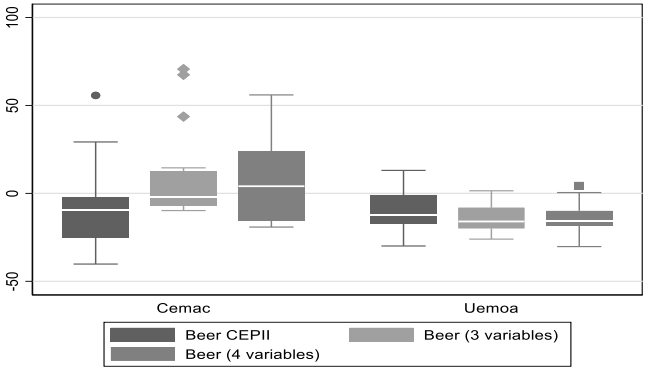


Table 6. The BEER cointegration relationship and misalignments

(Percentage, Franc zone, CPMG estimator)

	1990-1993	1994-1997	2010-2013	2014-2016
WAEMU (simple average)	**8**	**-18**	**-9**	**-15**
WAEMU (weigthed average)	**15**	**-10**	**-5**	**-13**
Benin	-6	-33	-16	-22
Burkina Faso	13	-20	-12	-15
Côte d'Ivoire	20	-1	3	-14
Guinea Bissau	-26	-32	-23	-27
Mali	25	-3	-3	2
Niger	12	-22	-7	-16
Senegal	18	-4	-7	-14
Togo	4	-25	-4	-14
CEMAC (simple average	**22**	**7**	**-3**	**7**
CEMAC (weigthed average)	**22**	**6**	**-5**	**-4**
Cameroon	12	-10	-11	-14
Centrafrique	11	-16	-6	46
Chad	18	-13	1	0
Congo	1	36	8	20
Equatorial Guinea	56	47	6	6
Gabon	35	-3	-15	-18

Table 7. Wilcoxon tests: comparative analysis of average adjustment speeds on the long-run equilibrium exchange rate
(CPMG Estimator, 1990-2016)

	Mean adjustement speed	Standard Deviation	Wilcoxon Tests*		
			Z-stat	Probability	Compar-isons
Franc Zone (FZ, 14 countries**)**	-27.0	19			
WAEMU	*-27.0*	*14.0*			
CEMAC	*-28.0*	*27.0*			
Africa excl. FZ (27 countries**)**	-20.0	19.0	1.457	0.145	14/27
Developing countries excl. FZ (59 countries**)**	-17.0	19.0	2.263	0.024	14/59
All countries excl. **FZ (85** countries**)**	-17.0	17.0	2.626	0.008	14/85

*The speeds are obtained from the CPMG estimator on 99 countries. For the Wilcoxon test, the reference subset is the Franc Zone, 14 countries. The null hypothesis H0: In the Franc Zone, the average speed of adjustment of the REER to the equilibrium is equal to the average speed of adjustment of the comparison subset, respectively Africa, developing countries (DCs) and all countries.

An extension of the discussion consists in knowing whether the fixed exchange rate regime of the CFA franc has resulted in a slower speed of return to the equilibrium rate. The CPMG estimator is associated with a speed of adjustment by country so that we can compare those of the union with those of countries outside the franc zone. Because of the small size of the subsets, comparisons are made based on the non-parametric Wilcoxon test, which does not imply the normality hypothesis and compares the ranks of the distributions. The speeds of adjustment are obtained with a time dimension of 27 years so that caution should be exercised in the commentary. With this caution, the hypothesis that the adjustment to the equilibrium value would have been faster in the Franc Zone is not rejected, except for African countries outside the Franc Zone (Table 7).

III. Robustness analysis

Approximating productivity by GDP per capita is problematic. Oil rents in the CEMAC raise the level of permanent income of agents without reflecting productivity for other tradable goods that condition the effectiveness of productive diversification. The

consequences are possible for the BEER, and some for the PPP criterion adjusted for the Balassa-Samuelson effect. The second sensitivity test is related to the sample. Are the BEER model estimates affected when the sample is restricted to developing countries?

1. Productivity measured by GDP per capita excluding rents

Productivity is the driving force behind price convergence with the absolute PPP criterion, one of the fundamentals of BEER. For countries producing rent-generating natural resources, GDP per capita (current international PPP$) is not a good indicator of aggregate factor productivity. While the discovery and exploitation of, for example, oil raises permanent income, especially through the associated rent, productivity in the tradable goods sector does not, so that the tradable goods sector may suffer from "Dutch disease" (Corden and Neary 1982). Productive transformation requires that both the real exchange rate (RER) and the real effective exchange rate index (REER) be related to the productivity of tradable goods outside the rent sector.

In analyzing the BEER of the G20 countries, one of the analytical options adopted by Bénassy-Quéré, Béreau and Mignon (2008) is to approximate productivity by the relative price between non-tradable and tradable goods. This choice does not have only advantages. The relative price may be influenced by variables other than productivity. Moreover, the reasoning is circular. The REER is explained by an internal relative price that is a component of the REER. In our case, capturing the productivity effect through the relative internal price would finally require reasoning about a tradable good that is different from rent products, otherwise the objection made to per capita income would be maintained. Our correction consists in subtracting rents from GDP (current international PPP$) before relating the aggregate to the population. The World Bank measures the percentage of rents from 5 products (k): oil, natural gas, coal, mines, and forest products (see World Development indicators).

In a competitive market, at equilibrium, the price is equal to the marginal cost, which is the minimum of the average cost. For a country i and a product k, the approximation of rents at time t, denoted θ_{ik}, is deduced from the gap in dollars between the exogenous world price P_k and the average cost of local production (CM_{ik}). This gap is then weighted by the relative weight (μ_{ik}) of product k in GDP with $\theta_i \epsilon [0, 1]$. By this calculation procedure, a GDP per capita excluding rents is derived.

$$\text{GDPPC excluding rents} = (1-\theta_i)\,\text{GDPPC, with } \theta_i = \sum_{k=1}^{n}(P_k - CM_{ik})\mu_{ki}$$

For the Franc Zone, the importance of rents varies considerably over time and by union. Between 1990 and 2016, the figures in parentheses indicate the percentage of rents in GDP in the year when they were highest. The WAEMU is only concerned with gold mining in Burkina Faso (17.6%; 2016) and Mali (16.8%; 2012). With oil, the figures are far more spectacular in CEMAC: Equatorial Guinea (84.2%; 2000), Congo (59.6%; 2006), Gabon (45.8%; 2008) and Chad (38%; 2005).

GDP per capita excluding rents ($GDPPC_{ER}$) is used for both criteria for equilibrium rate analysis. For the absolute PPP criterion adjusted for the Balassa-Samuelson effect, the misalignment noted u'_{it} is now set as follows.

$$\text{Log}\,(RER)_{it} = \alpha + \beta' \log\left[(1-\theta)_{it}(GDPPC)_{it}\right] + u'_{it} \qquad (8)$$

$$\text{Log}\,\widehat{(RER)}_{it} = \underset{(0.01)}{0{,}265^{***}}\; log(GDPPC_{ER})_{it} - \underset{(0.11)}{2{,}937^{***}} \qquad (9)$$

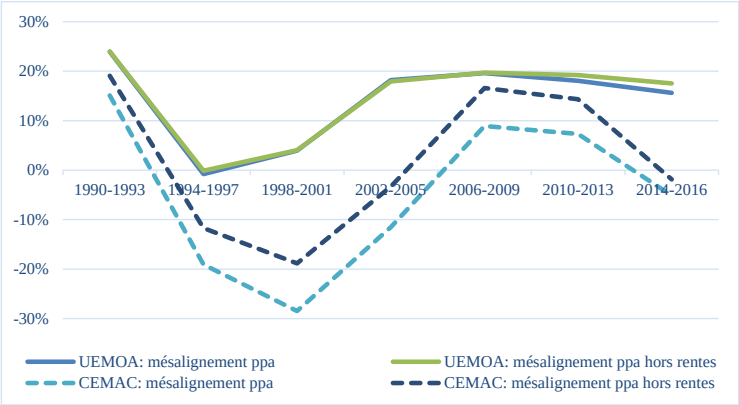
$$R^2 = 0.477 \; et \; n = 693$$

The new productivity measure does not induce a difference with the previous coefficient ($GDPPC_{ER}$). The stability of the elasticity is obviously consistent with differences in impact at the union and country level, particularly for the CEMAC. At the end of the period, the difference is limited to 2 percentage points in WAEMU, with an average overvaluation that varies between 16% and 18% (Figure 2). In the CEMAC, the difference highlights an undervaluation of 3 percentage points (-5% to -2%). Removing rents from GDP reduces

the tolerance for normal price appreciation of non-tradables. This is true for four oil-producing countries (Congo, Equatorial Guinea, Chad, and Gabon).

With the BEER model, the new productivity measure affects the previous results only very moderately. The curves in Figure 3 are almost identical for the WAEMU and moderately different for the CEMAC. Fundamentals other than productivity contribute to the mitigation of the impact.[19]

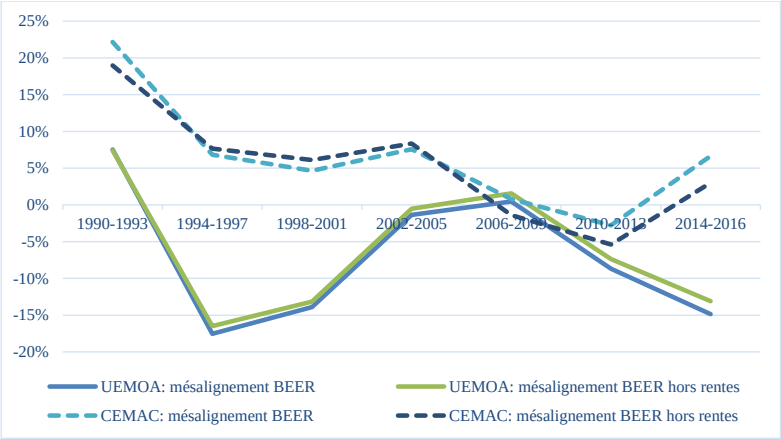
Figure 2 : PPP exchange rate misalignments and the sensitivity of the productivity measure (1990-2016, 99 countries)



Source: Authors from estimation of regressions (7) and (9).

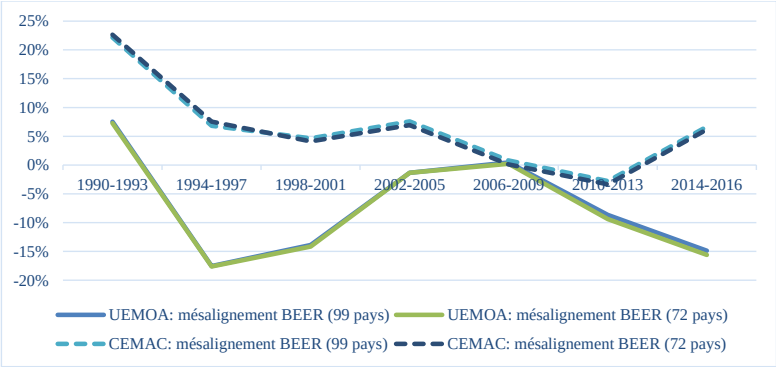
[19] A graphical comparison of our results with those of CEPII shows that at the WAEMU level, over the entire period, the reference to two or three fundamentals does not introduce any notable differences, nor does the way productivity is measured. The differences for the CEMAC are more marked, in line with what we know about international specializations (see Appendix).

Figure 3 : Misalignments and BEER (CPMG): sensitivity to the productivity measure



Source: Authors based on Tables 6 and 8.

Figure 4 : BEER misalignments and sample size sensitivity



Source: Authors based on regressions in Table 8.

2. Misalignments and sample composition

The second robustness test is on the size of the sample of countries that we only modify for the estimation of the cointegration model (BEER).[20]

The achievement of major macroeconomic balances, between savings and investment, is not independent of the chronic underemployment of developing countries, the degree of currency convertibility, which affects the level of net foreign assets, or the concentration of exports, which induces a particular sensitivity to variations in the terms of trade. These differences are sources of heterogeneity that can affect long-term misalignments. The model is therefore re-estimated, using the CPMG estimator, on the sample of 72 developing countries, i.e., 1872 observations.

Table 8 presents the regressions with the full sample and restricted to developing countries only, and with the two productivity measures. The estimates are obtained as before with the CPMG estimator. The regression coefficients, including the speeds of adjustment, are stable and the levels of significance are not greatly affected. Net foreign assets (NFA) is the only variable for which the coefficient varies between 13% and 22%. The two productivity indicators themselves produce a gap of between 10% and 15%. Unlike the PPP equilibrium exchange rate, which was not sensitive to the measure of productivity, the absence of rents in GDP per capita raises its impact on the coefficient of determination of the equilibrium exchange rate.

[20] As noted above, for the relationship between the RER and productivity, it is preferable to keep the sample covering the broadest spectrum of per capita income.

Table 8. The BEER model and the cointegration

(Sample of 72 countries with and without correction on productivity measure, 1990-2016)

	(1)	(2)	(3)	(4)
	CPMG	CPMG PED	CPMG	CPMG PED
	Balassa Samuelson (GDP per capita, PPP$)		Balassa Samuelson (GDP per capita, PPP$. excl rents)	
	Long-term coefficients			
Productivity	0.156***	0.169***	0.180***	0.186***
	(0.0232)	(0.0266)	(0.0251)	(0.0274)
NFA	0.615***	0.752***	0.749***	0.851***
	(0.0746)	(0.0925)	(0.0901)	(0.101)
ToT	0.0960***	0.0978***	0.111***	0.105***
	(0.0237)	(0.0265)	(0.0244)	(0.0264)
Openness	-0.226***	-0.252***	-0.256***	-0.259***
	(0.0262)	(0.0275)	(0.0250)	(0.0264)
	Short-term coefficients			
ECC	**-0.172*** **	**-0.184*** **	**-0.155*** **	**-0.173*** **
	(0.0174)	**(0.0225)**	**(0.0168)**	**(0.0217)**
Productivity	0.0768	0.00778	0.201***	0.128*
	(0.0782)	(0.0952)	(0.0561)	(0.0688)
NFA	0.523***	0.732***	0.492***	0.694***
	(0.145)	(0.188)	(0.148)	(0.193)
ToT	-0.0144	-0.00602	0.0109	0.00415
	(0.0285)	(0.0340)	(0.0287)	(0.0337)
Openness	-0.320***	-0.248***	-0.325***	-0.256***
	(0.0374)	(0.0394)	(0.0362)	(0.0376)
Constant	-0.00120	0.00198	0.00127	0.00490
	(0.00451)	(0.00632)	(0.00421)	(0.00560)
Observations	2 574	1 872	2 574	1 872
CD P-Value	0.884	0.857	0.965	0.995

Sources. See Appendices 1 to 3. ECC: error correction coefficient, ϕ_i in the general theory specification (5). CD P-value refers to the Pesaran (2004) test of cross-sectional dependence, whose statistics are normally distributed under the null hypothesis of no cross-sectional dependence. With the use of the CPMG estimator we reject the inter-individual correlation.

Overall, the results are stable, robust to variations in the sample and productivity measures (Figure 4). For WAEMU, the simple average over 2014-2016 shows, depending on the hypothesis used, an undervaluation of between 13% and 16% (see Tables A.3 and

A.4 in the Appendix). For CEMAC, the overvaluation is between 2% and 7%. Once again, the percentages vary significantly only for Equatorial Guinea. Excluding rents now produces an undervaluation of between 14% and 16% for the 99 and 72 country samples respectively, and an overvaluation of between 4% and 6% for these samples when rents are removed from GDP.

IV. Conclusion

The exchange rate of CFA francs is regularly discussed. The objective of the paper was to assess whether the 1994 parity remained in line with the equilibrium exchange rate of the two unions (WAEMU, CEMAC) and of each of their members. The two analytical criteria adopted showed differences between the monetary unions, between the sub-periods and countries considered. The two criteria also yield different results. The BEER model is more favorable to the WAEMU than the PPP criterion and vice versa for the CEMAC. The misalignments were found to be insensitive to the productivity measure and to the composition of the sample. At the end of the period (2014-2016), the deviations from the equilibrium rate do not seem to call for a readjustment of parity. However, among the 14 members, the Central African Republic stands out with a notable overvaluation. The situation in the country is the result of vulnerabilities and political fragility, the consequences of which cannot be reduced to a nominal exchange rate adjustment.

For economies that aspire to productive transformation, these conclusions may be reinterpreted less favorably. Sustained undervaluation is favored by those who see active exchange rate policy as a means of supporting growth and diversification. If undervaluation is to be the norm for the absolute PPP criterion, the franc zone can do better. But doubts remain about the effectiveness of this recommendation, which has worked especially well in Southeast Asia. In any case, there are many reasons why the parity of the CFA franc or the "eco" will remain on the table.

The management of the Covid-19 gives rise to active monetary policies. The past health crisis, inflation and the movement of foreign exchange reserves could revive questions

about the parity. The issue of overindebtedness has also made a comeback in Africa. In the franc zone, overindebtedness concerns the Congo and Chad. Since 1996 and the initiative launched by the IMF and the World Bank in favor of heavily indebted poor countries (HIPC), foreign debt had ceased to be a major concern. A new episode of overindebtedness is emerging with debts carried by China in particular. The international community's treatment of this issue will indicate to what extent debt can once again become one of the fundamentals of the equilibrium exchange rate. The African Continental Free Trade Area (AfCFTA) will also be an increasingly topical issue. This integration will bring opportunities, but also risks in terms of intra-continental competitiveness.

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Appendix to Chapter 1

Appendix 1: Sample and data

List of the 99 countries in the sample

Algeria, Angola, Argentina, *Australia*, Bangladesh, *Belgium*, Belize, Benin, Bhutan, Bolivia, Brazil, **Burkina Faso**, Burundi, **Cameroon**, Cape Verde, **Central African Republic**, **Chad**,*Chile*, China, Colombia, Comoros, **Congo**, Costa Rica, **Côte d'Ivoire**, *Cyprus*, *Denmark*, Dominica, DR Congo, Ecuador, Egypt, El Salvador, **Equatorial Guinea**, Ethiopia, *Finland*, *France*, **Gabon**, Gambia, Germany, Ghana, *Greece*, Grenada, Guatemala, Guinea, **Guinea-Bissau**, Honduras, *Iceland*, India, Indonesia, *Ireland*, *Israel*, *Italy*, Jamaica, *Japan*, Jordan, Kenya, Laos, Lebanon, Madagascar, Malawi, Malaysia, **Mali**, Mauritius, Morocco, Mozambique, *New Zealand*, **Niger**, Nigeria, *Norway*, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, *Portugal*, Rwanda, **Senegal**, Seychelles, Sierra Leone, South Africa, *Spain*, Sri Lanka, Sudan, *Sweden*, *Switzerland*, Tanzania, Thailand, **Togo**, Trinidad and Tobago, Turkey, Uganda, *United Arab Emirates*, *Uruguay*, *USA*, Venezuela, Yemen, Zambia.

N.B. In bold, Franc Zone countries. In italics, high-income countries.

Table A.1. Definition and sources of variables

Variables	Definitions	Source
RER	The ratio of the PPP conversion factor (the number of units of a country's currency needed to purchase the same quantity of goods and services in the domestic market as one U.S. dollar) divided by the market exchange rate.	WDI, World Bank
GDPPC	GDP per capita in purchasing power parity converted to international dollars.	World Bank, International Comparison Program database
REER	Geometric mean of nominal exchange rate indices vis-à-vis the top 10 bilateral trading partners. The weighting scheme refers to the relative importance of non-oil imports and exports adjusted for relative prices. Weights are calculated over the period 2009-2013. Base 100 =2010.	OCD-Ferdi from CEPII data (BACI 2018) and International Financial Statistics, IMF, 2017
Productivity	For the BEER, the productivity index is measured in relative terms by considering the main bilateral trading partners of the country under consideration. The weights are the same as those used to establish the REER. The index is a geometric mean, base 100 = 2010. Productivity is measured from GDPPC, with or without rents	OCD-Ferdi, based on CEPII data (BACI, 2018) and WDI, World Bank
NFA	Net foreign assets excluding the impact of the average terms-of-trade effect, as a percentage of GDP	Philip R. Lane and Gian Maria Milesi-Ferretti (2017)
TOT	Terms of trade, ratio of country's export prices to import prices	World Economic Outlook (2018), FMI.
Openness	Residual of a log regression of the ratio of exports and imports of goods and services as a percentage of GDP to total population, natural rents as a percentage of GDP, and a landlocked country's dummy	Calculated from data, WDI, World Bank
Rents	Sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents (expressed as a percentage of GDP).	WDI, The World Bank
CC/PIB	Current account balance in percentage of GDP	World Economic Outlook (2018), IMF.
M2/PIB	Broad money in percentage of GDP	WDI, World Bank

Table A.2. Descriptive statistics (1990-2016, 99 countries)

Variables	*Obs*	*Mean*	*Std.Dev*	*Min*	*Max*
REER	*2673*	*107.649*	*30.937*	*39.735*	*599.039*
Productivity	*2673*	*106.986*	*27.254*	*13.859*	*459.02*
NFA/PIB	*2673*	*-0.416*	*0.942*	*-5.421*	*17.268*
ToT	*2673*	*103.633*	*30.769*	*17.995*	*672*
Openness	*2673*	*71.939*	*40.079*	*11.087*	*531.737*
CC/PIB	*2666*	*-3.479*	*9.412*	*-124.557*	*49.98*
M2/PIB	*2299*	*50.601*	*40.091*	*2.857*	*267.388*
RER	*2673*	*0.544*	*0.318*	*0.076*	*1.856*
Rents/PIB	*2673*	*7.829*	*10.889*	*0*	*78.568*
GDPPC	*2673*	*12007.84*	*14187.27*	*242.001*	*84604.34*
GDPPC excl rents	*2673*	*13157.82*	*15090.23*	*289.732*	*90973.36*

Sources, see Table A.1. in the Appendix 1.

Appendix 2: Robustness and sensitivity of misalignments

Table A.3. PPA misalignments and productivity sensitivity

	1990-1993		1994-1997		2010-2013		2014-2016	
	GDPPC	*GDPPC HR*	*GDPPC*	*GDPPC HR*	*GDPPC*	*GDPPC HR*	*GDPPC*	*GDPPC HR*
WAEMU (simple average)	**24**	***24***	**-1**	***0***	**18**	***19***	**16**	***18***
WAEMU (weighted average)	**26**	***26***	**3**	***2***	**15**	***16***	**12**	***13***
Benin	15	*16*	0	*0*	14	*13*	10	*10*
Burkina Faso	56	*56*	20	*21*	17	*20*	10	*14*
Côte d'Ivoire	5	*4*	-9	*-10*	10	*10*	9	*9*
Guinea Bissau	-44	*-40*	-59	*-55*	17	*19*	20	*24*
Mali	12	*11*	-13	*-13*	9	*11*	10	*12*
Niger	48	*48*	23	*24*	37	*38*	33	*35*
Senegal	55	*54*	23	*22*	17	*15*	8	*8*
Togo	43	*43*	10	*11*	23	*28*	24	*28*
CEMAC (simple average)	**15**	***19***	**-19**	***-12***	**7**	***14***	**-5**	***-2***
CEMAC (weighted average)	**9**	***12***	**-21**	***-15***	**0**	***6***	**-15**	***-13***
Cameroon	39	*39*	22	*21*	6	*5*	2	*2*
Central African Republic	101	*101*	58	*60*	53	*53*	76	*78*
Chad	20	*20*	-7	*-5*	23	*29*	8	*11*
Congo	-42	*-31*	-60	*-46*	10	*27*	-31	*-23*
Equatorial Guinea	18	*23*	-59	*-40*	-35	*-26*	-53	*-50*
Gabon	-45	*-38*	-68	*-59*	-12	*-3*	-32	*-29*

N.B *ER* means that productivity is measured by GDP per capita excluding rents

Table A.4. Misalignments with the BEER model and sensitivity to productivity (CPMG Estimator)

	1990-1993		1994-1997		2010-2013		2014-2016	
	GDPPC	*GDPPC HR*	*GDPPC*	*GDPPC HR*	*GDPPC*	*GDPPC HR*	*GDPPC*	*GDPPC HR*
WAEMU (simple average)	**8**	**7**	**-18**	**-16**	**-9**	**-7**	**-15**	**-13**
WAEMU (weighted average)	**15**	**16**	**-10**	**-9**	**-5**	**-3**	**-13**	**-11**
Benin	-6	-7	-33	-33	-16	-16	-22	-21
Burkina Faso	13	12	-20	-20	-12	-11	-15	-12
Côte d'Ivoire	20	22	-1	3	3	4	-14	-15
Guinea Bissau	-26	-25	-32	-30	-23	-24	-27	-27
Mali	25	26	-3	-2	-3	-2	2	4
Niger	12	10	-22	-22	-7	-5	-16	-13
Senegal	18	18	-4	-4	-7	-6	-14	-12
Togo	4	3	-25	-24	-4	1	-14	-9
CEMAC (simple average)	**22**	**19**	**7**	**8**	**-3**	**-5**	**7**	**3**
CEMAC (weighted average)	**22**	**20**	**6**	**7**	**-5**	**-7**	**-4**	**-8**
Cameroun	12	11	-10	-9	-11	-12	-14	-16
Centrafrique	11	8	-16	-16	-6	-6	46	49
Chad	18	10	-13	-18	1	1	0	-2
Congo	1	2	36	42	8	13	20	22
Equatorial Guinea	56	49	47	52	6	-11	6	-14
Gabon	35	34	-3	-4	-15	-16	-18	-22

N.B. Productivity is measured here in relative terms by considering the country's GDP per capita compared to the average of its main trading partners. See text. As in the previous table, the letters ER mean that GDP per capita is measured excluding rents. The results are obtained with the CPMG estimator.

Chapter 2: Exchange rate undervaluation and African surges: what do we learn from exported products? *

*This chapter is joint work with Patrick Plane (CNRS-CERDI-UCA) and Luc Jacolin (Banque de France). A slightly different version was published as a Banque de France working paper. The current version is currently under review in Economic Modelling.

Résumé

Nous étudions le rôle de la sous-évaluation des taux de change des devises dans le déclenchement et le maintien des poussées des exportations de produits africains. Sur la période 1995-2017, 96 épisodes sont identifiés pour 41 pays africains à partir d'un panier de leurs principaux produits primaires et manufacturés exportés (149 produits, code SH à 4 chiffres). Nous calculons les mésalignements des taux de change réels spécifiques aux pays et aux produits et faisons l'hypothèse que la sous-évaluation stimule la compétitivité et donc les performances à l'exportation. Le modèle cloglog met en évidence la sous-évaluation des produits en tant que déterminant des épisodes de poussée. Cet effet s'avère robuste à la manière dont nous définissons les épisodes d'exportation, à l'introduction de covariables dans le modèle et à l'utilisation du Relogit comme estimateur alternatif.

Mots clés : Afrique, poussées d'exportations, taux de change, sous-évaluation, compétitivité, commerce.

Abstract

We study the role of undervaluation of currency exchange rates in triggering African product export surges. Over the period 1995-2017, 96 episodes are identified for 41 African countries from a basket of their primary and manufactured exported goods (149 products, 4-digit HS code). We compute country-product specific real exchange rate misalignments, that allow testing the hypothesis that undervaluation drives competitiveness and thus export surges. The complementary log-log model confirms that product-specific undervaluation promotes the occurrence of surge episodes. This effect proves robust to the way we define export episodes, the introduction of covariates in the model, and the use of the Relogit as an alternative estimator for rare events.

Keywords: Africa, export surges, exchange rate, undervaluation, competitiveness, trade.

JEL codes: ***F15, F41, F63, O11, O55.***

Introduction:

A recent strand of literature has shown that currency undervaluation can be a driving force of surge episodes as defined by a strong and sustained increase of the growth of a performance variable. Hausmann, Prichett and Rodrik (2005), and Rodrik (2008) reached this conclusion for the GDP growth, while Freund and Pierola (2012), Eichengreen and Gupta (2013), Cadot et al (2014, 2016) showed a similar result for sectoral exports. We use this identification methodology to study African exports at a disaggregated level. We cover 41 African countries over the 1995-2017 period and 149 distinct primary and manufactured products. Given the small size and openness of African economies, exports are crucial and competitiveness a prerequisite for the structural transformation and long-term economic growth.

The contribution of this article is at three levels. (i) First, we apply the above - mentioned surge literature to disaggregated exports (4-digit HS code). The export surge method has similarities with the hypothetical-deductive framework of the double-difference method, but is based on a backward reasoning. We start by identifying surges using a counterfactual. As in Freund and Pierola (2012), the performance over a seven-year period must be above the previous seven-year average, and higher than the growth rate of the world exports of the product (i.e., gain in market share). (ii) In a second stage, we identify what determines surge episodes. Our hypothesis is that production cost competitiveness, measured with respect to the main country exporters of a specific product, contributes to triggering surges.[21] (iii) Third, the impact of the undervaluation is tested and controlled for concomitant determinants of surge episodes by using the complementary log-log model, which accounts for the fact that export surges are rare events.

All primary and manufactured export products with annual export flows exceeding $1 million over three consecutive years are included in our study. The set of goods we consider is fixed over the 2009-2013 period. It excludes products incorporating natural resource rents-- i.e., those with an average production cost significantly lower

[21] In this article all references to undervaluation and real exchange rate misalignments are product-specific.

than the international price (crude minerals, gas and crude oil), and whose investment decisions are not sensitive to the undervaluation of the currency.

On average, for the 41 African countries and over the 1995-2017, exported products that we consider account for 78% for primary and for 51% for manufactured products, respectively. We identify 96 export surges over the sample, with an unconditional probability for a surge episode of 2.3%, slightly higher for primary products. The cloglog estimator suggests that country product undervaluation of the currency preceded surges. A one standard deviation of the undervaluation level increases the probability of this rare event by respectively 1.6 percentage points for primary products and 0.7 for manufactured goods, or by 22 and 11 percent in relative terms. This conclusion is robust to changes in the parameters defining surge episodes and to the use of the Rare events logistic regression (ReLogit) estimator as an alternative to the cloglog model.

The remainder of the paper is organized as follows. Section 1 briefly reviews the literature about the relationship between RER and surge episodes. We then define the way to calculate our country-product exchange rates. Section 2 depicts the methodology to measure export surges and to analyze their occurrence. Section 3 focuses on the regression model of surge episodes. We discuss the choice of the estimator and the covariates to be considered in addition to real exchange rate undervaluation. Section 4 discusses empirical results. Section 5 proposes the above-mentioned robustness checks. Finally, Section 6 draws the main conclusions and sets out some implications for economic policy.

I. Country-product real exchange rates, competitiveness, and export surges

1. Price-competitiveness and surge episodes

The competitiveness of export products depends on the intrinsic productivity of firms (i.e., the cost of primary factors of production), and on the price of their intermediate consumption. As shown by the World Bank's *Enterprise Surveys*, these intermediate consumptions often represent more than 60% of gross export values for most African firms (Chaffai *et al* 2012). In low-income economies with market failures

and weak institutions, the higher the share of intermediate goods, the higher the transaction cost level. For example, African transport and logistics typically accounts for 15% to 20% of the value of an imported container at destination against 5% on average in developed economies. Bribes and a poor institutional regulation add to the normal cost level of non-tradable transport services (Plane, 2021). Access to electricity is also unreliable and expensive. Low and medium voltage prices are above 10 US cents per kWh, twice as much as for Asian competitors for agricultural or manufactured products. Despite the average increase in broadband connectivity, access to Information and Communication Technologies (ICTs, thereafter) remains both limited and onerous (Chauvet and Jacolin, 2017). Given the costs of these intermediate inputs, we need to refer to a broad coverage of the prices of goods and services, including non-tradable goods. This option is more relevant for the measurement of competitiveness than a restrictive alternative measure such as unit labor cost (Nouira et al. 2011; Gelb, 2016).[22] The poor quality of the business environment favors the production of non-tradables whose extra costs can be passed on consumers in case of weak domestic competition and low-price elasticity of the demand. In this context, exchange rate adjustments can be used to remove price distortions, reduce transaction costs and resulting biases on the production structure. These adjustments act as implicit subsidies benefiting all tradables.

Hausmann et al. (2005) show that surge episodes of per capita GDP are positively correlated to the currency exchange rate undervaluation. Freund and Pierola (2012) focus on aggregate exports of manufactured products and find that both undervaluation and the reduction of the exchange rate volatility account for the occurrence of surges.[23] Undervaluation of the currency improves national firms' intensive and extensive margins -i.e., the emergence of new products and the openness of new export markets. Eichengreen and Gupta (2013) investigate export surge episodes for both merchandise and services. Regardless of the country's level of development, the real exchange rate stimulates all exports and is particularly effective for modern services. Palazzo and

[22] In some countries real wages may be high enough given the low productivity level or tight market conditions on some segments of the supply. Gelb *et al.* (2016) mention such a situation for specific middle manager jobs or skilled workers whose supply lags far behind productive sector needs.

[23] At an HS6 level of disaggregation, Cadot et *al.* (2014) focus on export surges in bilateral trade flows for 8 developing countries over the period 1995-2012.

Rapetti (2017) investigate the long run export performance of Argentina (1980-2015). Their results show that the highest proportion of surge episodes occurred over the period 2003-2008, when Argentina maintained a stable and competitive exchange rate that benefited labor-intensive industries the most. Guzman *et al.* (2018) also argue that a Stable and Competitive Real Exchange Rate (SCRER) has a positive impact on the development of tradables. By reducing uncertainty, its spurs apprenticeships and help to cope with high fixed or sunk cost investments.

2. **Measuring product-specific exchange rate undervaluation**

The PPP criterion adjusted for the country productivity level sheds light on the implicit profitability of exports. Assuming that the price of a 4-digit HS code product is the same for all producers (i.e., the law of one price), undervaluation of the currency vis-à-vis the main world exporters of the product reflects more or less the cost competitiveness. We define RER as the ratio of the PPP conversion factor in domestic currency to the official exchange rate (ER) (i.e., number of national currency units per U.S. dollar).

$$RER_{ct} = \frac{PPP_{ct}}{ER_{ct}}$$

We use ratios distributed over the 0-1 interval from the World Bank's *World Development Indicators* with the upper bound reflecting the value for the United States, the common reference for all countries. Misalignments are therefore benchmarked by the US dollar, implicitly supposed to be at the equilibrium exchange rate level. For a country (c) a ratio lower than unity in year (t) means an undervaluation insofar as the domestic purchasing power of the currency turns out to be higher than what the official exchange rate indicates. These ratios are then adjusted for the impact of the productivity level of tradables on the price of non-tradables (Balassa – Samuelson effect). For this adjustment, RERs ratios are regressed on per capita GDP levels by considering a worldwide sample that includes high income level economies. Regression residuals provide by-country yearly misalignments that approximate the deviation to the long run international convergence rule of non-tradable good prices.

In absolute PPP terms, most African currencies are undervalued against the dollar, and remain so after adjusting non-tradable prices for productivity differences. Specialized in a limited number of products, often with a low level of processing, African economies do not compete with US exporters on most product markets. Therefore, by product (p) and for year (t), competitiveness is calculated by the difference between the misalignment of the currency (c) and that of the ten largest trading competitors (j) on the (p) product, each weighted by its average contribution into the product's world exports over the period 2009-2013 (ρj). The set of ten largest exporters of both primary and manufactured goods represents 72 percent on average, with a minimum of 52 and 42 percent respectively for each category. This coverage appropriately reflects global conditions of production of the product (p). Let's briefly summarize the two steps involved in calculating exchange rate misalignments.

First, we conduct the regression below using OLS estimation over the largest country sample and estimate yearly country misalignment from its residuals (u_{ct}). We do not include country fixed effects, following Rodrik (2008), Couharde and Sallenave (2013) or Ribeiro et al (2020). This econometric estimation only aims to remove the long-run impact of productivity on the relative price of non-tradables from the RER. The joint introduction of country fixed effects and GDP per capita (GDPPC) would pose an identification problem since fixed effects are often viewed as a proxy for productivity (Cornwell, Schmidt and Sickles, 1990).

$$\log (RER)_{ct} = \alpha + \beta \log(GDPPC)_{ct} + f_t + u_{ct}$$

With f_t , year-fixed effects; and $u_{ct} < 0$, undervaluation or $u_{ct} > 0$, overvaluation.
Second, from the misalignments as determined by the above regression, for a product (*p)* and a country (*c*), we calculate the misalignment in year (*t*) as follows, ρ_{jp} being the share of the *j-th* trading competitor in worldwide exports of this specific product.

$$Misalignment_{cpt} = [\, u_{ct} - \sum_{j=1}^{10} \rho_{jp} u_{jt}]$$

Misalignments are calculated under assumptions close to those used in price level PPP theory. (i) By assuming that the law of one price holds for each tradable, misalignments mainly result from non-tradable prices or differences in the taxation of imported goods. (ii) In the absence of any specific information, the country productivity for a given product is supposed equal to that of the average economy, as reflected by the per capita GDP.

II. Measuring export surges and assessing their occurrence

1. The method for identifying surges

We define $v_{c,pt}$ as the value of exports of product p at constant price for a country c at time t, and the real growth rate of product exports: $g_{c,p,t} = \Delta\ln(v_{c,pt})$. To deflate nominal exports, we use the weighted unit export value of the product's ten largest exporting countries. Initiation is the first year of a seven-year period of a specific product export surge (i.e., Take-off phase). Let $g^1_{c,p,t}$ and $g^0_{c,p,t}$ denote, respectively be the average annual growth rate of the real export over the seven-year take-off, and the pre-acceleration growth rate in the previous seven-year period. Briefly, the identification of an export surge episode relies on the joint application of four criteria:

Criterion 1. The average real export growth of the product during a seven-year take-off phase must be strong and higher than the world average real growth.

$$g_{c,p,t} > \overline{g_p}$$

Freund and Pierola (2012) deflate exports at current prices by the US consumer price index (CPI). This option is questionable at the sectoral level and even more so at the product level. Each tradable good has its own price evolution affecting the occurrence of a surge differently from what is assumed using the US consumer price index. Moreover, US retail prices depend on the productivity and the labor market conditions of this economy. To get values at constant prices, assuming the law of one price, the most relevant option is to use the specific

export-product price. Accordingly, we deflate export value by the unit value index as determined from the ten major worldwide exporters of the given product over 2009-2013.

Criterion 2. The average real growth during the take-off phase must be 30% higher than that of the seven-year reference period (α = 1.3), and at least three percentage points higher than that of a seven-year reference period (β = 0.03).

$$g^1_{c,p,t} > \alpha \times g^0_{c,p,t} \text{ And } g^1_{c,p,t} > g^0_{c,p,t} + \beta$$

Criterion 3. The minimum value of real exports during the take-off period should be higher than the maximum pre-take-off value in order to filter out surge episodes resulting from volatility phenomena of the export volume.

$$min(v_{c,pt}, \dots, v_{c,p,t+6}) > \ max(v_{c,pt-7}, \dots, v_{c,p,t-1})$$

Criterion 4. The average post-take-off growth calculated by eliminating the year of highest growth must be higher than the average pre-take-off growth (See criterion 2; $\alpha \times g^0_{c,p,t}$). This criterion eliminates accelerations that would depend on a single year of strong export growth.

$$g^1_{c,p,t} \ \backslash\{max\ (g_{c,p,t} \dots, g_{c,p,t+6})\} > \alpha \times g^0_{c,p,t}$$

This export surge measurement has four important features:

(i) First, the surge episode is by no means a single measure of the performance. A country that experiences a high but steady export growth on a product does not induce a surge although the growth can be far above that of the world economy. Onset surges are predicated on clear breaks from past export performance conditions.

(ii) Second, the reference to the concept of "misalignment" should not be misleading. In our case, it has no normative implication for the equilibrium exchange rate, which is based on the macroeconomic performance as measured by the country's internal and

external balances. In other words, a country may experience undervaluation in the case of some export products and an overvaluation for others while keeping a global macroeconomic equilibrium. Each product-specific exchange rate misalignment depends notably on each country's competitors in a given product world market. It must be clear that our approach provides no direct indication on how appropriate the real exchange rate is for the economy as a whole.

(iii) Third, the number of exported products per country is set at a maximum of ten, respectively 5 primary and 5 manufactured products, the most important export products for each of the two categories. Including manufactured goods is justified not so much by their current, and limited, share in African exports but by their expected contribution to structural transformation (Rodrik, 2018). The composition of the basket of international partners is constant and the choice of products is based on the structure of exports over the period 2009-2013. Accordingly, we mainly center the performance on the intensive margin. Since we refer to the aggregate exports of the product on the world market, the extensive margin is only implicitly present through the potential opening of new markets.

iv) Fourth, the limited number of selected products is appropriate for most African countries. It is only restrictive for a small number of large and more developed economies. The underestimation of export surges is likely for North African countries. This limitation avoids overrepresentation of some large middle-income economies within the sample.

2. The database and the occurrence of surges

We use the BACI database (CEPII), built from data reported to the United Nations Statistical Division (Comtrade) and include all African countries with available products exports data. Our sample is constituted of a three-dimensional panel of 41 African countries and 149 products (4-digit HS code) exported over the period 1995-2017. To be considered, a product must have been exported consecutively for at least three years during the period and represent an average export flow of at least one million dollars. We exclude some raw materials - i.e., crude oil, gas and minerals, as well as products of

chapter 27 and chapters 84 and 86 to 89 of the HS 4 nomenclature. Export products of chapter 87 are considered for only 6 countries: Algeria, Egypt, Morocco, Nigeria, South Africa, and Tunisia. For the other African countries, these chapters account for either imported goods that are re-exported in neighboring countries (mirror data only provide an imperfect correction of such trade), or sales of secondhand products (e.g., helicopter reexports by Gabon, HS-8802).

By major African regions, Table 1 displays the contribution of the 5 selected products for primary and manufactured goods, respectively. Countries in brackets are those with the lowest and highest percentages in the regional subset considered. Products were selected on the basis of the export value in their sectoral category over the period 2009-2013. On average, the top 5 primary product exports, excluding crude oil, gas and minerals, account for 78% of the category over the 41 sampled African countries, ranging from 32 % (Egypt) and 100 % (Cabo Verde, Chad, Comoros, Central African Rep, Equatorial Guinea, Guinea-Bissau). Percentages vary across African sub-regions from 53% (Northern Africa) to 92% (Central Africa). For manufactured exports, the top five products account for 51% on average, ranging from 0,45% (Liberia) to 100 % (Mauritania). The selected manufactured products typically represent a smaller fraction of exports than primary ones.

Table 1. Selected products and regional contribution to primary and manufactured exports

(In percentages, excluding crude oil, gas and minerals)

	Mean	Standard deviation	Lower Share	Higher share
Central Africa				
Primary	92	8	80(CMR)	100 (CAF, GNQ, TCD)
Manufactured	59	38	5 (COG)	97 (TCD)
East Africa				
Primary	75	16	52 (TZA)	100 (COM)
Manufactured	48	15	24 (KEN)	81 (MWI)
Northern Africa				
Primary	53	18	32 (EGY)	81 (DZA)
Manufactured	43	17	23 (EGY)	65 (DZA)
Southern Africa				
Primary	69	26	36 (ZAF)	97 (AGO)
Manufactured	31	15	11 (AGO)	43 (ZAF)
West Africa				
Primary	84	14	51 (SEN)	100 (CPV, GNB)
Manufactured	56	29	0,4 (LBR)	100 (MRT)
Africa (total)				
Primary	78	19	32	100
Manufactured	51	27	0	100

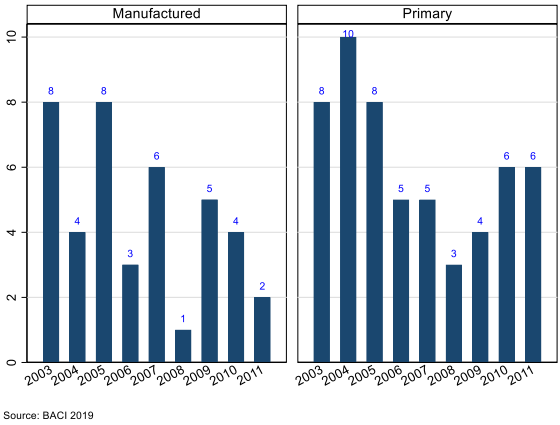
Source: Authors using BACI 2019. Countries are identified in the table by their ISO Alpha-3 code. Mean is the weighted average of the top 5 exported products over the period 2009-2013, excluding natural rent products and potential chapters for which we presume reexports or second-hand exports. The last two columns provide respectively regional lower and higher shares with the ISO three letter code of countries in parentheses.

Applying the set of previously mentioned criteria to primary and manufacturing products yields 96 episodes of export accelerations over 2001-2011. Figure 1 shows when export surges occurred and Figure 2, their geographic distribution by product in Africa as well as their weight in the export basket (Appendix 2). The earliest surge can only occur in 2001 (1995+6 years) and the latest in 2011 (2017-6 years). In fact, the first event dates back to 2003. Among the 96 episodes, 55 fall under the category of primary products, and 41 to manufactured products. Export surges are more frequent before the subprime crisis (2008) and the post subprime profile proves better for primary products, in relation with the Chinese economic growth, at least until 2010. The years beyond were much less stimulating with a Chinese GDP growth that fell from 10.6% in 2010 to 6.9% in 2017.To put it another way, although African market shares are very small for most manufactured goods, when the world economy slows down, it proves difficult for a

country to increase its market share, one of the conditions for a surge episode to occur (Criterion 1).

Figures 3 and 4 refer to export surges by product. For primary goods, cashew nuts (HS-0801) come first with 7 episodes. This economic specialization is present in ten African countries, especially in West Africa. Vietnam is the world's largest processor ahead of India. It imports a lot from Côte d'Ivoire but is promoting a policy of setting up operations in nearby countries. Cocoa beans (HS-1801) follow with 6 episodes. Ghana and Côte d'Ivoire are the most important worldwide producers, with a combined market share of about 60 %. Natural rubber (HS-4001), and fruits (HS-0804) then come with 4 episodes each. Turning to manufactured products, 3 export surges are accounted for in both Portland cement (HS-2523) and transport articles (HS-3923). The first product reflects the African dynamics of investments in both infrastructure and housing. Both sectors have benefited from the so-called "super-cycle" of raw materials that fueled the economic growth of a wide range of African countries.

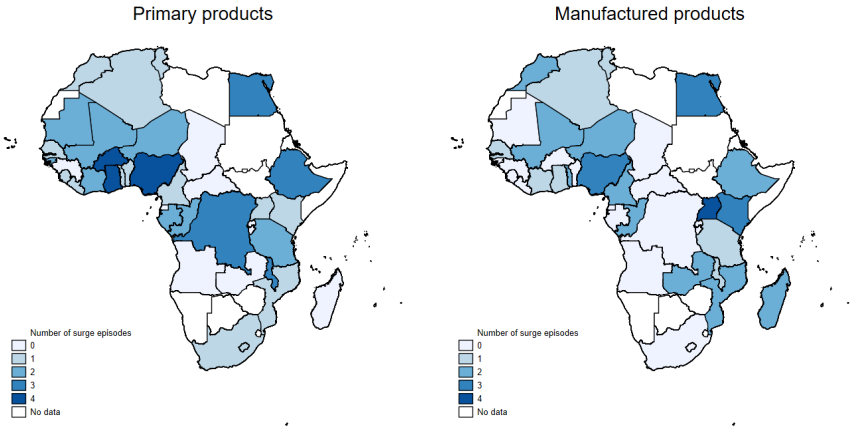
Figure 1: Africa and the timing of surge episodes (by category, number of products)



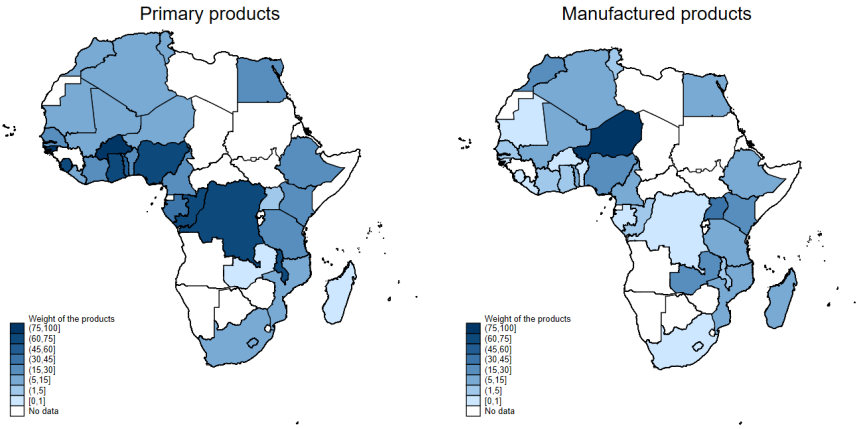
Source: BACI, 2019 and Authors' calculations.

Figure 2: Geographical distribution of Export surges

Number of surge episodes

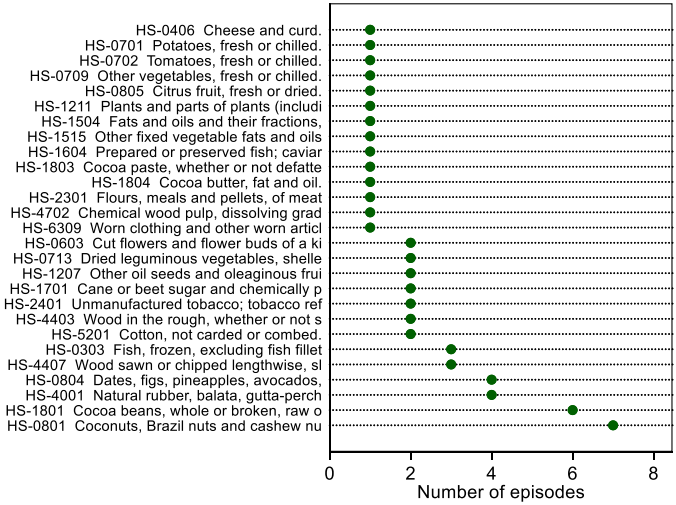


Percentage of product surges among all products considered for each category (%)



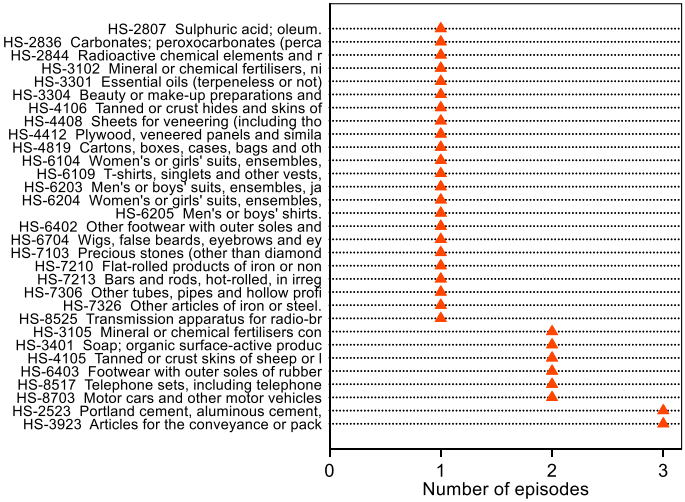
Source: Authors' calculations.

Figure 3: African export surges: primary products (2001-2011)



Source: Authors' calculations

Figure 4: African export surges: manufactured goods (2001-2011)



Source: Authors' calculations.

Table 2 lays out the unconditional probabilities of surges by type of products, per capita income levels, and regions. The occurrence of events is calculated over the total number of country-product-year observations for which an acceleration can potentially take place. As we focus on onset surges, the six years following the start of the episode are excluded. This is also the case for the years before 2001 and after 2011 where no surges are possible due to the defined event time span. We breakdown the whole period into two sub-periods separated by the subprime crisis starting in end 2007 with the U.S. housing bubble and the global financial crisis.

Table 2. Unconditional probabilities of surges

	2001-2007	2008-2011	2001-2011
Overall probability	2,5%	2,1%	2,3%
By type of products			
Primary	2,6%	2,4%	2,5%
Manufactures	2,3%	1,7%	2,1%
By geographical regions			
Southern Africa	0,5%	1,7%	0,9%
Northern Africa	3,9%	1,3%	3,0%
Central Africa	2,6%	0,4%	1,8%
East Africa	2,9%	1,4%	2,4%
West Africa	2,1%	3,5%	2,6%
By per capita income quintiles			
1st quintile	0,6%	2,2%	1,1%
2nd quintile	1,4%	2,6%	1,7%
3rd quintile	3,5%	1,8%	2,8%
4th quintile	3,8%	2,3%	3,2%
5th quintile	3,7%	1,5%	2,8%

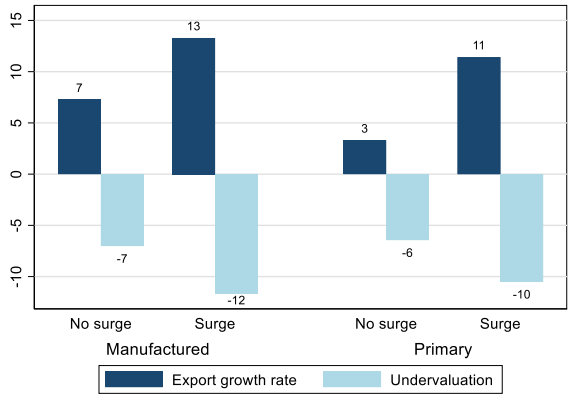
Source: Authors' calculations.

Over the whole period, the unconditional probability that an export surge occurs is 2.3%, with a higher probability for primary than manufactured products. An analysis by sub-regions shows that the occurrence of surges in North African countries is three times higher than in Southern Africa. Central Africa is particularly affected by the post 2007-2008 crisis, the unconditional probability of acceleration falling from 2.6% over 2001-2007 to 0.4% after 2008. The lower part of Table 2 classifies export surges by quintiles of the per-capita income level of sampled countries. The first and second quintiles are less likely to experience an export surge than those from the third to fifth quintiles. Cerra and Woldemichael (2017) evidence similar results for more aggregated exports. This may reflect the fact that high-

income countries are more successful in promoting manufactured exports. The diversification process is more difficult for low-income African agricultural exporters. Given the concentration on primary products where African market shares are non-negligible, it is more difficult to initiate export accelerations in manufactures.

How does export performance fit with exchange rate misalignments? Descriptive statistics provide interesting preliminary information. In Figure 5 we compare all country-product pairs with an undervaluation according to whether or not they experienced export surges over the period 2001-2017. Firstly, undervaluation goes hand in hand with higher export growth for both primary and manufactured products. Secondly, country-products surges provide higher export growth rates. Thirdly, the country-product export gains associated with export surges are significantly higher in the case of primary products. The average annual export growth rate over the 2001-2017 period rises from 3 % in the absence of export surges (with an average undervaluation of 6 %) to 11 % in the case of export surges (undervaluation of 10%).

Figure 5: Average variation in undervaluation and export growth: by product categories according to the presence or absence of surges episodes
(Period 2001-2017, exports at constant prices, in %)



N.B. Given the time span referenced in the surge definition (7 years), surges are only observable from 2001 onwards over the sample period (1995-2017). Average annual growth rate of exported products is unweighted.
Source: Authors using BACI 2019.

III. Predicting surges and identifying their determinants

Given that an export surge is a rare event, our binary dependent variable model is characterized by a preponderance of zeros. The data then suffers from a class imbalance problem. In this case, standard probit and logit estimators provide biased results toward zero. To account for the structure of the sample, we use the complementary log-log (cloglog) model. The cloglog is related to the gompit model. It differs from the logit and the probit by its non-symmetric transformation, which allows an appropriate treatment of rare events. The formal specification of the cloglog model is as follows:

$$\boldsymbol{Pr}\left(\boldsymbol{ES_{c,p,t}} = \mathbf{1} | \boldsymbol{X_{c,p,t}}\right) = \boldsymbol{F}(\boldsymbol{\beta X_{c,p,t}})$$

Where $\mathbf{F}(\mathbf{z}) = \mathbf{1} - \mathbf{exp}\{-\mathbf{exp}(\mathbf{z})\}$, $\boldsymbol{ES_{c,p,t}}$ is a dummy variable that is equal to 1 in case of export surge (*ES*) for a country (*c*), product (p) at year (t), and zero otherwise. $\boldsymbol{X_{c,p,t}}$ is a set of controls.

Taking up the approach of Hausmann (2005) and more recently Libman (2019), we rule out the uncertainty about the starting year of an export surge by centering the dependent variable over a three-year window around the initiation year (*t-1, t, t+1*). Given the way the filter parameters are defined (See section II.1), surge episodes cannot happen over the first and last seven-year spells. In addition, as a beginning of an acceleration is detected, observations from *t + 2* to *t + 6* are removed from the sample. By doing so we focus on the starting years of the country-product-episode. In other words, the sample only includes the three-year window for country-export-episodes, but the whole period in case of no country-export-product surge (control group).

Because of data limitations, this cross-sectional analysis does not control for all relevant export growth factors such as imported inputs. An exchange rate shock may make the firm more competitive due to local value-added content, but also increase the cost of imported inputs. This information however is not available. Other factors may also be not statistically significant over the whole country-product pairings. For example, the growth of

cashew nut exports (HS 0801) from Africa may result from rising competitiveness, but also relates with rising climatic constraints in their Asian competitors.

Table 3 provides descriptive statistics for the main variables included in the regression analysis. The undervaluation level is the variable of interest. Over the period 2001-2017, its average level over the sample is 7.4%. To have an appropriate estimation of its coefficient we introduce a set of controls denoted $\boldsymbol{X_{c,p,t}}$. These variables are measured as average over the seven-year period preceding the surge. Controls range into two categories: country related variables, generally with a limited variance over time, and specific country-product variables that are related either to the international or the domestic environment.

1. **Country related variables**

As is customary when conducting sectoral or aggregate export analyses, we introduce indicators reflecting time variant development levels (Fernandes *et al.,* 2016). A higher ***per capita GDP*** goes hand in hand with better established and larger firms, which have a higher ability to seize international market opportunities. Real per capita GDP is expected to be positively correlated with export surges, probably more for manufactured than for primary products. We posit a potential non-linear effect that we simply test through a quadratic-type relationship as generally the case for aggregate exports (Klinger and Lederman 2006, Parteka 2007, Cadot, Carrère and Strauss-Kahn 2011).

The secondary education index is incorporated in the regression to assess the role of human capital through the productivity level. A positive effect is expected for all types of products. This index is preferred to the primary enrollment rate which discriminates less across African countries.[24]

The Exchange rate classification scheme. In order to provide a broad picture of underlying impacts of exchange rate arrangements, we use three aggregated classes from the de facto exchange rate arrangement classification (Ilzetzki *et al.*,2019). The first category is for pegged (or related) exchange rate regimes. The second class is for intermediary systems based on all

[24] SE Index is a subindex of the FERDI's Human Assets Index (HAI) retrospective series. See Feindouno and Goujon (2019).

crawling peg options (codes 2 and 3). The third and last category gathers all exchange rate floating systems (codes 4 to 6). A pegged regime may provide more stability on expectations about the macroeconomic policy but may result in rigidities or foreign exchange shortages constraining the tradable sector. Intermediate and floating exchange rate systems may offer more flexibility, but possibly at the cost of more uncertainty and less credibility of macroeconomic policy. The independence of monetary and fiscal policy increases, but at the cost of the volatility of the nominal exchange rate finally creating a "fear of floating" (Calvo and Reinhart, 2002).

Domestic conflicts. Since the early 2000s, rebel and self-defense militias as well as various groups affiliated to Islamic jihad organizations erode North and West Africans states. For this region alone, Trémolières *et al.* (2020) counts no less than 3 700 violent events for 2018. Conflicts in the lake Chad caused 68 000 victims since 2009. Civil wars in Sierra Leone (1991-2002) or Côte d'Ivoire (1999-2010) have had repeated negative impacts on cocoa exports and disincentivized investment in manufactured production. This bleak picture contrasts with the first decade of the 2000s when African civil wars declined to half of their mid-1990s levels (Straus, 2012). We expect that the end of a conflict stimulates export catch-up phases whose effects may potentially correlate with real exchange rate changes. To identify the impact of domestic political disturbances or upheavals, we consider the weighted conflict index of the Cross-National Time Series (CNTS) from EUI (European University Institute). The CNTS combines 9 broad items using data coming from the *New York Times*. The dataset records occurrences of events and weights them according to gravity: general strikes, purges, government crises, riots, assassinations, anti-government demonstrations, as well as events with the highest weighted factors: guerilla warfare, and revolutions (Banks and Wilson, 2015). This conflict index ranges from zero (peaceful domestic environment), to 15.28 (highest intensity of conflict). We hypothesize that domestic conflicts are negatively correlated with export surges.

2. **Country-product related variables**

As mentioned earlier, the main innovation of this paper is to highlight the role that exchange rate undervaluation plays in product-specific export surges. An African cashew producer is indirectly affected by the macroeconomic exchange rate misalignment, but directly by its unit cost, *vis-à-vis* other cashew producer countries.

The misalignments are obtained from the regression bellow, based on the largest worldwide sample of countries to seize the long-run average impact of productivity on the price of non-tradable goods. Based on 176 countries that we consider over the period 1995-2017, this panel provides information about misalignments for all national currencies *vis-à-vis* the US dollar.

$$\text{Log}\,\widehat{(RER)}_{ct} = \underset{(0.003)}{0.224^{***}}\, log(\,Per\ capita\ GDP)_{ct} - \underset{(0.03)}{2.767^{***}}$$

$$R^2 = 0.48, \qquad n = 176\ countries, \qquad t = 1995\ to\ 2017.\ Standard\ error\ in\ parentheses$$

The coefficient on the regression of GDP per capita is quite close to that identified by Rodrik (2008). For a specific country-product pair, the exchange rate misalignment is measured by the difference between the country's residual and the weighted average of those of the ten largest competing countries on the product. From the distribution of real exchange rate misalignments, only observations with an undervaluation are retained, meaning that when this event does not occur, the observation is equal to zero. The underlying assumption is that, on average, overvaluation is unlikely to lead to export surges. The inclusion of overvaluation as an additional variable in the regressions proved to be statistically insignificant, with no impact on the specific coefficient of undervaluation.[25] We now extend the information space to additional controls that combine country, product and time.

Market shares. These are measured on an annual basis by a country's exports of a specific product (p) in world exports of that product. The impact of this variable is ambiguous. In the case of primary agricultural products, African market shares can be large, as is the case for

[25] Results incorporating the overvaluation variable are provided in Appendix 3.

Ghanaian and Ivorian cocoa, which reduces the probability of export surges. Turning to manufactured products, a well-structured marketing and distribution network make it easier to increase export sales in a context where initial market shares are still low. When fixed and sunk costs are partly covered, mature countries have a better resilience to unforeseen events. Accordingly, within a sample restricted to African countries, we suppose that market shares are positively correlated to surge episodes of manufactured goods.

The relative number of Internet users per 100 inhabitants. Digital infrastructure is an efficient means to reducing transaction costs and informational issues. As such, the Internet enables productivity gains, supports business performance, and improves economic governance (Paunov and Rollo, 2015, 2016; Cariolle et al., 2019; Asongu and Nwachukwu, 2016). Hjort and Poulsen (2019) evidence the economic implications of the broadband Internet in African countries. Using data from the World Bank *Enterprise Surveys*, they show that this technological change has led to a rapid development of direct exports, in particular due to the greater fluidity of relations with foreign customers and the use of online communication between firms in customer-supplier relationships. Similarly, Cariolle and da Piedade (2023) show that increased digital connectedness leads to greater sophistication (complexity) of exported goods, particularly in Africa. Internet also enlarges the size of the formal sector and attracts foreign direct investments that are generally found to be a powerful channel to drive the diversification of exports (Freund and Weinhold, 2004, Jacolin *et al.*, 2021). Access to ICTs is very uneven across Africa. For a country, it is assumed that the competitive position depends on the evolution of the gap with competing countries. So, we construct an indicator of the internet access for each country-product pair. We test the relative impact of this variable using the same subset of exporting competitors and weights as for exchange rate misalignments. In other words, as the set of competing countries is product-specific, this relative variable varies with country's export products. We posit a positive relationship between Internet access and export surges.

Relative Corruption index. Bribes and a weak governance can be akin to a tariff, discouraging international transactions by increasing costs (Anderson and Marcouiller, 2002). To investigate the role of this variable we compute the relative corruption index using Standaert (2015)'s Bayesian Corruption Index (BCI) and the same methodology as for the relative

number of Internet users. By the relative corruption index, we compare the country's BCI to that of its competitors on the same export product. Thus, the resulting measure reflects the difference in the quality of institutions and the implications for transaction cost levels. An increase of this relative index means a less market-friendly environment.

Table 3. Descriptive statistics of export surge determinants (2001-2017)

Variables	Obs	Mean	Standard deviation	Min	Max	Sources	Expected signs
Export Surges (=1, dummy)	4090	0.07	0.256	0	1	BACI	
Market share (in %)	6416	1.925	5.528	0	67.84	BACI	-/+
Undervaluation (in %)	6416	-7.4	16.4	-127.7	0	WDI	-
Log (per cap GDP)	5920	7.016	1.055	5.267	9.92	WDI	+
Log (per cap GDP) ²	5920	50.343	15.615	27.743	98.407	WDI	-
Relative Internet users	6416	-29.413	21.175	-82.322	24.725	WDI	+
Log (Secondary education)	5091	3.224	0.961	-2.323	4.605	HAI-FERDI	+
Relative Corruption index	6416	0.8	0.722	-.732	3.357	*Standaert (2015)*	-
Conflict index	5470	0.161	0.865	0	15.281	CNTS	-
Pegged regime	6048	0.406	0.491	0	1	Ilzetzki *et al.* (2019)	-/+
Intermediate regime	6048	0.561	0.496	0	1	Ilzetzki *et al.* (2019)	-/+
Floating regime	6048	0.033	0.179	0	1	Ilzetzki *et al.* (2019)	-/+

NB: for surge episodes, the dummy takes the value one. These descriptive statistics are given for the entire sample, including both primary and manufactured products. The correlation table is provided in Appendix 1. Source: Authors' calculations. HAI, Human Asset Index; WDI, World Development Indicators, World Bank. The BACI database is from CEPII.

IV. Regression results

1. Determinants of export surges (take-off)

Table 4 provides a set of econometric relations between the onset of surges and currency undervaluation vis-à-vis major country-product competitors. Cases other than undervaluation have a value of zero. The coefficient of interest is controlled or not by regional dummies. Columns distinguish aggregated from by-sector results. The expected negative sign is obtained in all cases, which means that undervaluation, a negative value, stimulates export surges. Only in column 3 does the cloglog model fail to give statistical significance at the conventional confidence levels.

Table 4. Baseline regression: Onset of export surges (2001-2012)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manuf	(6) Manuf
Undervaluation	-0.047***	-0.070***	-0.044	-0.071***	-0.050**	-0.064***
	(0.018)	(0.018)	(0.030)	(0.027)	(0.021)	(0.022)
Southern Africa		-0.086***		-0.108***		-0.066**
		(0.023)		(0.039)		(0.026)
Central Africa		-0.023		-0.003		-0.043**
		(0.015)		(0.020)		(0.021)
East Africa		0.001		-0.011		0.011
		(0.014)		(0.020)		(0.017)
West Africa		0.005		0.033*		-0.028
		(0.013)		(0.017)		(0.017)
Observations	4,090	4,090	2,150	2,150	1,940	1,940
Number of surges	96	96	55	55	41	41

Notes: Cloglog estimates. The regression coefficients are marginal effects. The dependent variable is the dummy variable equal to 1 over a 3-year window centered on the onset date of the surge. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

In Table 5, these initial results prove robust to the introduction of the set of controls. Several of them are relevant with some variations depending on product categories. For primary products, the relative corruption and the secondary school enrollment are significant as well as the exchange rate regime. It appears that both pegged and intermediate exchange rate regimes outperform the floating regime, the reference category in the regressions. Manufactured goods prove sensitive to the number of Internet users. This expected result fits with what Huang *et al*. (2018) and Huang and Song (2019) or at the provincial level, Fernandes *et al*. (2019) found for Chinese firms' probability to export. It is also in line with Hjort and Poulsen (2019) who show, for Sub Saharan African countries, that access to a fast Internet connection has increased firm entry, productivity, and exports.

Surprisingly, the impact of the relative corruption index is weaker in the case of manufactured goods than for primary products, at odds with the "sand in the wheel" hypothesis of the corruption-trade linkage literature (Anderson and Marcouiller, 2002). In a

context of acute external competition with low firm profit margins, corruption is an additional obstacle for export surges. One potential reason for this weak correlation is that the so-called impact is already captured by other controls, especially those reflecting the development level (per capita GDP, Secondary education, Internet users, etc).

Table 5. Regression results with covariates: onset of export surges (2001-2012)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manuf	(6) Manuf
Log (Per cap GDP)	0.031	0.084	-0.082	-0.062	0.163**	0.269***
	(0.068)	(0.068)	(0.100)	(0.099)	(0.082)	(0.083)
Log (Per cap GDP)^2	-0.004	-0.008*	0.004	0.003	-0.013**	-0.021***
	(0.005)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)
Log (Secondary education)	0.022***	0.023***	0.031***	0.030***	0.014**	0.011
	(0.005)	(0.006)	(0.007)	(0.010)	(0.007)	(0.007)
Undervaluation	-0.072***	-0.073***	-0.078**	-0.090**	-0.054**	-0.040**
	(0.020)	(0.018)	(0.038)	(0.035)	(0.022)	(0.020)
Market share	-0.001*	-0.001*	-0.001	-0.001	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Relative Internet users	0.001**	0.001**	0.001	0.001	0.001**	0.001**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Relative Corruption index	-0.020***	-0.018**	-0.023**	-0.022**	-0.017*	-0.000
	(0.007)	(0.008)	(0.010)	(0.010)	(0.010)	(0.011)
Conflict index	0.055	0.062	0.086	0.077	0.026	0.054
	(0.053)	(0.055)	(0.090)	(0.089)	(0.057)	(0.057)
Pegged regime	0.713***	0.691***	0.723***	0.645***	0.607***	0.545***
	(0.087)	(0.070)	(0.087)	(0.111)	(0.080)	(0.089)
Intermediate regime	0.703***	0.684***	0.699***	0.636***	0.611***	0.539***
	(0.084)	(0.072)	(0.083)	(0.110)	(0.079)	(0.090)
Southern Africa		-0.019		-0.034		-0.020
		(0.020)		(0.031)		(0.022)
Central Africa		0.028		0.041		0.004
		(0.021)		(0.032)		(0.022)
East Africa		0.010		0.021		-0.001
		(0.015)		(0.022)		(0.020)
West Africa		-0.008		0.032		-0.051***
		(0.015)		(0.022)		(0.018)
Observations	2,815	2,815	1,478	1,478	1,337	1,337
Number of surges	66	66	36	36	30	30

Notes: Cloglog estimates. The Regression coefficients are marginal effects. The dependent variable is the dummy variable equal to 1 over a 3-year window centered on the onset date of the surge. Control variables are averages over the 7 year-period prior the surge. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

The main finding is that undervaluation remains statistically significant. As with the set of simple regression analysis, the coefficient again varies by sector. It is higher for primary than for manufactured goods. The sensitivity to current undervaluation is therefore stronger for the triggering of export surges of traditional products which are less subject to international marketing uncertainties, less demanding in terms of investments and profitability horizon, more open to substitutions between crops, especially for those with an annual production cycle.

Over the sample, a one-standard-deviation of the undervaluation level increases the probability of an export acceleration by 1.31 percentage points, or a 19 percent increase in the probability of experiencing an export surge.[26] When we decompose the sample, the effect is respectively 1.62 for primary products, and 0.72 percentage point for manufactured goods, respectively an increase of 22 and 11 percent in the occurrence of export surges. Countries with a better human capital are more likely to experience export surges while the reverse occurs with a higher level of the relative corruption index. Broadly speaking, the results we get for these product export surges are in line with what Freund and Pierola (2012) find at a more aggregated level. A regression with jointly integrated overvaluation and undervaluation levels, i.e., with all misalignment information, yields similar results (See Appendix 3).

For a fairly large number of products, the variation in the nominal effective exchange rate translated into a product-specific undervaluation contributed to export performance. In Egypt, for example, the six export surges were concentrated in the period 2003-2006, and were preceded by a depreciation of the Egyptian pound by more than half against the currencies of the main export competitors (2000-2004). For these six products, undervaluation rates have ranged from 36% to 81% (see Tables B.4 and B.5 in the Appendix). Similarly, the

[26] This result is obtained from column 2 of table 5 and determined as follows: -0.073×-0.18= 1.31, where -0.18 represents a standard deviation of undervaluation over the period 2001-2011. In order to determine what this means in the sample, the following procedure is adopted: 1.31/(3×2.3), where 1.31 is the marginal effect induced by a one standard deviation decrease in the level of undervaluation. 2.3 is the unconditional probability of observing an acceleration (see Table 2), which we multiply by 3 as onset surges are defined over a three years period (t-1, t, t+1).

depreciation of the Kenyan shilling (1998-2002) helped cut flower exports to accelerate after 2004 (HS 0603) through a 25% undervaluation rate of the currency, just as the depreciation of the cedi (1991-2002) supported Ghana's exports of cocoa beans and processed products (HS 1801, HS 1803; HS 1804) with product-specific undervaluation rates ranging from 25% to 49%.

In some cases, the real undervaluation stemmed from a process of upgrading and increasing the sophistication level of exported products, hence resulting in the build-up of new competitive advantage. In Morocco, for instance, the export surge in the automotive sector (HS 8703) from 2012 onwards was spurred by significant foreign direct investment (Tangier-Renault project) – an efficient source of technological transfer– and enhanced by the 2014 *Industrial Acceleration Plan*. The combination of industrial policy and proactive behavior of foreign investors translated into comparative advantage on an upscale in the technological content of exports, as shown by gains in the *complexity* ranking of the *Harvard Growth lab* (Hausmann and Hidalgo, 2011), along with a product undervaluation of around 28% in the years preceding the surge. Rather than nominal variations in the dirham exchange rate, which appreciated *vis-à-vis* the dollar and the euro in the years preceding the start of export surges, in 2007, more favorable relative costs relative to European competitors and successful industrialization policies were key.

In Gabon, such policies took the shape of a Special Economic Zones (notably in Nkok) and a drive to capture a larger share of the global value chain of wood products. Aside from the ban on exports of raw timber (which carries its share of economic distortions), such industrialization policies included a flexible application of the provisions of the labor code, availability of serviced industrial land with an access to a lower cost of electricity, and last but not least a better access to the port of Owendo. This leads us to conclude that export surges may arise in a variety of policy levers, including horizontal policies through product-specific undervaluation or vertical industrial policies.

V. Robustness and sensitivity

The robustness checks are implemented in two ways. First, we provide alternative calculations of export surges using different definition parameters. Previous results were

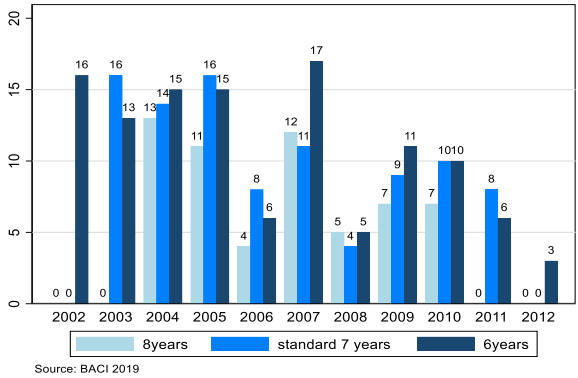
obtained from the scenario of Freund and Pierola (2012) with respect to the value of the parameters (α, β), and the duration of surges: at least 7 years. Of course, these are ad hoc empirical hypotheses. In a second step, we ask whether an alternative estimator (i.e., ReLogit) modifies the conclusions as regard the impact of the undervaluation of currencies.

1. **Export surges and the choice of alternative parameters**

The export surge has been defined with respect to a seven-year period. Do the results change if we extend the period to 8 years or restrict it to 6 years? As shown in Figure 6, export surges drop by almost half with the 8-year window, and only 25 episodes out of the 59 relate to manufactured products. When a 6-year window is considered, we get 117 exports surges with 66 episodes for primary products and 51 for manufactured.

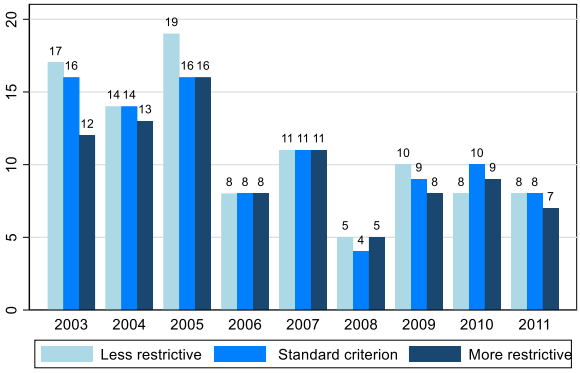
The second robustness check consists in modifying criterion 2 (Cf., section II.1). The real average growth that has been considered so far for calculating export surges $g^1_{c,p,t}$ was 30% and at least 3 percentage points higher than that of the previous seven-year period (α = 1.3, β = 0.03). What happens for alternative pairs of parameters: α = 1.1 and β = 0.02; or α = 1.5 and β = 0.04? Figure 7 depicts the number of export surges under these two modalities of measurement. Compared to the standard criterion, episodes moderately change and the proportion of surges across categories of products is quite stable. We detect 100 episodes for the first option, respectively 56 and 44 for primary and manufactured products, against 89 episodes for the second option: 52 and 37, respectively.

Figure 6 : **Sensitivity of export surges to the time window**



Source: BACI 2019

Figure 7 : Modification of criterion 2 and export surges over the period



Source: BACI 2019

Table 6 summarizes the results. To save space, only our interest variable- i.e., undervaluation, is reported. Full regressions are provided in the Appendix 4. At the onset of surges, regardless of the specification, undervaluation remains negative and statistically significant at the conventional statistical levels except in one case for manufactured goods (Horizon 6), which is only significant at 81%.

Table 6. Robustness checks with alternative filter parameters and time horizons

	(1) All	(2) Primary	(3) Manuf
	Onset of surges		
Horizon 6 (a = 1.3 and β = 0.03; 6 years)			
Undervaluation	-0.106***	-0.092**	-0.039
	(-0.026)	(-0.044)	(-0.031)
Horizon 8 (a = 1.3 and β = 0.03; 8 years)			
Undervaluation	-0.057***	-0.060*	-0.022*
	(-0.017)	(-0.032)	(-0.011)
Lower criterion 2 (a = 1.1 and β = 0.02; 7 years)			
Undervaluation	-0.084***	-0.101***	-0.048**
	(-0.019)	(-0.035)	(-0.021)
Higher criterion 2 (a = 1.5 and β = 0.04; 7 years)			
Undervaluation	-0.065***	-0.075**	-0.037**
	(-0.017)	(-0.031)	(-0.016)

Notes: cloglog estimates. The coefficients reported are marginal effect evaluated at the sample means. The dependent variable is the dummy variable equal to 1 over a 3-year window centered on the onset date. All controls are averages over 7 years prior to the surge initiation. The Table only displays the coefficient of the variable of interest. Refer to Appendix 4 for all results. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

2. **Alternative estimation technique**

As an alternative estimation method, we use the rare event logit (ReLogit) proposed by King and Zeng (2001). Unlike the cloglog, which follows an asymmetric distribution, the ReLogit follows a symmetric distribution since it is based on a modified logit specifically designed to better handle and mitigate the biases associated with rare events.

Regression results are presented in Table 7 for the period of the surge over the initial time horizon (7 years) and filter parameters ($\alpha = 1.3$ and $\beta = 0.03$). With this standard scenario, in all empirical cases the coefficient of the undervaluation variable remains strongly statistically significant.

Table 7. Onset of export surges - ReLogit estimates (2001-2012)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manuf	(6) Manuf
Log (Per cap GDP)	-0.767***	-0.618***	-0.821	-0.309	-0.430***	-0.089
	(0.212)	(0.197)	(1.243)	(0.977)	(0.162)	(0.237)
Log (Per cap GDP) ²	0.008	-0.008	0.019	-0.008	-0.019	-0.060**
	(0.019)	(0.019)	(0.083)	(0.063)	(0.017)	(0.026)
Log (Secondary education)	0.483***	0.532***	0.573***	0.589***	0.368**	0.415**
	(0.105)	(0.129)	(0.140)	(0.183)	(0.152)	(0.171)
Undervaluation	-1.642***	-1.710***	-1.396**	-1.713**	-1.782***	-1.511***
	(0.412)	(0.406)	(0.712)	(0.679)	(0.499)	(0.554)
Market share	-0.017	-0.016	-0.017	-0.013	-0.011	-0.016
	(0.011)	(0.012)	(0.012)	(0.011)	(0.041)	(0.051)
Relative Internet users	0.017**	0.018**	0.015	0.016	0.019**	0.023**
	(0.007)	(0.007)	(0.010)	(0.010)	(0.009)	(0.010)
Relative Corruption index	-0.433***	-0.428***	-0.451**	-0.439**	-0.385*	-0.160
	(0.159)	(0.161)	(0.213)	(0.192)	(0.219)	(0.260)
Conflict index	1.120	1.165	1.955	1.805	0.249	0.651
	(1.081)	(1.114)	(1.626)	(1.610)	(1.398)	(1.519)
Pegged regime	1.366*	0.947	1.090	-1.910	0.633	0.889
	(0.700)	(0.609)	(4.533)	(3.805)	(0.558)	(0.562)
Intermediate regime	1.081	0.754	0.657	-2.054	0.505	0.533
	(0.696)	(0.553)	(4.522)	(3.757)	(0.492)	(0.453)
Southern Africa		-0.412		-0.475		-0.399
		(0.409)		(0.634)		(0.557)
Central Africa		0.548		0.912		0.068
		(0.428)		(0.624)		(0.600)
East Africa		0.012		0.515		-0.543
		(0.297)		(0.411)		(0.496)
West Africa		-0.193		0.688*		-1.354***
		(0.305)		(0.411)		(0.499)
Observations	2,815	2,815	1,478	1,478	1,337	1,337
Number of surges	66	66	36	36	30	30

Notes: ReLogit estimates. The coefficients reported are not marginal effect. The dependent variable is the dummy variable equal to 1 over a 3-year window centered on the onset date. All control variables are averages over 7 years prior to the surge initiation. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

VI. Conclusion

The role of product-specific currency undervaluation is explored to shed light on the performance of African disaggregated exports. The surge episode identification methodology is used for primary and manufactured products. Over the period 1995-2017, we identify 96 episodes of export surges, over a total of 149 primary and manufactured export products (4-digit HS code). The majority of episodes occurred in middle-income African countries. Country-product pairs of real exchange rate misalignments are calculated on an annual basis. For this variable of interest, the use of the cloglog estimator allows the identification of the impact controlled for other determinants. On average, exchange rate undervaluation preceded exports surges. A one standard deviation increase in the level of the country product undervaluation increases the probability of a surge by 1.3 percentage points. By splitting the sample into primary and manufactured goods, the effect is 1.6 and 0.7 percentage points, or 22% and 11% increases in the occurrence of surges, respectively. Our results are robust to changes in the filter parameters of surges, to their time frame of duration, and to the use of the ReLogit as an alternative to the cloglog estimator. Product-specific exchange rate undervaluation highlights the role of cost competitiveness in accelerating export growth for both primary and manufactured goods.

What can we learn from this empirical analysis? The undervaluation of currencies in relation to products favors episodes of export surges. By supporting the production of tradable goods in a non-discriminatory way, variations in the nominal exchange rate may be important to drive product-specific currency undervaluation and to provide a competitiveness advantage. But the official exchange rate is an undifferentiated tool, hence potentially ill-adapted to meet each product market expectations. Identifying product-specific exchange rate misalignments is the first step to consider before matching country-product pairs to appropriate industrial policy instruments. Our empirical analysis has dealt with this objective. As shown by different country cases (Egypt Morocco, Gabon), optimal policy tools may vary widely but need to be tailored to each country's characteristics and sustainable development objectives (integration in global value chains, more technology-intensive exports). The nominal exchange rate matters, but it is only one of economic policy instruments that may contribute

to product-specific undervaluation. Taking all country-product pairs together, we conclude that product-specific undervaluation: (i) simulates export surges; (ii) may, but does not necessarily, result from changes in the nominal exchange rate; (iii) potentially plays in coordination with other elements of vertical industrial policy and territorial attractiveness.

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Appendix to Chapter 2:

Appendix 1: Sample and data

List of countries

Algeria, Angola, Benin, Burundi, Burkina Faso, Cabo Verde, Central African Rep, Cameroon, Chad, Cote D'Ivoire, Comoros, Congo Dem. Rep., Congo Rep. of, Egypt, Ethiopia, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Tanzania, Sierra Leone, South Africa, Togo, Tunisia, Uganda, Zambia.

Table B. 1. Correlation table

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Export Surges (=1, dummy)	1.000											
(2) Market share (in %)	-0.008	1.000										
(3) Undervaluation (in %)	-0.048	-0.012	1.000									
(4) Log(per cap GDP)	-0.031	0.078	-0.320	1.000								
(5) Log(per cap GDP)²	-0.036	0.071	-0.306	0.997	1.000							
(6) Log(Secondary education)	0.024	0.119	-0.228	0.537	0.520	1.000						
(7) Relative internet users	0.019	0.157	-0.052	0.141	0.136	0.062	1.000					
(8) Relative Corruption index	-0.025	-0.156	0.168	-0.155	-0.137	-0.147	-0.357	1.000				
(9) Conflict index	-0.007	0.037	-0.040	0.063	0.057	0.080	0.031	-0.058	1.000			
(10) Pegged regime	-0.026	-0.040	0.238	0.080	0.079	-0.091	-0.078	0.362	-0.090	1.000		
(11) Intermediate regime	0.043	0.052	-0.218	-0.071	-0.070	0.112	0.079	-0.389	0.052	-0.934	1.000	
(12) Floating regime	-0.049	-0.037	-0.048	-0.026	-0.028	-0.083	-0.004	0.087	0.127	-0.153	-0.209	1.000

Table B. 2. List of primary products

1	**HS-0303**	Fish, frozen, excluding fish fillets
2	**HS-0306**	Crustaceans, whether in shell or not
3	**HS-0901**	Coffee, whether or not roasted or decaff
4	**HS-2301**	Flours, meals and pellets, of meat or me
5	**HS-4403**	Wood in the rough, whether or not stripp
6	**HS-0902**	Tea, whether or not flavoured.
7	**HS-2203**	Beer made from malt.
8	**HS-2402**	Cigars, cheroots, cigarillos and cigaret
9	**HS-5201**	Cotton, not carded or combed.
10	**HS-0207**	Meat and edible offal, of the poultry of
11	**HS-0801**	Coconuts, Brazil nuts and cashew nuts
12	**HS-1006**	Rice.
13	**HS-0804**	Dates, figs, pineapples, avocados, guava
14	**HS-1207**	Other oil seeds and oleaginous fruits
15	**HS-1515**	Other fixed vegetable fats and oils
16	**HS-1701**	Cane or beet sugar and chemically pure
17	**HS-4407**	Wood sawn or chipped lengthwise, sliced
18	**HS-1801**	Cocoa beans, whole or broken, raw
19	**HS-1803**	Cocoa paste, whether or not defatted.
20	**HS-1804**	Cocoa butter, fat and oil.
21	**HS-4001**	Natural rubber, balata, gutta-percha
22	**HS-0803**	Bananas, including plantains, fresh or d
23	**HS-1211**	Plants and parts of plants
24	**HS-2401**	Unmanufactured tobacco; tobacco refuse.
25	**HS-4401**	Fuel wood, in logs, in billets, in twigs
26	**HS-0905**	Vanilla.
27	**HS-0907**	Cloves (whole fruit, cloves and stems).
28	**HS-4402**	Wood charcoal (including shell or nut
29	**HS-1604**	Prepared or preserved fish; caviar
30	**HS-0709**	Other vegetables, fresh or chilled.
31	**HS-1001**	Wheat and meslin.
32	**HS-2202**	Waters, including mineral waters
33	**HS-0406**	Cheese and curd.
34	**HS-0701**	Potatoes, fresh or chilled.
35	**HS-0805**	Citrus fruit, fresh or dried.
36	**HS-0603**	Cut flowers and flower buds of a kind
37	**HS-0713**	Dried leguminous vegetables, shelled
38	**HS-2403**	Other manufactured tobacco and manufactu
39	**HS-4406**	Railway or tramway sleepers (cross-ties)
40	**HS-1202**	Ground-nuts, not roasted or otherwise
41	**HS-1508**	Ground-nut oil and its fractions
42	**HS-0708**	Leguminous vegetables, shelled or unshelled
43	**HS-4002**	Synthetic rubber and factice derived fro
44	**HS-0307**	Molluscs, whether in shell or not, live,
45	**HS-0702**	Tomatoes, fresh or chilled.
46	**HS-0810**	Other fruit, fresh.
47	**HS-0102**	Live bovine animals.
48	**HS-5203**	Cotton, carded or combed.
49	**HS-0302**	Fish, fresh or chilled, excluding fish f
50	**HS-1504**	Fats and oils and their fractions, of fi
51	**HS-0106**	Other live animals.
52	**HS-1703**	Molasses resulting from the extraction o
53	**HS-0104**	Live sheep and goats.
54	**HS-6309**	Worn clothing and other worn articles.
55	**HS-0401**	Milk and cream, not concentrated nor con
56	**HS-1101**	Wheat or meslin flour.
57	**HS-2104**	Soups and broths and preparations
58	**HS-1301**	Lac; natural gums, resins, gum-resins an
59	**HS-1509**	Olive oil and its fractions, whether or
60	**HS-0304**	Fish fillets and other fish meat
61	**HS-0806**	Grapes, fresh or dried.
62	**HS-0808**	Apples, pears and quinces, fresh.
63	**HS-2204**	Wine of fresh grapes
64	**HS-4702**	Chemical wood pulp, dissolving grades.
65	**HS-1005**	Maize (corn).
66	**HS-2208**	Undenatured ethyl alcohol of an alcoholi

Table B. 3. List of manufactured products

1	**HS-2523**	Portland cement, aluminous cement, slag
2	**HS-2804**	Hydrogen, rare gases and other non-metal
3	**HS-2807**	Sulphuric acid; oleum.
4	**HS-2809**	Diphosphorus pentaoxide; phosphoric acid
5	**HS-2814**	Ammonia, anhydrous or in aqueous solutio
6	**HS-2822**	Cobalt oxides and hydroxides; commercial
7	**HS-2836**	Carbonates; peroxocarbonates
8	**HS-2844**	Radioactive chemical elements
9	**HS-2901**	Acyclic hydrocarbons.
10	**HS-2905**	Acyclic alcohols and their halogenated,
11	**HS-3004**	Medicaments (excluding goods of heading
12	**HS-3102**	Mineral or chemical fertilisers,
13	**HS-3105**	Mineral or chemical fertilisers
14	**HS-3301**	Essential oils (terpeneless or not)
15	**HS-3304**	Beauty or make-up preparations
16	**HS-3401**	Soap; organic surface-active products
17	**HS-3507**	Enzymes; prepared enzymes not elsewhere
18	**HS-3802**	Activated carbon; activated natural mine
19	**HS-3811**	Anti-knock preparations, oxidation
20	**HS-3823**	Industrial monocarboxylic fatty acids
21	**HS-3902**	Polymers of propylene or of other
22	**HS-3923**	Articles for the conveyance or packing
23	**HS-3924**	Tableware, kitchenware, other household
24	**HS-4105**	Tanned or crust skins of sheep or lambs,
25	**HS-4106**	Tanned or crust hides and skins of other
26	**HS-4107**	Leather further prepared after tanning
27	**HS-4408**	Sheets for veneering
28	**HS-4412**	Plywood, veneered panels
29	**HS-4802**	Uncoated paper and paperboard
30	**HS-4804**	Uncoated kraft paper and paperboard
31	**HS-4819**	Cartons, boxes, cases, bags
32	**HS-4907**	Unused postage, revenue or similar stamp
33	**HS-5205**	Cotton yarn (other than sewing thread)
34	**HS-5208**	Woven fabrics of cotton, containing 85 %
35	**HS-5408**	Woven fabrics of artificial filament yar
36	**HS-5701**	Carpets and other textile floor covering
37	**HS-6104**	Women's or girls' suits, ensembles, jack
38	**HS-6107**	Men's or boys' underpants, briefs, night
39	**HS-6109**	T-shirts, singlets and other vests, knit
40	**HS-6110**	Jerseys, pullovers, cardigans, waistcoat
41	**HS-6203**	Men's or boys' suits, ensembles, jackets
42	**HS-6204**	Women's or girls' suits, ensembles, jack
43	**HS-6205**	Men's or boys' shirts.
44	**HS-6206**	Women's or girls' blouses, shirts
45	**HS-6210**	Garments, made up of fabrics of heading
46	**HS-6304**	Other furnishing articles
47	**HS-6305**	Sacks and bags
48	**HS-6402**	Other footwear with outer soles
49	**HS-6403**	Footwear with outer soles of rubber
50	**HS-6405**	Other footwear.
51	**HS-6406**	Parts of footwear (including uppers)
52	**HS-6704**	Wigs, false beards, eyebrows and eyelash
53	**HS-6810**	Articles of cement, of concrete
54	**HS-7005**	Float glass and surface ground or polish
55	**HS-7010**	Carboys, bottles, flasks, jars, pots
56	**HS-7102**	Diamonds, whether or not worked, but not
57	**HS-7103**	Precious stones (other than diamonds) an
58	**HS-7113**	Articles of jewellery and parts thereof,
59	**HS-7202**	Ferro-alloys.
60	**HS-7208**	Flat-rolled products of iron or non-allo
61	**HS-7210**	Flat-rolled products of iron or non-allo
62	**HS-7213**	Bars and rods, hot-rolled
63	**HS-7214**	Other bars and rods of iron or non-alloy
64	**HS-7215**	Other bars and rods of iron or non-alloy
65	**HS-7225**	Flat-rolled products of other alloy
66	**HS-7304**	Tubes, pipes and hollow profiles,
67	**HS-7306**	Other tubes, pipes and hollow profiles
68	**HS-7308**	Structures (excluding prefabricated buil
69	**HS-7326**	Other articles of iron or steel.
70	**HS-8207**	Interchangeable tools for hand tools
71	**HS-8502**	Electric generating sets and rotary
72	**HS-8504**	Electrical transformers
73	**HS-8517**	Telephone sets, including telephones for
74	**HS-8525**	Transmission apparatus for radio
75	**HS-8536**	Electrical apparatus for switching
76	**HS-8537**	Boards, panels, consoles, desks, cabinet
77	**HS-8544**	Insulated (including enamelled
78	**HS-8703**	Motor cars and other motor vehicles
79	**HS-8704**	Motor vehicles for the transport of good
80	**HS-8708**	Parts and accessories of the motor
81	**HS-9015**	Surveying
82	**HS-9401**	Seats (other than those of heading 94.02
83	**HS-9406**	Prefabricated buildings.

Table B. 4. Primary products – pre-surge misalignment and year of surge

Country	Product (HS-4)	Year	Weight*	Pre-surge misalignment
Algeria	HS-0804 Dates, figs, pineapples, avocados,	2011	7.0%	-37.5%
Benin	HS-0801 Coconuts, Brazil nuts and cashew nuts	2008	27.0%	46.1%
Burkina Faso	HS-1515 Other fixed vegetable fats and oils	2011	1.3%	19.8%
Burkina Faso	HS-5201 Cotton, not carded or combed.	2003	74.5%	10.3%
Burkina Faso	HS-0801 Coconuts, Brazil nuts and cashew nuts	2011	4.7%	45.3%
Burkina Faso	HS-0804 Dates, figs, pineapples, avocados,	2003	1.5%	9.0%
Cabo Verde	HS-1604 Prepared or preserved fish; caviar	2009	46.7%	34.2%
Cameroon	HS-1801 Cocoa beans, whole or broken, raw	2004	26.0%	37.3%
Congo Dem. Rep. of	HS-1211 Plants and parts of plants	2006	4.3%	58.4%
Congo Dem. Rep. of	HS-4403 Wood in the rough, whether or not	2004	40.7%	46.5%
Congo Dem. Rep. of	HS-4407 Wood sawn or chipped lengthwise	2006	23.8%	45.1%
Congo Rep. of	HS-4001 Natural rubber, balata, gutta-perch	2005	4.7%	19.8%
Congo Rep. of	HS-4403 Wood in the rough, whether or not	2007	65.6%	-13.8%
Cote D' Ivoire	HS-4001 Natural rubber, balata, gutta-perch	2010	11.7%	59.6%
Cote D' Ivoire	HS-0801 Coconuts, Brazil nuts and cashew nuts	2004	4.5%	29.3%
Egypt	HS-0406 Cheese and curd.	2003	7.5%	-73.5%
Egypt	HS-0701 Potatoes, fresh or chilled.	2005	4.7%	-80.7%
Egypt	HS-0805 Citrus fruit, fresh or dried.	2003	11.4%	-52.9%
Ethiopia	HS-0603 Cut flowers and flower buds	2003	9.8%	16.0%
Ethiopia	HS-0709 Other vegetables, fresh or chilled.	2006	12.7%	-4.3%
Ethiopia	HS-0713 Dried leguminous vegetables	2010	7.3%	5.8%
Gabon	HS-4001 Natural rubber, balata, gutta-perch	2005	11.0%	50.5%
Gabon	HS-4407 Wood sawn or chipped lengthwise	2011	30.9%	26.5%
Ghana	HS-1801 Cocoa beans, whole or broken	2004	52.8%	-28.1%
Ghana	HS-1803 Cocoa paste, whether or not defatte	2004	9.0%	-48.7%
Ghana	HS-1804 Cocoa butter, fat and oil.	2009	4.5%	-24.8%
Ghana	HS-0801 Coconuts, Brazil nuts and cashew nuts	2011	4.2%	16.4%
Guinea Bissau	HS-0303 Fish, frozen, excluding fish fillet	2010	11.1%	14.7%
Guinea Bissau	HS-0801 Coconuts, Brazil nuts and cashew nuts	2011	84.4%	46.2%
Kenya	HS-0603 Cut flowers and flower buds	2004	18.5%	-25.4%
Liberia	HS-1801 Cocoa beans, whole or broken	2008	6.7%	37.1%
Malawi	HS-2401 Unmanufactured tobacco; tobacco	2005	65.8%	24.2%
Malawi	HS-5201 Cotton, not carded or combed.	2004	3.6%	13.2%
Malawi	HS-0713 Dried leguminous vegetables	2007	5.3%	19.1%
Mali	HS-1207 Other oil seeds and oleaginous	2006	6.5%	-0.5%
Mali	HS-0804 Dates, figs, pineapples, avocados,	2003	3.3%	-14.9%
Mauritania	HS-1504 Fats and oils and their fractions,	2009	1.2%	-35.4%
Mauritania	HS-2301 Flours, meals and pellets, of meat	2010	6.0%	-22.2%
Morocco	HS-0702 Tomatoes, fresh or chilled.	2007	11.2%	-15.8%
Mozambique	HS-4407 Wood sawn or chipped lengthwise	2007	6.9%	68.1%
Niger	HS-1701 Cane or beet sugar and chemically	2010	3.2%	48.7%
Niger	HS-6309 Worn clothing and other worn article	2005	7.4%	-6.6%
Nigeria	HS-1207 Other oil seeds and oleaginous	2005	6.3%	-33.0%
Nigeria	HS-1801 Cocoa beans, whole or broken	2003	31.0%	-18.7%
Nigeria	HS-4001 Natural rubber, balata, gutta-perch	2006	19.4%	23.4%
Nigeria	HS-0801 Coconuts, Brazil nuts and cashew nuts	2003	4.9%	-9.5%
Senegal	HS-0303 Fish, frozen, excluding fish fillet	2007	17.7%	3.5%
Sierra Leone	HS-1801 Cocoa beans, whole or broken	2004	67.0%	37.2%
South Africa	HS-4702 Chemical wood pulp, dissolving grad	2010	5.7%	-21.3%
Tanzania	HS-2401 Unmanufactured tobacco; tobacco ref	2005	15.9%	20.6%
Tanzania	HS-0801 Coconuts, Brazil nuts and cashew nu	2009	8.8%	24.5%
The Gambia	HS-0303 Fish, frozen, excluding fish fillet	2008	4.6%	10.6%
Togo	HS-1801 Cocoa beans, whole or broken, raw o	2004	45.1%	48.8%
Tunisia	HS-0804 Dates, figs, pineapples, avocados,	2004	13.3%	-6.4%
Uganda	HS-1701 Cane or beet sugar and chemically	2005	4.6%	33.5%

* The weight corresponds to the product's share of total exports in its category. Pre-surge misalignment is the average misalignment over the 7-year period prior to the surge.

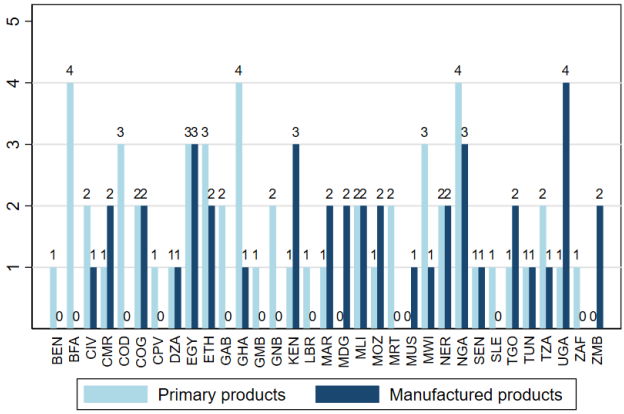
Table B. 5. Manufactured products – pre-surge misalignment and year of surge

Country	Product (HS-4)	Year	Weight*	Pre-surge misalignment
Cote D' Ivoire	HS-3923 Articles for the conveyance or pack	2009	4.1%	-2.6%
Cameroon	HS-3401 Soap; organic surface-active produc	2005	8.2%	16.0%
Cameroon	HS-4819 Cartons, boxes, cases, bags	2005	3.9%	-6.4%
Congo Rep. of	HS-4408 Sheets for veneering	2007	1.2%	-16.2%
Congo Rep. of	HS-7326 Other articles of iron or steel.	2005	1.1%	-50.4%
Algeria	HS-8703 Motor cars and other motor vehicles	2005	11.8%	-93.8%
Egypt	HS-3102 Mineral or chemical fertilisers	2006	8.5%	-36.2%
Egypt	HS-6203 Men's or boys' suits, ensembles	2003	3.5%	-42.9%
Egypt	HS-6204 Women's or girls' suits, ensembles,	2004	2.6%	-44.0%
Ethiopia	HS-6109 T-shirts, singlets and other vests	2010	3.7%	24.7%
Ethiopia	HS-6403 Footwear with outer soles of rubber	2005	3.2%	24.1%
Ghana	HS-3304 Beauty or make-up preparations and	2011	4.8%	-30.8%
Kenya	HS-2523 Portland cement, aluminous cement,	2005	5.0%	-7.8%
Kenya	HS-2836 Carbonates; peroxocarbonates	2003	7.1%	-29.9%
Kenya	HS-3923 Articles for the conveyance or pack	2006	3.6%	-35.9%
Morocco	HS-3105 Mineral or chemical fertilisers	2010	10.8%	2.0%
Morocco	HS-8703 Motor cars and other motor vehicles	2007	4.5%	-28.1%
Madagascar	HS-3301 Essential oils (terpeneless or not)	2007	4.8%	-9.3%
Madagascar	HS-6205 Men's or boys' shirts.	2007	5.4%	1.5%
Mali	HS-4105 Tanned or crust skins of sheep	2010	7.1%	6.4%
Mali	HS-8517 Telephone sets, including telephone	2003	2.2%	-16.1%
Mozambique	HS-7103 Precious stones (other than diamond	2011	6.1%	65.8%
Mozambique	HS-7306 Other tubes, pipes and hollow	2010	6.8%	53.5%
Mauritius	HS-6104 Women's or girls' suits, ensembles	2009	4.3%	4.5%
Malawi	HS-4412 Plywood, veneered panels	2004	2.7%	40.8%
Niger	HS-2844 Radioactive chemical elements	2009	92.0%	22.3%
Niger	HS-8517 Telephone sets, including telephone	2009	0.5%	34.4%
Nigeria	HS-4105 Tanned or crust skins of sheep	2004	4.8%	-28.3%
Nigeria	HS-4106 Tanned or crust hides and skins	2003	14.9%	-24.7%
Nigeria	HS-6402 Other footwear with outer soles	2006	4.4%	-13.7%
Senegal	HS-7213 Bars and rods, hot-rolled	2007	3.3%	0.9%
Togo	HS-3923 Articles for the conveyance or pack	2003	5.5%	3.8%
Togo	HS-6704 Wigs, false beards, eyebrows	2009	2.5%	54.5%
Tunisia	HS-6403 Footwear with outer soles of rubber	2003	3.5%	6.8%
Tanzania	HS-3105 Mineral or chemical fertilisers	2005	6.1%	14.8%
Uganda	HS-2523 Portland cement, aluminous cement,	2004	17.6%	31.9%
Uganda	HS-3401 Soap; organic surface-active produc	2003	4.7%	31.7%
Uganda	HS-7210 Flat-rolled products of iron or non	2003	4.4%	4.6%
Uganda	HS-8525 Transmission apparatus for radio	2005	17.0%	15.4%
Zambia	HS-2523 Portland cement, aluminous cement,	2008	12.1%	-1.5%
Zambia	HS-2807 Sulphuric acid; oleum.	2007	10.9%	-44.2%

* The weight corresponds to the product's share of total exports in its category. Pre-surge misalignment is the average misalignment over the 7-year period prior to the surge.

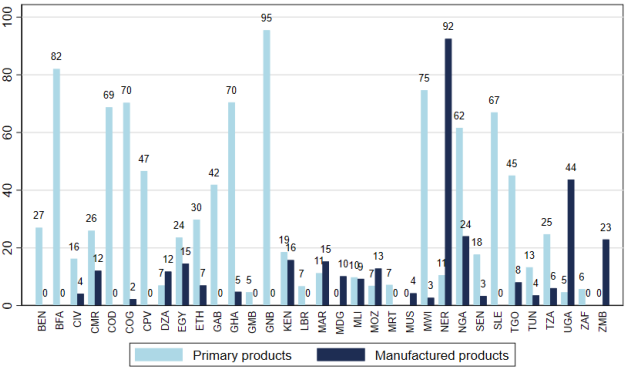
Appendix 2: Surge episodes and their contribution to product categories

Figure B. 1 : Number of export surges, by country among top 5 products of each category



Source: BACI 2019

Figure B. 2: Percentage of product surges among all products considered for each category (%)



Source: BACI 2019

Appendix 3: Regressions with the overvaluation level as an additional control (Cloglog)

Table B. 6. Baseline regression results. Onset of export surges: cloglog results (2001-2012)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manu	(6) Manu
Log (GDP per cap)	0.024	0.076	-0.082	-0.065	0.143*	0.253***
	(0.067)	(0.069)	(0.099)	(0.098)	(0.086)	(0.084)
Log (GDP per cap) ²	-0.004	-0.008*	0.004	0.003	-0.012**	-0.020***
	(0.005)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)
Log (Secondary education)	0.022***	0.024***	0.031***	0.030***	0.015**	0.012*
	(0.005)	(0.006)	(0.007)	(0.009)	(0.007)	(0.007)
Undervaluation	-0.069***	-0.071***	-0.078**	-0.088**	-0.050**	-0.038*
	(0.020)	(0.019)	(0.039)	(0.035)	(0.024)	(0.020)
Overvaluation	**-0.012**	**-0.014**	**0.000**	**-0.005**	**-0.034**	**-0.019**
	(0.028)	**(0.027)**	**(0.034)**	**(0.032)**	**(0.049)**	**(0.041)**
Market share	-0.001*	-0.001*	-0.001	-0.001	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Relative Internet users	0.001***	0.001***	0.001	0.001*	0.001**	0.001**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Relative Corruption index	-0.020***	-0.018**	-0.023**	-0.022**	-0.017	-0.000
	(0.007)	(0.008)	(0.010)	(0.009)	(0.010)	(0.012)
Conflict index	0.055	0.063	0.086	0.077	0.020	0.051
	(0.052)	(0.055)	(0.091)	(0.089)	(0.058)	(0.058)
Pegged regime	0.712***	0.637***	0.723***	0.645***	0.604***	0.545***
	(0.044)	(0.068)	(0.102)	(0.086)	(0.117)	(0.071)
Intermediate regime	0.701***	0.630***	0.698***	0.636***	0.605***	0.538***
	(0.047)	(0.069)	(0.101)	(0.083)	(0.119)	(0.070)
Southern Africa		-0.019		-0.034		-0.020
		(0.020)		(0.031)		(0.022)
Central Africa		0.029		0.041		0.004
		(0.021)		(0.032)		(0.022)
East Africa		0.009		0.021		-0.002
		(0.015)		(0.022)		(0.020)
West Africa		-0.008		0.032		-0.051***
		(0.015)		(0.022)		(0.017)
Observations	2,815	2,815	1,478	1,478	1,337	1,337
Number of surges	66	66	36	36	30	30

Notes: Cloglog estimates. The regression coefficients are marginal effects. The dependent variable is the dummy variable equal to 1 over a 3-year window centered on the onset date of the surge. Control variables are averages over the 7 year-period prior the surge. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Appendix 4: Robustness - alternative parameters (Cloglog)

Table B. 7. Robustness about the onset surges: Horizon 6 and 8

	(1) All	(2) Primary	(3) Manu	(4) All	(5) Primary	(5) Manu
	Horizon 6 (α = 1.3 and β = 0.03; 6 years)			**Horizon 8 (α = 1.3 and β = 0.03; 8 years)**		
Log (Per cap GDP)	0.069	0.067	0.114	0.023	-0.082	0.105**
	(0.084)	(0.115)	(0.102)	(0.071)	(0.113)	(0.043)
Log (Per cap GDP) ²	-0.008	-0.006	-0.012*	-0.004	0.005	-0.009***
	(0.006)	(0.007)	(0.007)	(0.005)	(0.007)	(0.003)
Log (Secondary education)	0.034***	0.019*	0.042***	0.016***	0.018**	0.007
	(0.009)	(0.011)	(0.010)	(0.006)	(0.008)	(0.004)
Undervaluation	-0.106***	-0.092**	-0.039	-0.057***	-0.060*	-0.022*
	(0.026)	(0.044)	(0.031)	(0.017)	(0.032)	(0.011)
Market share	-0.003***	-0.002**	-0.009	-0.001	-0.001	-0.000
	(0.001)	(0.001)	(0.008)	(0.001)	(0.001)	(0.001)
Relative Internet users	0.000	0.001	0.000	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Relative Corruption index	-0.030**	-0.022	-0.013	-0.012*	-0.005	-0.007
	(0.013)	(0.015)	(0.014)	(0.007)	(0.007)	(0.006)
Conflict index	0.090	0.140	0.028	0.046	-0.006	0.063**
	(0.082)	(0.102)	(0.090)	(0.048)	(0.079)	(0.028)
Pegged regime	0.097	0.890***	0.072	0.006	-0.059	0.188***
	(0.080)	(0.122)	(0.059)	(0.043)	(0.050)	(0.054)
Intermediate regime	0.071	0.880***	0.027	0.027	-0.044	0.205***
	(0.080)	(0.125)	(0.057)	(0.043)	(0.049)	(0.053)
Southern Africa	-0.033	-0.068	0.000	-0.004	-0.028	-0.005
	(0.027)	(0.042)	(0.027)	(0.017)	(0.031)	(0.010)
Central Africa	0.027	0.041	-0.017	0.032*	0.012	0.020
	(0.027)	(0.036)	(0.029)	(0.019)	(0.030)	(0.014)
East Africa	0.023	0.034	-0.002	-0.007	0.006	-0.016*
	(0.022)	(0.026)	(0.028)	(0.014)	(0.022)	(0.009)
West Africa	-0.014	0.058**	-0.104***	-0.007	0.032	-0.029***
	(0.021)	(0.026)	(0.022)	(0.014)	(0.021)	(0.011)
Observations	2,686	1,403	1,283	2,647	1,397	1,250
Number of surges	84	46	38	41	23	18

Notes: cloglog estimates. The coefficients reported are marginal effect evaluated at the sample means. The dependent variable is a dummy that is equal to 1 over a 3-year window centered on the onset date of the surge. Controls are averages over the 7 year-period prior the surge. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Table B. 8. Robustness about the onset surges: Lower criterion 2 and Higher criterion 2

	(1) All	(2) Primary	(3) Manu	(4) All	(5) Primary	(6) Manu
	Lower criterion (α = 1.1 and β = 0.02; 7 years)			**Higher criterion (α = 1.5 and β = 0.04; 7 years)**		
Log (Per cap GDP)	0.078	-0.108	0.294***	0.078	-0.075	0.247***
	(0.074)	(0.112)	(0.084)	(0.062)	(0.085)	(0.075)
Log (Per cap GDP) ²	-0.008	0.006	-0.022***	-0.007*	0.004	-0.019***
	(0.005)	(0.007)	(0.006)	(0.004)	(0.005)	(0.005)
Log (Secondary education)	0.025***	0.030***	0.011	0.023***	0.026***	0.013**
	(0.007)	(0.009)	(0.007)	(0.006)	(0.008)	(0.007)
Undervaluation	-0.084***	-0.101***	-0.048**	-0.065***	-0.075**	-0.037**
	(0.019)	(0.035)	(0.021)	(0.017)	(0.031)	(0.016)
Market share	-0.001**	-0.001	-0.002	-0.001	-0.000	-0.001
	(0.001)	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)
Relative Internet users	0.001***	0.001*	0.001***	0.001**	0.001	0.001*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Relative Corruption index	-0.018**	-0.024**	0.008	-0.018**	-0.020**	-0.004
	(0.008)	(0.010)	(0.012)	(0.007)	(0.009)	(0.011)
Conflict index	0.053	0.057	0.047	0.072	0.057	0.087*
	(0.059)	(0.093)	(0.062)	(0.048)	(0.074)	(0.048)
Pegged regime	0.696***	0.688***	0.588***	0.597***	0.589***	0.459***
	(0.080)	(0.104)	(0.089)	(0.069)	(0.048)	(0.077)
Intermediate regime	0.690***	0.678***	0.582***	0.601***	0.592***	0.461***
	(0.079)	(0.104)	(0.090)	(0.068)	(0.043)	(0.077)
Southern Africa	-0.022	-0.039	-0.023	0.000	-0.012	-0.002
	(0.021)	(0.033)	(0.024)	(0.018)	(0.031)	(0.019)
Central Africa	0.036*	0.037	0.013	0.052**	0.064**	0.025
	(0.022)	(0.033)	(0.023)	(0.021)	(0.032)	(0.020)
East Africa	0.015	0.023	0.007	0.024*	0.035	0.013
	(0.016)	(0.024)	(0.020)	(0.015)	(0.023)	(0.018)
West Africa	-0.005	0.036	-0.056***	0.007	0.049**	-0.036**
	(0.016)	(0.024)	(0.019)	(0.015)	(0.022)	(0.016)
Observations	2,811	1,477	1,334	2,827	1,480	1,347
Number of surges	71	39	32	60	33	27

Notes: cloglog estimates. The coefficients reported are marginal effect evaluated at the sample means. The dependent variable is a dummy that is equal to 1 over a 3-year window centered on the onset date of the surge. Controls are averages over the 7 year-period prior the surge. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Appendix 5: What happens during surges episodes?

Just as currency undervaluation helps trigger export surges, does it support performance over the duration of these surges? The interest of this new facet of the empirical analysis is to exploit the intra-individual dimension of the panel. Right hand side regressors are lagged. By doing so we get a better causality interpretation by avoiding the endogeneity bias. The risk of this bias is quite limited for the main variable of interest as the exchange rate policy is not determined with regard to the country competitors on a specific product. In addition, Smith (2004) finds that agricultural goods and manufacturing exports respond to the exchange rate movement with a lag of 12 to 15 months. Country-product pairs of observations are considered on a yearly basis. The dependent variable takes the value 1 for each year of the seven-year period defining the surge, and then we stop the series for the years beyond. By contrast, in case of no country-product surge (control group), the dependent variable takes the value 0 over the whole period (2001-2017).

Table B. 9. Baseline regressions: during surge periods (2001-2017)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manuf	(6) Manuf
Undervaluation	-0.079***	-0.094***	-0.089**	-0.124***	-0.072**	-0.056*
	(0.026)	(0.027)	(0.041)	(0.039)	(0.032)	(0.033)
Southern Africa		-0.132***		-0.164***		-0.102***
		(0.025)		(0.043)		(0.028)
Central Africa		-0.036**		0.007		-0.079***
		(0.017)		(0.023)		(0.023)
East Africa		-0.002		-0.013		0.004
		(0.015)		(0.023)		(0.018)
West Africa		0.007		0.063***		-0.060***
		(0.014)		(0.020)		(0.019)
Observations	5,596	5,596	2,947	2,947	2,649	2,649
# of surges	96	96	55	55	41	41

Notes: cloglog estimates. The coefficients reported are marginal effects evaluated at the sample mean. The dependent variable is the dummy variable equals to 1 over a 7-year window following the onset date. Undervaluation is lagged. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

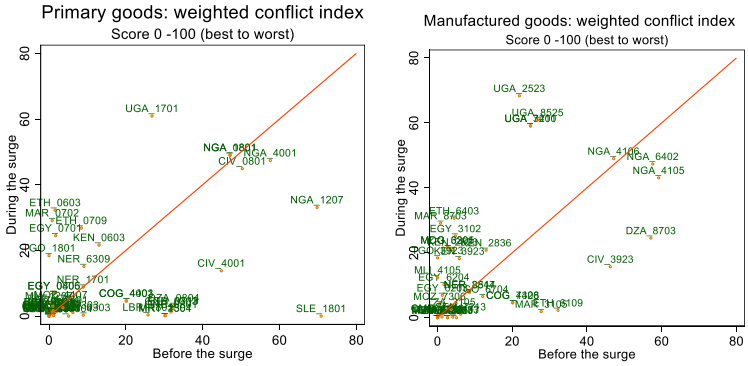
In Table B.9. as for the onset phase, the regression coefficient of undervaluation is statistically significant for both categories of products, whether we control or not for

regional heterogeneities by dummy variables. In Table B.11., we keep previous covariates about onset surges and add a post 2008 dummy variable to capture the effects of the worldwide financial crisis. We also add a variable to control for the catching up effect for country-products whose performance may have benefited from the end of violent social and political unrest in the years prior to the onset surge. The list of country-product pairs in this situation limits to 17 out of the 96 export surges. To set up this list, the conflict index has been normalized to vary between 0 and 100. Severe conflict cases are those with at least a 15 percentage points less when comparing the period during which the acceleration takes place and the period preceding its triggering (Figure B.3 and Table B.10.). A lower conflictuality, stimulates economic recovery and may affect the impact of undervaluation in the post-conflict period. To capture this phenomenon, a dummy variable taking the value 1 for the 13 identified cases is created. We also use this variable in a multiplicative form with the conflict index.

Table B. 10. List of countries and products with severe conflict issues

Country	Product (HS-4)	Type	year	Country	Product (HS-4)	Type	year
Algeria	0804	Primary	2011	Guinea-Bissau	0303	Primary	2010
Congo	4408	Manu	2007	Guinea-Bissau	0801	Primary	2011
Congo	7326	Manu	2005	Liberia	1801	Primary	2008
Congo	4001	Primary	2005	Mauritania	1504	Primary	2009
Congo	4403	Primary	2007	Mauritania	2301	Primary	2010
Ethiopia	6109	Manu	2010	Morroco	3105	Manu	2010
Ethiopia	0713	Primary	2010				

Figure B. 3: Conflict patterns before and during export surge episodes



Regression results are close to the previous ones. A structural variable such as the per capita GDP level plays a significant role. ICTs also matter. This variable probably correlates to other components of the domestic infrastructure for which information on yearly basis is limited. The multiplicative variable about the conflict index is not significant, but the positive dummy suggests the presence of a catch-up effect with respect to pre-triggering social or political disorganizations. In any case, the coefficient of the undervaluation remains robust. Moreover, while the number of observations varies according to the specification of the model, the sensitivity to this variable is systematically the highest for primary products. Dropping from the sample the particular case of the 13 country-product pairs with a catching-up process in post-conflict period does not affect the outcome significantly (Appendix 3c).

Unlike our previous findings, the *fear of floating* is no longer a factor influencing the performance during the seven-year period of surges. It's also worth noting that the pegged regime does not penalize export surges as some arguments potentially suggest in line with the rigidity of a hard anchoring to a currency. The franc zone achieves, for example, 18% of the total export surges with a CFA franc that is fixed since 1994 vis-à-vis the French franc, and the euro after 1999. Table B.11. confirms what we found for the onset phase. In other words, undervaluation still remains an efficient instrument to stimulate exports. From columns 2, 4 and 6, we note that a one standard deviation decrease in undervaluation raises the probability of an export surge by 3.5 percentage points for primary products, 1.6 for manufactured goods. By contrast to what happens for the take-off, country-related structural variables are more significant and strengthen the performance during the surge. The results survive to the introduction to the overvaluation variable (Table B.12.), the use of an alternative estimator or alternatives definitions of surges episodes ((Tables B.13. to Tables B.15.)

Table B. 11. Regression results. During surge periods (2001-2017)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manuf	(6) Manuf
Log (Per cap GDP)	0.267***	0.305***	0.073	-0.025	0.503***	0.675***
	(0.058)	(0.060)	(0.073)	(0.068)	(0.080)	(0.087)
Log (Per cap GDP) ²	-0.020***	-0.022***	-0.007	0.000	-0.036***	-0.047***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.006)	(0.006)
Log (Secondary education)	0.006	-0.002	0.016**	0.010	-0.006	-0.015**
	(0.005)	(0.005)	(0.007)	(0.008)	(0.007)	(0.007)
Undervaluation	-0.133***	-0.133***	-0.163***	-0.175***	-0.101***	-0.089***
	(0.026)	(0.027)	(0.040)	(0.045)	(0.031)	(0.028)
Market share	-0.000	-0.000	-0.000	0.000	-0.001	-0.001
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Relative Internet users	0.001***	0.001***	0.001***	0.001***	0.001***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relative Corruption index	0.007	0.010	0.011	0.002	0.001	0.024***
	(0.006)	(0.007)	(0.010)	(0.009)	(0.007)	(0.008)
Conflict index	-0.060***	-0.064***	-0.137***	-0.131***	-0.019*	-0.017
	(0.017)	(0.018)	(0.044)	(0.042)	(0.011)	(0.011)
Conflict dummy	0.188***	0.181***	0.189***	0.161***	0.190***	0.164***
	(0.014)	(0.014)	(0.018)	(0.018)	(0.021)	(0.021)
Conflict index * Conflict dummy	-0.142	-0.128	-0.127	-0.072	-0.100	-0.096
	(0.111)	(0.109)	(0.147)	(0.140)	(0.168)	(0.157)
Pegged regime	0.064**	0.042	0.099**	0.049	0.025	0.039
	(0.030)	(0.031)	(0.048)	(0.047)	(0.035)	(0.034)
Intermediate regime	0.074**	0.054*	0.091*	0.064	0.057	0.038
	(0.030)	(0.031)	(0.048)	(0.046)	(0.035)	(0.033)
Southern Africa		-0.080***		-0.094**		-0.071**
		(0.025)		(0.043)		(0.028)
Central Africa		-0.002		0.051*		-0.063**
		(0.021)		(0.029)		(0.027)
East Africa		0.013		-0.003		0.040*
		(0.017)		(0.023)		(0.023)
West Africa		0.003		0.062***		-0.052**
		(0.016)		(0.023)		(0.023)
Post 2008	0.080***	0.079***	0.084***	0.088***	0.072***	0.061***
	(0.011)	(0.011)	(0.016)	(0.015)	(0.014)	(0.013)
Observations	5,596	5,596	2,947	2,947	2,649	2,649
# of surges	96	96	55	55	41	41

Notes: cloglog estimates. The coefficients reported are marginal effects evaluated at the sample mean. The dependent variable is the dummy variable that equals 1 over the 7-year period following the onset surge. All control variables are lagged. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Table B. 12. Regression results. During the period of surges: cloglog estimations (2001-2017)

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manu	(6) Manu
Log (GDP per cap)	0.263***	0.302***	0.081	-0.020	0.458***	0.637***
	(0.057)	(0.059)	(0.072)	(0.068)	(0.079)	(0.085)
Log (GDP per cap) ²	-0.020***	-0.022***	-0.008	0.000	-0.034***	-0.044***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.006)
Log (Secondary educ)	0.006	-0.002	0.016**	0.010	-0.005	-0.014**
	(0.005)	(0.006)	(0.007)	(0.008)	(0.007)	(0.007)
Undervaluation	-0.130***	-0.131***	-0.171***	-0.180***	-0.085***	-0.079***
	(0.027)	(0.028)	(0.041)	(0.046)	(0.032)	(0.030)
Overvaluation	**-0.012**	**-0.008**	**0.025**	**0.019**	**-0.079****	**-0.053***
	(0.024)	**(0.024)**	**(0.031)**	**(0.030)**	**(0.036)**	**(0.032)**
Market share	-0.000	-0.000	-0.000	0.000	-0.001	-0.001
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Relative internet users	0.001***	0.001***	0.001***	0.001***	0.001***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relative Corruption index	0.008	0.010	0.009	0.001	0.003	0.025***
	(0.006)	(0.007)	(0.010)	(0.008)	(0.007)	(0.008)
Conflict index	-0.060***	-0.064***	-0.136***	-0.131***	-0.019*	-0.018
	(0.017)	(0.018)	(0.043)	(0.042)	(0.011)	(0.011)
Conflict Dummy	0.188***	0.181***	0.190***	0.161***	0.183***	0.160***
	(0.014)	(0.014)	(0.018)	(0.018)	(0.022)	(0.021)
Conflict index*Conflict Dummy	-0.141	-0.128	-0.129	-0.073	-0.096	-0.099
	(0.111)	(0.109)	(0.147)	(0.140)	(0.169)	(0.158)
Pegged regime	0.063**	0.041	0.101**	0.052	0.023	0.037
	(0.030)	(0.031)	(0.048)	(0.047)	(0.035)	(0.034)
Intermediate regime	0.072**	0.053*	0.094*	0.066	0.051	0.034
	(0.030)	(0.031)	(0.048)	(0.047)	(0.034)	(0.033)
Southern Africa		-0.080***		-0.095**		-0.068**
		(0.025)		(0.043)		(0.028)
Central Africa		-0.001		0.047		-0.060**
		(0.021)		(0.029)		(0.027)
East Africa		0.013		-0.004		0.038*
		(0.016)		(0.023)		(0.023)
West Africa		0.003		0.061***		-0.052**
		(0.016)		(0.023)		(0.023)
Post 2008	0.080***	0.080***	0.084***	0.088***	0.076***	0.064***
	(0.011)	(0.011)	(0.016)	(0.015)	(0.014)	(0.013)
Observations	5,596	5,596	2,947	2,947	2,649	2,649
# of surges	96	96	55	55	41	41

Notes: Cloglog estimates. The coefficients reported are marginal effect evaluated at the sample means. The dependent variable is a dummy that is equal to 1 over a 7-year window following the onset date. All controls are lagged. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Table B. 13. During the period of export surges - ReLogit estimates

	(1) All	(2) All	(3) Primary	(4) Primary	(5) Manuf	(6) Manuf
Log (Per cap GDP)	-0.562***	3.285***	-0.693***	-0.760***	-0.430***	-0.366**
	(0.094)	(0.754)	(0.144)	(0.183)	(0.121)	(0.163)
Log (Per cap GDP) ²	0.012	-0.238***	0.022*	0.035**	0.005	0.009
	(0.009)	(0.051)	(0.013)	(0.015)	(0.011)	(0.015)
Log (Secondary education)	0.102**	-0.043	0.180***	0.095	-0.017	-0.061
	(0.051)	(0.062)	(0.066)	(0.082)	(0.081)	(0.079)
Undervaluation	-1.864***	-1.579***	-1.908***	-2.065***	-1.843***	-1.525***
	(0.294)	(0.311)	(0.405)	(0.474)	(0.418)	(0.448)
Market share	-0.003	-0.003	-0.004	0.001	-0.000	-0.006
	(0.005)	(0.006)	(0.006)	(0.005)	(0.014)	(0.016)
Relative Internet users	0.011***	0.011***	0.014***	0.014***	0.006*	0.002
	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Relative Corruption index	-0.012	0.093	0.073	-0.006	-0.131	0.048
	(0.072)	(0.074)	(0.111)	(0.099)	(0.086)	(0.115)
Conflict index	-0.679***	-0.679***	-1.359***	-1.364***	-0.227	-0.324*
	(0.198)	(0.205)	(0.465)	(0.472)	(0.156)	(0.185)
Conflict Dummy	2.375***	2.275***	2.227***	2.027***	2.684***	2.590***
	(0.202)	(0.193)	(0.243)	(0.251)	(0.391)	(0.428)
Conflict index * Conflict dummy	-2.452	-1.996	-2.013	-1.475	-2.257	-2.122
	(1.586)	(1.574)	(1.945)	(1.988)	(2.984)	(3.004)
Pegged regime	0.528*	0.380	0.895*	0.426	0.114	0.255
	(0.297)	(0.363)	(0.462)	(0.515)	(0.383)	(0.400)
Intermediate regime	0.498*	0.550	0.733	0.608	0.283	0.091
	(0.287)	(0.357)	(0.448)	(0.508)	(0.368)	(0.372)
Southern Africa		-0.886***		-0.926**		-0.957***
		(0.280)		(0.465)		(0.342)
Central Africa		-0.008		0.564*		-1.180***
		(0.227)		(0.320)		(0.369)
East Africa		0.139		-0.063		-0.167
		(0.191)		(0.260)		(0.293)
West Africa		0.083		0.742***		-0.805**
		(0.186)		(0.253)		(0.319)
Post 2008	0.882***	0.874***	0.884***	0.961***	0.843***	0.712***
	(0.140)	(0.121)	(0.192)	(0.193)	(0.199)	(0.193)
Observations	5,596	5,596	2,947	2,947	2,649	2,649
# of surges	96	96	55	55	41	41

Notes: ReLogit estimates. The coefficients reported are not marginal effect. The dependent variable is the dummy variable equals to 1 over a 7-year window following the onset date. All control variables are lagged. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Table B. 14. Robustness during the period of surges: Horizon 6 and 8

	(1) All	(2) Primary	(3) Manu	(4) All	(5) Primary	(6) Manu
	Horizon 6 (α = 1.3 and β = 0.03; 6 years)			**Horizon 8 (α = 1.3 and β = 0.03; 8 years)**		
Log (Per cap GDP)	0.380***	0.293***	0.451***	0.212***	0.072	0.337***
	(0.062)	(0.076)	(0.095)	(0.053)	(0.071)	(0.057)
Log (Per cap GDP) ^{2}	-0.028***	-0.021***	-0.033***	-0.015***	-0.005	-0.024***
	(0.004)	(0.005)	(0.007)	(0.004)	(0.005)	(0.004)
Log (Secondary education)	0.010*	0.017**	0.003	0.001	0.021***	-0.017***
	(0.006)	(0.008)	(0.007)	(0.005)	(0.006)	(0.005)
Undervaluation	-0.119***	-0.131***	-0.086***	-0.106***	-0.106***	-0.095***
	(0.028)	(0.045)	(0.032)	(0.019)	(0.032)	(0.017)
Market share	-0.002***	-0.001*	-0.006**	-0.000	-0.001	0.001
	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)
Relative Internet users	0.001***	0.001***	0.000	0.001***	0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relative Corruption index	0.002	0.001	0.013	0.008*	0.005	0.009
	(0.009)	(0.012)	(0.010)	(0.004)	(0.004)	(0.005)
Conflict index	-0.090***	-0.126***	-0.040*	-0.026**	-0.030	-0.012*
	(0.024)	(0.040)	(0.022)	(0.011)	(0.020)	(0.006)
Conflict issues	0.156***	0.119***	0.149***	0.108***	0.092***	0.094***
	(0.017)	(0.021)	(0.025)	(0.010)	(0.013)	(0.014)
Conflict index*Conflict dummy	-0.209	-0.166	-0.114	-0.145*	-0.366**	0.051
	(0.146)	(0.186)	(0.194)	(0.087)	(0.151)	(0.085)
Pegged regime	0.074**	0.059	0.113**	0.048*	0.014	0.090**
	(0.037)	(0.053)	(0.046)	(0.028)	(0.033)	(0.042)
Intermediate regime	0.092**	0.098*	0.085*	0.067**	0.028	0.101**
	(0.037)	(0.052)	(0.046)	(0.028)	(0.032)	(0.042)
Southern Africa	-0.089***	-0.135***	-0.071***	-0.010	-0.012	-0.025
	(0.024)	(0.047)	(0.025)	(0.016)	(0.028)	(0.015)
Central Africa	0.000	0.087***	-0.114***	0.002	0.032*	-0.027
	(0.020)	(0.026)	(0.028)	(0.015)	(0.018)	(0.021)
East Africa	0.006	0.019	-0.008	0.002	0.017	-0.008
	(0.017)	(0.022)	(0.024)	(0.012)	(0.017)	(0.015)
West Africa	-0.016	0.078***	-0.127***	0.006	0.063***	-0.044**
	(0.016)	(0.022)	(0.023)	(0.013)	(0.017)	(0.018)
Post 2008	0.033***	0.029*	0.034**	0.076***	0.076***	0.056***
	(0.012)	(0.016)	(0.014)	(0.008)	(0.011)	(0.009)
Observations	5,350	2,810	2,540	5,838	3,089	2,749
# of surges	117	66	51	59	34	25

Notes: cloglog estimates. The coefficients reported are marginal effect evaluated at the sample means. The dependent variable is a dummy that is equal to 1 over a 7-year window following the onset date. All controls are lagged. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Table B. 15. Robustness during the period of surges: Lower criterion 2 and Higher criterion 2

	(1) All	(2) Primary	(3) Manu	(4) All	(5) Primary	(6) Manu
	Lower criterion (α = 1.1 and β = 0.02; 7 years)			**Higher criterion (α = 1.5 and β = 0.04; 7 years)**		
Log (Per cap GDP)	0.334***	-0.022	0.714***	0.339***	0.015	0.647***
	(0.064)	(0.079)	(0.091)	(0.058)	(0.064)	(0.078)
Log (Per cap GDP) ^{2}	-0.024***	-0.000	-0.050***	-0.024***	-0.002	-0.044***
	(0.004)	(0.005)	(0.006)	(0.004)	(0.004)	(0.005)
Log (Secondary education)	-0.001	0.006	-0.011	-0.003	0.004	-0.014**
	(0.006)	(0.008)	(0.007)	(0.005)	(0.008)	(0.006)
Undervaluation	-0.128***	-0.169***	-0.085***	-0.120***	-0.124**	-0.100***
	(0.028)	(0.048)	(0.031)	(0.025)	(0.048)	(0.023)
Market share	-0.001	-0.000	-0.001	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Relative Internet users	0.001***	0.001***	0.001*	0.001***	0.002***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Relative Corruption index	0.017**	0.005	0.037***	0.005	0.003	0.011
	(0.007)	(0.009)	(0.008)	(0.006)	(0.008)	(0.007)
Conflict index	-0.070***	-0.142***	-0.021*	-0.049***	-0.107***	-0.011
	(0.020)	(0.044)	(0.012)	(0.015)	(0.036)	(0.008)
Conflict issues	0.192***	0.172***	0.166***	0.165***	0.142***	0.148***
	(0.015)	(0.020)	(0.022)	(0.013)	(0.017)	(0.018)
Conflict index*Conflict dummy	-0.121	-0.050	-0.099	-0.310***	-0.384**	-0.104
	(0.113)	(0.145)	(0.171)	(0.116)	(0.160)	(0.129)
Pegged regime	0.047	0.042	0.053	0.025	0.036	0.018
	(0.031)	(0.044)	(0.036)	(0.029)	(0.044)	(0.029)
Intermediate regime	0.059*	0.062	0.046	0.045	0.053	0.033
	(0.031)	(0.044)	(0.036)	(0.029)	(0.044)	(0.028)
Southern Africa	-0.059**	-0.035	-0.079***	-0.044*	-0.061	-0.036
	(0.024)	(0.034)	(0.030)	(0.024)	(0.044)	(0.023)
Central Africa	-0.007	0.042	-0.067**	0.046**	0.081***	-0.008
	(0.022)	(0.030)	(0.028)	(0.021)	(0.030)	(0.023)
East Africa	0.014	-0.013	0.044*	0.042***	0.021	0.066***
	(0.017)	(0.025)	(0.024)	(0.016)	(0.026)	(0.019)
West Africa	-0.004	0.055**	-0.066***	0.033**	0.096***	-0.022
	(0.018)	(0.025)	(0.024)	(0.016)	(0.024)	(0.020)
Post 2008	0.078***	0.089***	0.062***	0.081***	0.087***	0.062***
	(0.012)	(0.016)	(0.013)	(0.011)	(0.016)	(0.011)
Observations	5,576	2,929	2,647	5,635	2,960	2,675
# of surges	100	56	44	89	52	37

Notes: cloglog estimates. The coefficients reported are marginal effect evaluated at the sample means. The dependent variable is a dummy that is equal to 1 over a 7-year window following the onset date. All controls are lagged. Standard errors are adjusted for clustering at the product-year level: *** p<0.01, ** p<0.05, * p<0.1.

Chapter 3: Digital Connectedness and Exports Upgrading: Is Sub-Saharan Africa Catching Up?

*This chapter is a joint work with Joël Cariolle (FERDI). It has been published as a Working paper of the African Economic Research Consortium (AERC). A slightly different version of this chapiter has been published in Word Economy.

Résumé

Nous mettons en évidence une nouvelle dimension du réseau d'infrastructures de câbles sous-marins, appelée "interconnectivité numérique", qui reflète la proximité numérique d'un pays avec les principaux marchés mondiaux, et évaluons son impact sur la sophistication des exportations. A partir d'un échantillon de 60 pays en développement - dont 23 pays d'Afrique subsaharienne - sur la période 1995-2017, nous montrons que l'interconnectivité numérique contribue de manière positive et significative à la complexité du panier d'exportation, avec cependant une certaine hétérogénéité spatiale au sein de notre échantillon. En effet, les estimations montrent que, par rapport au reste du monde, une augmentation de 10 points de pourcentage de la part du PIB mondial directement câblée vers les pays d'Afrique subsaharienne entraîne une augmentation supplémentaire allant de 4,6 à 5,3 points de l'indice de complexité des exportations. En outre, alors que partout ailleurs l'effet positif de l'interconnectivité numérique diminue avec la distance par rapport aux marchés mondiaux, en Afrique subsaharienne, il augmente. Enfin, conformément à la littérature, l'amélioration de la connectivité numérique se traduit par des exportations accrues de biens différenciés et une plus grande participation aux chaînes de valeurs mondiales.

Mots-clés : Complexité économique ; Internet ; Infrastructures de connectivité ; Afrique subsaharienne, Exportations, Diversification des exportations.

Abstract

We highlight a new dimension of the submarine cable infrastructure network, termed 'digital connectedness', reflecting a country's digital proximity to main world markets, and assess its impact on export upgrading. Using an instrumental variables approach conducted on a sample of 60 developing countries—including 23 sub-Saharan African countries—over the period 1995–2017, we find that digital connectedness contributes positively and significantly to the export basket complexity, but also points out spatial heterogeneity within our sample. In fact, estimations stress that, compared to the Rest of the World, a 10pp increase in the share of world GDP directly cabled to SSA countries leads to a supplementary increase ranging from 4.6 index points to 5.3 index points in the export complexity index. Moreover, while everywhere else the positive effect of digital connectedness declines with distance from global markets, in Sub-Saharan Africa the benefit increases. Finally, in line with the literature, improved digital connectedness also translates into higher exports of differentiated goods and greater participation in the global value chain.

Keywords: Economic complexity; Internet; Connectivity infrastructures; Sub-Saharan Africa, Exports, Trade diversification.

I. Introduction

Sub-Saharan Africa (SSA) plays a very marginal role in global trade. Possible reasons for this relative marginalization include high transaction costs, poor infrastructure network, and structural handicaps related to unfavourable geographic factors. Despite the rapid growth rates recorded over the last two decades, sub-Saharan African countries have not engaged in an industrialization path that has enabled post-independence income levels catch up (Rodrik, 2016). The international context of high commodity prices, low interest rates, and China's increasing appetite for African natural resources has explained the concomitance of high growth rates with slow structural economic transformations and of increasing and upstream participation to agricultural global value chains with low and stagnant regional value chain (Rodrik, 2016; Balié et al., 2019; de Melo & Twum, 2021). However, beyond the country's position in the global or regional networks of productive activities, to paraphrase Hausmann et al. (2007), what SSA exports matters for its long-term economic growth and industrialization. In this regard, the agricultural and food industries in SSA weight about a quarter of its GDP, employs roughly two-thirds of a population mostly located in rural areas (Balié et al., 2019), and tempering the regional prospects for structural change triggered by industrial sectors development and sophisticated goods and services exporting (Rodrik, 2016; Lim, 2021).

Could an improved access to information and knowledge spur structural change and export basket upgrading in the region? The literature stresses that improved access to information and knowledge produced in different parts of the world has the power to induce structural change in trade patterns, especially for remote low-income countries (Akerman et al., 2015). In particular, various studies have shown that trade is constrained by information frictions, and that these frictions increase with the geographical distance between potential trade partners (Rauch & Trinidade, 2003; Bahar et al., 2014; Akerman et al., 2015; Lendle et al., 2015). In fact, the rapid decay of information and knowledge diffusion with the physical distance makes neighbouring countries more likely to exchange similar products with similar and geographically proximate trade partners (Rauch, 1999; Rauch & Trinidade, 2003; Chaney, 2014; Bahar et al., 2014; Jun et al., 2020). Access to communication networks, by reducing information frictions, facilitates the matching between producers and distributors, assemblers and suppliers, investment

need and saving capacity, importers and exporters (Rauch & Trinidade, 2003; Akerman et al., 2015), incites firms to export diversified, differentiated, or more sophisticated products (Rauch, 1999; Jun et al., 2020) and, thereby contributes to the export basket complexification. Without access to these networks, patterns of exports quality upgrading and trade network densification are geographically sticky (Jun et al., 2020). This is particularly true when the knowledge embedded in exports is "tacit" or "multifarious"[27], and, therefore, relies on more direct forms of human interactions (Bahar et al., 2014; Hidalgo, 2021). Therefore, in the light of this literature, African economies' isolation from main world markets, explained by important trade costs and a poor access to information, is a critical obstacle to an increased participation to world exchanges.

However, with the recent and massive deployment of submarine cable (SMC) connectivity infrastructure in SSA and the resulting rise in Internet penetration (Cariolle, 2021) (see Figure 1), information and communication technologies (ICTs) are increasingly seen as a game-changing solution for the region, given its potential for (service) trade in remote areas (Lendle et al., 2015). Empirically, ICT diffusion facilitates catching up with developed countries through the "leapfrogging" process and the rise of mobile telephony in Africa illustrates this point quite well (Aker & Mbiti, 2010). Keeping aside the plentiful, relevant but yet anecdotal evidence on successful African entrepreneurship[28], the empirical literature provides evidence that digitalization improves business performance and foster Internet spillovers (Hjort & Poulsen, 2019; Cariolle & Le Goff, 2021; Paunov & Rollo, 2015, 2016), reduces the size of the informal sector (Jacolin et al., 2021), and facilitates job creation (Hjort & Poulsen, 2019). In relation to trade, Freund and Weinhold (2004), and then Clark and Wallsten (2006), stressed that Internet diffusion has stimulated trade flows and foreign direct investment (FDI). But more recently, Lendle et al. (2015) have shown that the deterrent effect of geographical distance between trade partners was substantially lower (65%) when transactions were made on one of the world's largest online marketplaces, compared to total trade. Their results, therefore, support the "death of distance", predicted by Cairncross (1997), in that modern digital infrastructures and

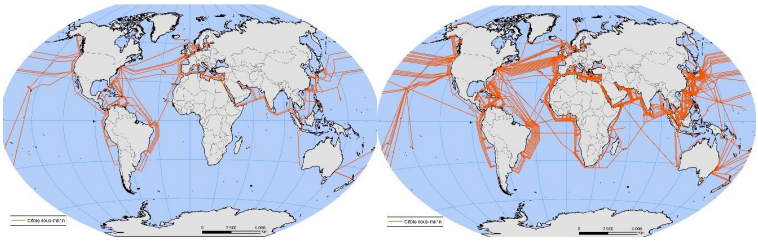
[27]Tacit knowledge is not codifiable and hard to communicate, while multifarious knowledge is knowledge specific to an economic activity or task (Hidalgo, 2021).

[28]See, for example, Ouassi-Olsson, L. "Investing in the exceptional African creativity", *Entreprenante Afrique*, 4 October 2021. https://www.entreprenanteafrique.com/en/investing-in-the-exceptional-african-creativity/

technologies are now able to carry sufficient information to reduce distance-related international search costs.

Figure 1 : Submarine cable deployment worldwide, 2000 versus 2017

(a) 2000 **(b) 2017**



Source: Telegeography.

Looking more specifically at the contribution of the digital infrastructure deployment, the trade dividends are very large according to evidence from industrialized economies (Röller & Waverman, 2001; Czernich et al., 2011), but the research focused on developing countries is scarcer and display more mixed findings. Focusing on an industrialized country like Norway, Akerman et al. (2022) exploit the staggered roll-out of local fiber-optic broadband access-points to estimate the causal effect of Internet adoption on Norwegian firms' bilateral exports. They find that the reduction in information friction induced by Internet access enlarges the choice set of exporters and importers, making demand for traded products more elastic to trade costs and to distance. In developing economies, Hjort and Poulsen (2019) have brought strong evidence that SMC deployment in SSA has spurred trade and job creation, but looking at the separate effect of SMCs' bilateral deployment on firm's participation to bilateral exports in a sample of 48 developed and developing countries over the period 1997–2014, Imbruno et al. (2022) show that this effect is heterogeneous: it increased the number of bilateral exporters from developed countries but reduced this number in developing countries, by 5.4% in sub-Saharan Africa. This finding suggests that exporters from developed and developing areas differ in their ability to undertake information technology upgrading, as previously stressed in the context of Argentinian-Brazilian exports by Bustos (2011).

It is worth noting that establishing a trade relation requires considerable effort to gather information that is not necessarily freely available but assimilated through search and learning efforts. Firms can face some additional obstacles, including non-tariff barriers and issues related to incomplete information or limited capability to process information (Allen, 2014; Dasgupta & Mondria, 2018), to establish a successful trade relationship. Using data from Chilean exporters, Morales et al. (2019) found that extended gravity has a large impact on export entry costs. They estimate that having similarities with a prior export destination in terms of geographic location, language, and income per capita jointly reduce the foreign market entry cost by 69% to 90%. Introducing the principle of relatedness—a measure of the overall similarity between an activity and a location—the economic literature on the process by which countries learn how to produce what they export, has demonstrate how poor knowledge diffusion constrains the ability of countries to penetrate new export markets. Indeed, countries are more likely to start exporting products that are related to their current export basket or that of their geographical neighbours (Hidalgo et al., 2007; Hidalgo & Hausmann, 2009; Bahar et al., 2014; Jun et al., 2020).[29] The importance of knowledge diffusion in the diversification of economic activities has also been observed in the development of regional industries, technologies, and research activities, suggesting that similarity between economic activities enables knowledge diffusion in general (Hidalgo et al., 2018).

This paper examines the implications of the recent and rapid deployment of SMCs along African coasts for African trade patterns and makes three contributions to the empirical literature. First, we highlight a new dimension of the SMC infrastructure deployment, termed 'digital connectedness', reflecting a country's digital proximity to world markets, and assess its impact on export sophistication. This indicator is the share of world GDP to which a country is connected through direct SMC connections, therefore considering the international connectivity infrastructure from a more qualitative perspective. In fact, we start from the premise that, while the number of SMCs that lay in a country matters, the size of economies to which a country is connected to should matter too. The mechanism emphasized is rather straightforward and is based on the literature on

[29]In this line of research, Regolo (2013) shows that similarly-endowed trade partners tend to exhibit a more diversified trade structure than differently-endowed ones, which is explained by greater competition stemming from identical trade costs. We guess that this mechanism could be extended to information costs.

information frictions and export sophistication (Rauch, 1999; Rauch & Trinidade, 2003; Chaney, 2014; Akerman et al, 2015: Jun et al, 2020; Hidalgo, 2021): the greater the digital connectedness, the closer the country to main production and consumption centres, the easier for exporters to gather information on buyers, sellers, production technologies, inputs price and quality, market regulations and institutions, and so on, the larger the incentives and capacity to enter these markets and export more sophisticated products.

Second, we measure export sophistication using a measure of export basket complexity (Hidalgo, 2021). To do so, we rely mainly on the Economic Complexity Index (ECI), calculated using the MIT's Observatory of Economic Complexity trade data set. As defined by Hartman et al. (2017), the ECI assesses the sophistication of the export structure of a country by combining information on the diversity of exported product and the number of countries exporting that product (ubiquity). Studying the effect of digital infrastructure deployment on economic complexity is of primary importance for economic development research, given the recent trends in ICT growth in developing areas, especially SSA, and also because complexity appears to be a strong predictor of a country's future growth path, wealth carbon emission, and income inequality (Hidalgo & Hausman, 2009; Hidalgo, 2021).

Third, to address possible reverse causality between the shape of the SMC network and countries' integration in world markets, we use classical panel data econometrics methods and adopt an instrumental variables framework (two-stage least squares, hereafter, 2SLS). Our approach consists in instrumenting the connectedness variable by the number of (indirect) 2nd order SMC connections, that is, the cumulative number of distinct SMC connections a given country's first-order SMC connections have. We also reduce the concern for omitted variable bias by including time and country fixed effects.

The first set of estimations conducted on a sample of 60 developing countries over the 1995–2017—of which 23 are from SSA—shows that while digital connectedness significantly increases the export basket complexity in all countries, there is geographical and temporal heterogeneity within our sample. In fact, IV estimations stress that the effect of digital connectedness on export complexity is particularly strong over the period 2006–2015, and point to SSA countries' catch-up. In fact, our results stress that, compared to the Rest of the World (RoW), a 10pp increase in the share of world GDP reached by

SSA countries' direct SMC connections[30] leads to a supplementary increase ranging from 4.6 index points (FE–OLS estimations) to 5.3 index points (IV–2SLS estimations). The overall increase in SSA's export complexity resulting from a 10pp increase in its connectedness equals 8.5pp, corresponding to 47% of the ECI sample standard deviation.

The second set of estimations aims at identifying the factors that accentuate or attenuate the effect of connectedness on export complexity. Building on the findings of the literature on information frictions and trade patterns, we first test whether the effect of digital connectedness is conditioned by the geographical and maritime distance of countries to major world markets and find evidence in support of this hypothesis. Our results highlight that the positive effect of connectedness declines with both geographical and maritime distances to world markets, except for SSA, where both distances increase the benefits of digital connectedness. This finding is reinforced by additional evidence on the positive contribution of declining maritime transport costs in SSA, as reflected in increased maritime connectivity, to the positive effect of connectedness on export complexity. Thus, these estimates add evidence to existing studies on the role of geographic distance in international trade (Blum & Goldfarb, 2006).[31]

Third, we highlight a mediating effect of Internet penetration and human capital, not specific to SSA countries, which is consistent with studies highlighting the importance of digital absorptive capacity to take advantage on the digitalization process (Choi et al., 2020; de Melo & Solleder, 2022). The contribution of critical dimensions of digital absorptive capacity, such has Internet penetration and educational attainment, are investigated and found to mediate the effect of connectedness over long period, but not to explain SSA catch-up in export complexity.

Last, in a series of robustness checks, we extend our analysis to other dimensions of export upgrading. The results show that digital connectedness increases exports of differentiated goods and the participation in global value chains. Regarding the GVCs participation, the impact is much stronger on backward participation and larger for sub-

[30] A scenario that is highly plausible since a new connection to China would represent a 15pp increase in this share. This actually happened in 2017 to Djibouti when the Asia Africa Europe-1 (AAE-1) cable was deployed to connect France, Italy, to the Middle East, Central Asia, India, South-East Asia and China.

[31] See Goldfarb and Tucker (2019) for a review of research on the distance–trade nexus in a digitalization context.

Saharan African countries. This result, therefore, corroborates previous evidence based on the ECI.

The remainder of this paper is structured as follows. Section II is devoted to the methodology and data, as well as our identification strategy. In Section III, we interpret the empirical results. Section IV is dedicated to robustness checks, and Section V concludes on the main messages of the paper.

II. Empirical framework

Our analysis starts from the premise that the reduction in search, replication, transport, tracking, and verification costs resulting from telecommunication SMC deployment has spurred goods and services exports sophistication. We consider that the size of economies to which a country is connected through SMCs is critical for information and knowledge diffusion, and thereby, for the diversification and sophistication of exported products. Therefore, we highlight the contribution of a new dimension of the SMC network, that we term 'digital connectedness', reflecting a country's digital proximity to main production and consumption centres, and assess its impact on export sophistication. In particular, we question the role of distance and other structural determinants of trade, digitalization and industrialization, in channelling this relationship. Considering that digital connectedness and export complexity might be mutually reinforcing, we employ an original instrumental variable approach to identify causal relationships. The next subsections present the data used in this study and our empirical strategy.

1. Data

1.1 Economic complexity index

The alternative view[32] of the development process provided by research combining the statistical physics of networks and development economics has delivered new analytical tools[33] to quantify the economic relevance of the "historically disregarded productive

[32]According to Hidalgo (2009: 2), the main takeaway of this research field can be summed up as follow: "what a country produces matters more than how much value it extracts from its products".

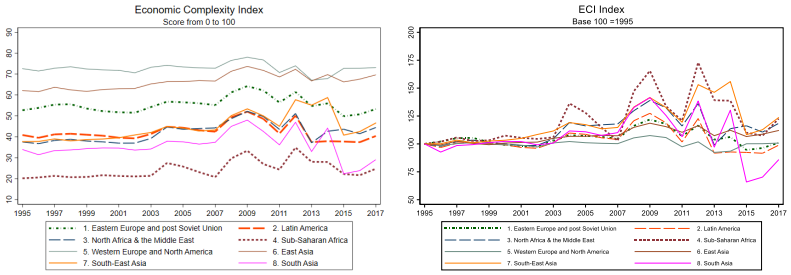
[33]Developing new concept and measures such as Economic Complexity, Product Complexity, Product Relatedness, and Country Fitness (Hidalgo, 2021; Tacchella et al., 2012).

structure". For this paper, we rely on one of these tools, i.e., the economic complexity index (ECI). As defined by Hartman et al. (2017), the ECI assesses the sophistication of productive structure of a country by combining information on the diversity of exported products and the number of countries exporting these products (ubiquity). The intuition behind ECI is that sophisticated economies are not only diversified, but they export products and services that are exported by few countries (Hidalgo, 2021).

Figure 2 presents the ECI by region. From left-hand side panel, we can easily notice that Western Europe, North America, and East Asia display higher level of complexity, while SSA displays the lowest. The right-hand side panel however indicates sub-Sahara as the region with the greatest increase of complexity between 1995 and 2014, and also the greatest volatility in the index from 2003 to 2015, period corresponding to world geopolitical and financial turmoil and high uncertainty upon commodity markets.

Note that, while the ECI is our main dependent variable, we also mobilize other measures of export upgrading such as the augmented Economic Complexity Index (ECI+), Rauch (1999)'s classification of exports goods, and forward and backward participation in global value chains (GVCs).

Figure 2: ECI evolution by region, 1995–2017



Source: Authors based on raw data from MIT.

1.2 Digital connectedness

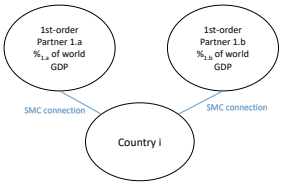
We use the telecommunication submarine cable (SMC) network as the international infrastructure driving knowledge diffusion, and thereby, as a critical source of economic

complexity. To date, SMCs are the cheapest and fastest path for international telecommunications (OECD, 2014)[34], so that more than 95% of international telecommunications passes through this infrastructure. The SMC network is, therefore, a critical determinant of a country's Internet bandwidth, speed, stability, and affordability (Hjort & Poulsen, 2019; Cariolle, 2021; Cariolle & Le Goff, 2021). A direct SMC connection with a partner country will considerably smooth telecommunications and reduce bilateral information and communication costs, compared to non-connected ones. In fact, telecommunications destined to a non-connected partner have to be carried through indirect cable paths, and thereby, will suffer from a slower, narrower, and more expensive bandwidth. The search for low latencies, lower cost, traffic stability, and autonomy, has indeed been a critical incentive for deploying shorter and direct cables connections between OECD countries, and lately, with emerging and developing ones (OECD, 2014).

Therefore, direct cable connections to the largest economies will provide exporters with a better access to information on these markets and facilitate telecommunications between their components. To build a synthetic measure of digital proximity of a country to the main production and consumption centres, we use data on the SMC network worldwide, combine it with worldwide data on GDP, and build an original indicator measuring a country's cumulative share of the world GDP reached by direct—i.e., first-order—cable connections, as schematized in Figure 3. In this figure, country *i* is directly (or first-order) connected (subscript 1) to countries a and b through SMCs (irrespective of their number), giving a global connectedness indicator consisting in aggregating the weight of countries a and b in world GDP.

[34]In 2014, "A single intercontinental submarine fibre can potentially carry more data, with less delay than could be achieved by combining all the world's active geostationary communications satellites together." (OECD, 2014: 20).

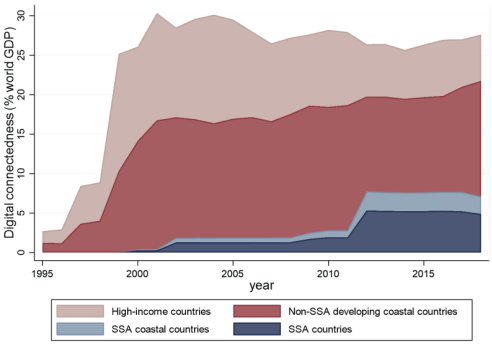
Figure 3: Digital connectedness



Source: Authors' own construction.

Plotting this indicator average evolution in the world and in sub-Saharan Africa, in particular in Figure 4, we can see that, despite a remarkable jump in the early 2010s, an African country is still, on average, connected to some 5% of the world's GDP in 2017 (7% excluding landlocked countries), against 20% for an average developing non-African coastal country, and 27% for an average high-income country. Acknowledging that trade is limited by information frictions, and that capabilities and knowledge diffusion constrain export complexification, our intuition is that the African very limited digital connectedness to the main world markets may explain a still low export basket's complexity. However, the recent and sharp growth in its digital connectedness to world markets would be expected to have spurred knowledge diffusion and contributed to a rapid catch up for the recent years.

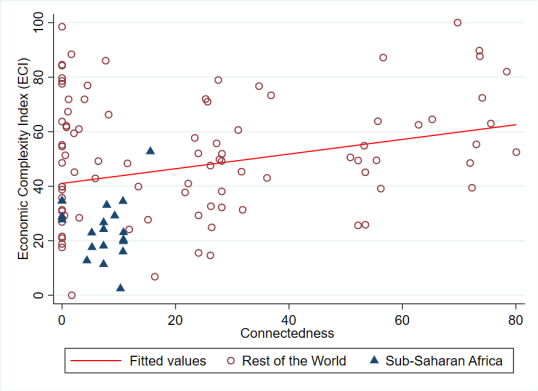
Figure 4: Trends in digital connectedness (% world GDP), 1995–2017



Note: On the X-axis is reported the average cumulative share of world GDP reached by direct (first-order) SCM connections.

Source: Authors' own construction based on raw data from Telegeography and World Development Indicators.

Figure 5: Export complexity vs digital connectedness, 2017



Source: Authors' own construction based on raw data from Telegeography and MIT.

2. Empirical strategy

2.1 The model

Combining our original data set on international connectivity with data from MIT's Observatory of Economic Complexity, we construct an unbalanced panel of 60 countries (including 23 sub-Saharan ones) over the period 1995–2017. Table C.4. (in the Appendix) reports descriptive statistics of the variable used in our model, while Table C.1. shows the sample composition. Our baseline model is specified as follows:

$$ECI_{i,t} = \alpha_i + \alpha_t + \beta_1 GDP\_connectedness_{it} + (\beta_2 GDP\_connectedness_{it} \times SSA_i) + \beta_3 X_{i,t} + \varepsilon_{it} \quad (1)$$

Where, $\boldsymbol{ECI_{i,t}}$ is the complexity index for country *i* at time *t*; $\boldsymbol{GDP\_connectedness_{it}}$ is the cumulative percentage of world GDP reached by direct cables laid in country *i* at time *t*; SSA_i a dummy variable equal to 1 for sub-Saharan countries and 0 otherwise; $\boldsymbol{X_{i,t}}$ is a set of control variables; $\boldsymbol{\alpha_i}$and $\boldsymbol{\alpha_t}$ are, respectively, country and time fixed effects; $\boldsymbol{\varepsilon_{it}}$ is the error term. Since we are interested in an eventual catch-up of SSA, our parameters of interest are β_1 and β_2. Following the related literature, we control for Internet penetration rates, country size and development level, trade remoteness to world markets (to account to eventual threshold effect in this variable we also control for its squared value), rents from natural resource exports, FDI inflows, trade openness, democracy, electricity access,

and real effect exchange rates. The description, expected sign, related literature, and source underlying these control variables are provided in Table C.3. These control variables' descriptive statistics are reported in Table C.4.

2.2 Instrumental variable

Increased digital connectedness can be a trigger of economic complexity or a consequence of it. The econometric challenge, therefore, consists in solving an eventual reverse causality problem by isolating a causal link going exclusively from GDP connectedness to ECI. To do so, we adopt the IV approach exploiting information on the shape of the SMC network linking partners to whom a country is connected. We specifically use the number of distinct second-order SMC connections (schematized in Figure 6) — excluding duplicates and common partners (i.e., only plain lines considered) — as an instrumental variable (IV) predicting connectedness (Figure 7). We, therefore, estimate the previous (second-stage) Equation 1 with this first-stage equation, using the two-step least-square (2SLS) estimator:

$$Connectedness_{i,t} = \alpha_i + \alpha_t + \gamma_1 2ndorder\_con_{it} + (\gamma_2 2ndorder\_con_{it} \times SSA_i) + \gamma_3 X_{i,t} + \epsilon_{it} \quad (2)$$

Correcting for heteroscedasticity and clustering standard errors at the country-level.

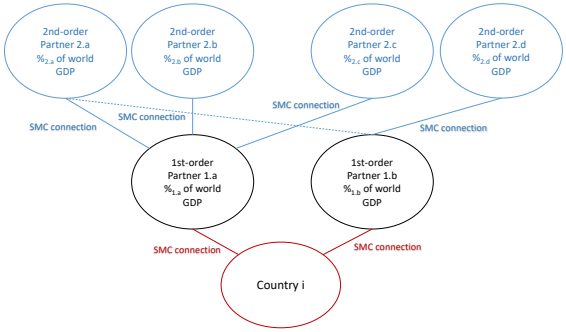
Given its large costs underlying related investments and operations, the ability of a cable to link together a large number of countries depends on served countries/regions/continents' geographical characteristics, in particular, on the possible scale economies induced by bringing Internet to multiple countries, regions, and continents.[35] This is the case for most cables connecting Africa to the rest of the world, such as the Africa-Coast-to-Europe (ACE), WACS, EASSy, WASC or TEAMS cables, deployed in the 2000s and 2010s to serve a large number of countries located in the same regions and/or along the path to connect Africa to other continents. This is also the case of the SEAMEWE-3/4/5 or AAE1 cables, connecting countries located on the path linking

[35] As an illustration of the large costs related to this infrastructure deployment, the WACS connecting South Africa and the West African coast to Europe since 2012 cost US$600 million, while the AAE-1 connecting Asia, Africa and Europe since 2017 cost US$800 million. For more information, see: https://subtelforum.com/submarine-cable-map/ or https://www.submarinenetworks.com/en/insights/a-new-coming-for-submarine-cable-systems-the-independent-infrastructure-developers

far-East Asia to Europe through the Middle-East and North Africa. This characteristic of the cable network, therefore, fulfils the conditions of a good instrument.

Our IV's rationale is, therefore, quite straightforward: countries that are connected to country themselves poorly (densely) connected world markets will display low (high) connectedness. Our exogeneity claim lies in the fact that the shape and density of the SMC network is determined by historical long-term conditions favourable to western industrialized countries' interconnectedness (which are excluded from the estimation sample), by geographical factors and aggregate economic considerations, independent from a given country's economic situation or policy (Eichengreen et al., 2016; World Bank, 2018; Cariolle, 2021).[36] This claim is plausible for first-order cable connections, but even more likely if we focus on the density of second-order cable connections, which is the rationale of our main instrument (Figure 6). Table C.6. reports IV estimates using the number of first-order and second-order cable connections as instruments to test over-identification restrictions.

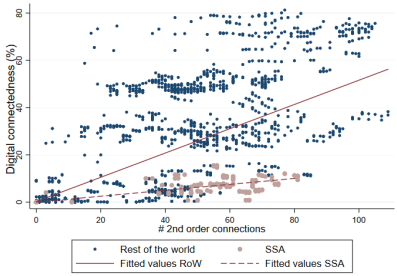
Figure 6: Second-order SMC connections



Source: Authors' own construction.

[36]The concern for a possible influence of policy on SMC network density is further lowered controlling for internet penetration rates, which is the combined outcome of telecommunications policies and a country's digital absorptive capacity. Moreover, estimations additionally controlling for a critical component of the terrestrial infrastructure, i.e., the country number of Internet Exchange Points, remain strictly unchanged. Results can be provided upon request.

Figure 7: Second-order SMC connections and digital connectedness, 1995–2017



Source: Authors' own construction based on data from Telegeography and World Development Indicators.

III. Main results

1. Baseline estimations and regional effects

Table 1 presents OLS fixed-effect estimates of Equation 1 based on a sample of 60 developing and transition economies (including 23 from sub-Saharan Africa) covering the period 1995–2017. Overall, it appears that digital connectedness is positively related to economic complexity. Suspecting eventual autocorrelation given the large time dimension of our panel, we conduct the Inoe-Solon test for auto-correlated residual and detect the presence of order-1 autocorrelation in residuals (see Table C.5. in the Appendix). Therefore, we report in column (3) estimates of Equation 1 with Driscoll–Kraay AR (1) standard errors, and do not find that correcting for AR (1) residuals reduces the significance of estimated relationships.

Given that the deployment of the SMC has occurred recently in sub-Saharan Africa, we split our sample into four periods in order to properly assess temporal and regional heterogeneity. Column 6, column 8, and column 12 show that the impact of connectivity is larger in sub-Saharan Africa than anywhere else, suggesting a catch-up effect at play on the continent. This effect is noteworthy inasmuch as SSA is compared to the best-performing developing countries in our sample (China and South Korea), which exhibit connectedness levels similar to Western and North American countries (Figure 2). One should also note that the 2006–2015 period is the one in which the highest catch-up effect

has been recorded (column 12 and column 13).[37] With respect to controls variables, remoteness and natural rent prove to be detrimental to the export basket complexity while an increase in the income level, in trade openness or a depreciation of the REER is associated with an increase in the complexity of the export basket. All the remaining control variables are statistically not significant.

Table 2 reports FE-2SLS estimates, while Table C.6. reports estimates of the same estimator using both first-order and second-order cable connections as instrument set. The statistics regarding the quality of the instruments are satisfactory[38], rejecting the null hypothesis that the equation is under-identified and displaying high first-stage F-statistics, well-above 10. Instrument estimates are positive and statistically significant at 1% in the first-stage regression. The FE-2SLS estimates support a positive causal effect of connectedness on export complexity. IV estimates indicate that the effect is statistically significant at 1% and slightly higher than FE estimates (Table 1). Estimates in column (4) endorse the SSA's technology catch-up over the 2006–2015 period, already documented in Table 1. In magnitude, a ten percentage points (pp) increase in the share of world GDP directly wired to SSA countries leads to an additional 8.4 points increase in the export complexity index. This increase is 5.3 index-points higher than the rest of the developing world, over-performance mainly explained by the lower performance of Latin America and South Asia (column 5). However, contrary to previous FE estimations, IV estimates in column (5) do not show any more SSA catching-up China and South Korea.[39]

[37]The period 2006–2015 also corresponds to the episodes of sharp increases in SSA's economic complexity highlighted in Figure 2. The SSA's average ECI score is 27.13, an increase of 11.46% over the average score over the entire 1995–2017 period.

[38]First-stage F-stat, Cragg-Donad F-stat, LM-weak test, and in Table C.6 in Appendix 1, Hansen tests.

[39]When Latin-America is taken as reference group, interaction terms are positive and significant, except for South Asia, with SSA displaying the strongest marginal effect. Estimates can be provided upon request.

Table 1. OLS fixed effect estimates

Dep var. ECI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Period	1995–2017					2000–2017		2005–2017		2010–2017		2006–2015	
Connectedness	0.223**	0.109**	0.110***	0.128***	0.226***	0.128***	0.317***	0.205**	0.137***	0.240*	3.337***	0.268***	0.126
	(0.108)	(0.0527)	(0.0231)	(0.0470)	(0.0383)	(0.0470)	(0.0477)	(0.101)	(0.0487)	(0.134)	(0.878)	(0.0908)	(0.0945)
SSA x connected				0.340*	0.195	0.340*	0.287	0.436**	0.562**	0.280	-2.947***	0.464**	0.567**
				(0.199)	(0.174)	(0.199)	(0.206)	(0.198)	(0.224)	(0.256)	(0.992)	(0.195)	(0.227)
Lat Am x connected					-0.205***		-0.281**		-0.209		-3.624***		-0.181
					(0.0536)		(0.140)		(0.146)		(0.890)		(0.167)
MENA x connected					-0.131***		-0.125		-0.0376		-3.350***		0.0585
					(0.0341)		(0.0798)		(0.0985)		(0.872)		(0.129)
South-East Asia x connected					0.0239		0.0404		0.240***		-3.009***		0.278**
					(0.0466)		(0.0730)		(0.0803)		(0.924)		(0.112)
South Asia x connected					-0.280***		-0.320***		-0.117		-3.396***		-0.0648
					(0.0560)		(0.0751)		(0.0797)		(0.911)		(0.112)
Controls, country FE, year FE							Yes						
N	2497	1150	1150	1150	1150	896	896	633	633	363	363	528	528
R^2	0.041	0.652	0.471	0.657	0.693	0.656	0.697	0.661	0.703	0.685	0.729	0.699	0.737

Notes: Standard errors are robust to heteroscedasticity and clustered by country except in column (3) where Driscoll Kraay AR (1) standard errors are reported. *** p<0.01, ** p<0.05, * p<0.1. FE dummy variable estimator, except in column (3) where within FE estimates are reported. Driscoll–Kraay standard errors are robust to very general forms of cross-sectional and temporal dependence when the time dimension becomes large.

Table 2. 2SLS fixed-effect estimates – Regional effects

Dep var. ECI	(1)	(2)	(3)	(4)	(5)
Period:		1995–2017		2006–2015	
(A) Connectedness (con)	0.161**	0.124*	0.304***	0.304**	0.278
	(0.0682)	(0.0657)	(0.0531)	(0.123)	(0.205)
(B) SSA x con		0.265	-0.0779	0.532**	0.250
		(0.223)	(0.194)	(0.258)	(0.292)
(C) Lat Am x con			-0.315***		-0.667**
			(0.0738)		(0.261)
(D) MENA x con			-0.169***		-0.0954
			(0.0603)		(0.358)
(E) South-East Asia x con			-0.0721		0.0562
			(0.0586)		(0.136)
(F) South Asia x con			-0.442***		-0.326**
			(0.0907)		(0.153)
			First-stage estimates		
F-stat (A)	63.28***	82.58 ***	117.37***	50.06***	97.92***
F-stat (B)		40.82 ***	19.41***	47.65***	30.14***
F-stat (C)			25.70***		5.42***
F-stat (D)			7.28***		2.02*
F-stat (E)			345.76***		143.67***
F-stat (F)			13.96***		615.46***
Cragg-Donald F-stat	382.685***	503.183	121.077	115.980	6.482
LM-stat	24.113***	31.373	20.245	17.771	10.44
Controls, country FE, year FE			Yes		
N	1150	1150	1150	528	528
R^2	0.650	0.657	0.689	0.698	0.731

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. FE 2SLS dummy variable estimator. Control estimates are not reported in the table.

2. Does distance still matter?

As pointed earlier, the question of whether digitalization of exchanges has spurred the death of distance in international trade is central (Lendle et al., 2016; Goldfarb & Tucker, 2019), and this subsection is aimed at reframing this as problematic within the connectedness–complexity nexus. In Table 3, we test whether the positive effect of connectedness is conditioned by the country's geographical distance to main export markets. To do so, we interact the trade remoteness variable used as control with digital connectedness and SSA dummy variables, applying the same interaction procedure with our instrument set. The results show that the positive effect of connectedness decays with geographic distance to world markets, and this conclusion holds whether we restrict the estimation span to the 2006–2015 period or when we consider only coastal countries in the analysis. However, they suggest, in a 10% confidence level, that the effect of connectedness on export complexity increases with world markets remoteness in SSA

coastal countries (column 6). This series of estimations suggest that, despite digitalization and trade digitization, the geographical distance hampers trade complexification, but with a probable exception in SSA. We further this nonlinearity in the next regressions, using more sophisticated measures of distance-related trade costs.

Table 3. Digital connectedness and the geographical distance to main world markets

Dep var. ECI	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	All Countries			Coastal Countries		
Period:	1995–2017		2006–2015	1995–2017		2006–2015
(A) Connectedness (con)	0.330***	0.296**	0.889***	0.321***	0.290**	0.803***
	(0.118)	(0.119)	(0.233)	(0.120)	(0.125)	(0.243)
(B) Con x remoteness	-0.0038**	-0.0038**	-0.016***	-0.0032*	-0.0035*	-0.014***
	(0.00185)	(0.00187)	(0.00424)	(0.00193)	(0.00193)	(0.00426)
(C) Con x SSA		0.570	-0.710		0.540	-0.974
		(0.742)	(0.889)		(0.798)	(0.927)
(D) Con x SSA x remoteness		-0.00538	0.0263		-0.00277	0.0350*
		(0.0119)	(0.0174)		(0.0135)	(0.0192)
Additional controls						
SSA x remoteness		0.0211	-0.0673		0.00723	-0.133
		(0.0577)	(0.0664)		(0.0831)	(0.118)
Remoteness index	0.0758	0.0671	0.323***	0.0477	0.0460	0.252**
	(0.0535)	(0.0619)	(0.0938)	(0.0680)	(0.0685)	(0.111)
	First-stage estimations					
F-stat (A)	30.99	35.72	21.26	22.96	26.37	17.41
F-stat (B)	33.22	33.97	38.19	33.91	28.26	33.07
F-stat (C)		139.04	77.79		144.25	58.62
F-stat (D)		94.45	41.9		102.11	36.96
Cragg-Donald F-stat	220.269	194.980	36.606	156.917	137.18	23.743
LM-stat	24.993***	19.48***	11.42***	21.721***	24.13***	7.726***
Controls, country FE, year FE	Yes					
N	1150	1150	528	1039	1039	484
R^2	0.646	0.655	0.681	0.649	0.663	0.688

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. FE 2SLS dummy variable estimator. Control estimates are not reported in the table. To address the mediating effects of remoteness, the squared term of the remoteness variable has been dropped from the econometric equation.

In a second step, we built an alternative variable reflecting the sea-distance to world markets, using data on bilateral maritime distances from the CERDI-Sea Distance Database (Bertoli et al., 2016). It is likely that the Euclidian distance between capitals, used in the remoteness index, improperly reflects the trade costs related to distance, and that considering sea distances would be more relevant for our problematic since many exports are merchandizes shipped and transported by boats overseas. Based on this data, we compute the average sea distance of country to its ten main trade partners (including

imports and exports), and interact this variable with connectedness and SSA variables in Equation 1, and with the instrument in Equation 2. Results, reported in Table 4, are consistent with previous estimations based on the remoteness index.[40] They indeed support that sea distance dampens the positive effect of digital connectedness on export complexity. They also confirm a relationship that was only 10% significant with the trade remoteness variable (Table 4, column 6), stressing that, in contrast to other developing regions the effect of connectedness increases with sea distance in SSA. For example, an increase of 3,000km in sea distance to main trade partners (approximately one standard deviation) reduces the positive effect of connectivity on export complexity in non-SSA countries by 47% but increases by 75% the positive effect of connectivity on export complexity in SSA countries. This effect is not driven by the presence of South Africa in the sample (column 4), and is robust to the exclusion of trade remoteness from control variables (column 5). Moreover, the simple interaction of connectedness with the SSA dummy is associated with a negative and significant sign, suggesting that SSA's complexity catch-up is driven by increased connectedness in countries that are the farthest from world markets. Therefore, (sea) distance to world markets could have been a structural handicap for the complexification of African countries' export basket, which is being offset through the digital interconnection process.

[40]We obtain a 23% correlation between these two distance variables in our baseline sample (Table C.2. in the Appendix 1).

Table 4. Digital connectedness and the sea distance to main trade partners

Dep var. ECI	(1)	(2)	(3)	(4)	(5)
Period:	1995–2017			2006–2015	
(A) Connectedness (con)	0.194	1.201***	1.593***	1.590***	-0.133
	(0.363)	(0.291)	(0.420)	(0.396)	(0.195)
(B) Con x sea distance	-0.000004	-0.000178***	-0.00025***	-0.00025***	0.000015
	(0.00006)	(0.00005)	(0.00008)	(0.00007)	(0.00004)
(C) Con x SSA		-2.437***	-2.612***	-2.695***	-2.417***
		(0.486)	(0.485)	(0.605)	(0.925)
(D) Con x SSA x sea dist.		0.000348***	0.000398***	0.000408***	0.000271***
		(0.0000679)	(0.0000808)	(0.0000909)	(0.0000999)
Additional controls					
SSA x Sea distance		-0.000912	-0.00167	-0.00152	0.000081
		(0.000804)	(0.00115)	(0.00140)	(0.00095)
Sea distance	0.000154	0.000861	0.00203	0.00194	-0.00223**
	(0.00067)	(0.00103)	(0.00146)	(0.00158)	(0.000875)
	First-stage estimations				
F-stat (A)	10.44	14.8	15.57	20.9	19.42
F-stat (B)	10.68	16.77	18.7	31.19	18.72
F-stat (C)		36.46	38.45	41.85	34.51
F-stat (D)		29.72	29.84	37.32	34.75
Cragg-Donald F-stat	61.486	47.031	28.296	30.515	90.671
LM-stat	17.894***	8.326***	9.080***	8.387***	13.471***
Controls, country FE, year FE		Yes		Yes†	Yes††
N	737	737	528	518	797
R^2	0.624	0.674	0.707	0.708	0.774

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. FE 2SLS dummy variable estimator. Control estimates are not reported in the table. To avoid potential collinearity with the sea-distance interaction variable and ensure the comparability of results with Table 3, the squared term of the remoteness variable has been dropped from the econometric equation. † In column (4) South Africa was excluded from the sample. †† In column (5), the trade remoteness variable was excluded from the econometric equation.

To further understand the role of distance in our relationship, we investigate whether maritime transport costs could mediate the effect of digital connectedness on export complexity, using the UNCTAD's liner shipping connectivity index as interaction variable. This index measures a country's connectivity to global shipping network based on five metrics: the number of ships, their container-carrying capacity, maximum vessel size, number of services, and number of companies that deploy container ships in a country's ports. Results are reported in Table 5 and stress that shipping connectivity is complementary to digital connectedness, i.e., it increases the contribution of connectedness to export complexity, and that this complementarity is stronger in SSA, especially when South Africa is excluded from the sample (column 4).

Therefore, this bunch of estimations stresses that distance still matter to explain the effect of connectedness on economic complexification nexus, but it does in a different way for

SSA countries. While increased geographical or sea distance to world markets attenuate the positive effect of digital connectedness on export complexity in most developing economies, an increased distance is, however, found to accentuate this effect in SSA. This means that SSA catch-up in economic complexity is explained by the connectedness of the remotest African countries from world markets (excluding South Africa). These countries probably suffer from the greatest structural handicaps to trade, and therefore it is probably there that the return to increased connectedness (the reduction in information and transaction costs) could be the stronger. This explanation is corroborated by the positive, but less robust, contribution to the connectedness–complexity nexus of shipping connectivity, reflecting decreasing maritime shipping costs in SSA compared to other developing regions.

Table 5. Digital connectedness and the shipping connectivity channel

Dep var. ECI	**(1)**	**(2)**	**(3)**	**(4)**
Period:	**1995–2017**		**2006–2015**	
(A) Connectedness (con)	0.174	0.104	0.0228	-0.0324
	(0.265)	(0.161)	(0.209)	(0.196)
(B) Con x SCI	0.00314	0.00370*	0.00424*	0.00468*
	(0.00262)	(0.00209)	(0.00243)	(0.00240)
(C) Con x SSA		-0.277	-0.333	-0.743
		(0.573)	(0.635)	(0.609)
(D) Con x SSA x SCI		0.0445	0.0568	0.109**
		(0.0423)	(0.0478)	(0.0477)
Additional controls				
SSA x SCI		-0.189	-0.413	-0.973
		(0.485)	(0.514)	(0.596)
Shipping connectivity index (SCI)	-0.328*	-0.304*	-0.258	-0.244
	(0.179)	(0.178)	(0.186)	(0.213)
	First-stage estimations			
F-stat (A)	6.67***	20.24***	23.28 ***	10.47***
F-stat (B)	35.49***	112.35***	88.97***	39.06***
F-stat (C)		144.19***	143.52***	57.20***
F-stat (D)		103.68***	143.09***	49.54***
Cragg-Donald F-stat	19.19	46.389	38.863	40.42
LM-stat	5.034**	8.360***	8.988***	8.972***
Controls, country FE, year FE		Yes		Yes†
N	681	681	492	482
R^2	0.631	0.676	0.706	0.712

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. FE 2SLS dummy variable estimator. Control estimates are not reported in the table. To avoid potential collinearity with the SCI interaction variable and ensure the comparability of results with Table 3 and Table 4, the squared term of the remoteness variable has been dropped from the econometric equation.
† In column (4), South Africa is excluded from the sample

3. The absorptive capacity channel

In a third step, we study other key channel of the connectedness–complexity nexus, namely, the country's digital absorptive capacity. We posit that digital connectedness will trigger structural transformations and export's structure complexification if a country and its driving force are able to absorb technological change and transform access to digital technologies into transaction cost reductions. We consider that this absorptive capacity is reflected by the penetration of the Internet within the whole population on the one hand, and by a country's human capital level on the other hand. While Internet use in the population is a natural proxy for the familiarity of a given population with Internet related technologies, educational attainment has been pinpointed as being a critical factor of technology absorption (Paunov & Rollo, 2015, 2016; Choi et al., 2020), as evidenced by the literature on the skilled-biased technological and organization change (Akerman et al., 2015).

In Table 6, we report estimations of the digital absorptive capacity channel. In columns (1) to (3), the share of population using Internet is used as proxy for this capacity and interacted with the connectedness and SSA dummy variables. Result stress that, in line with our expectation, Internet penetration is found to drive the positive effect of digital connectedness. However, this conditioning effect appears to be less significant over 2006–2015 period (column 3). Moreover, estimation in column (3) suggests that rising Internet penetration rates in SSA are not a factor explaining the observed catch-up in economic complexity, probably because of persistently low Internet penetration rates over the sub-continent.

Another critical dimension of the digital absorptive capacity is human capital, especially education level (Choi et al., 2020). In columns (4) to (12), we proxy educational attainment by the primary, secondary, and tertiary gross enrolment rates[41], and interact separately these variables with the connectedness and SSA dummy variables. First, estimations

[41]To avoid sample attrition, we filled-in missing values through linear interpolation and extrapolation. It seemed reasonable to us using these technics since we expect these variables to change slowly over time. Estimates using the original primary enrolment rate variable (best documented) shows little difference with those using the inter-extrapolated one.

stress the mediating effect of school enrolment, especially primary enrolment, is significant over the whole 1995–2017 period rather than 2006–2015. Moreover, estimates in column (5) support that increasing primary school enrolment in well-connected SSA countries is particularly beneficial to export complexity. Second, estimates in column (4) and column (5) stress that reaching a minimum primary enrolment rate is necessary for the positive effect of digital connectedness on export complexity to be felt. Based on estimates in column (4), this rate is established at 99%, which corresponds to the first quartile of the sample distribution. Third, the mediating effects of secondary and tertiary enrolment rates are positive and significant, in a 10% or 5% significant level and over long period only, but are not found to differ in SSA.

IV. Robustness analysis

In this final section, we test the robustness of our results and interpretations using complementary measures of the export sophistication process. First, we test whether previous regional effects in the connectedness–complexity nexus hold for differentiated exports, exports exchanged on organized markets, or exports with reference price, using Rauch's product classification (Rauch, 1999). Second, we investigate whether these relationships are corroborated by increased global value chains participation. Third, we use additional measurements of export upgrading, such as the ECI+ or the Hausman et al. (2007)'s export sophistication index (EXPY). All regression tables associated with this section are available in the Appendix.

1. Digital connectedness and exports according to Rauch's classification

How does the increase in digital connectedness materialize in exports? To answer this question, we use the Rauch's (1999) classification, which is widely used in empirical work on the relationship between ICT and trade. The Rauch classification consists of three product groups and it presents an important feature in that it allows us to distinguish between products whose exchange faces high information search costs (differentiated goods) and those facing moderate or low information search costs (homogeneous goods sold on an organized exchanges market or with a reference price). Rauch provides two classifications, a "conservative" one that minimizes the number of homogenous products

while the "liberal" classification maximizes them. To construct our exports per group's category following the two classifications, we rely on the four-digit level of the Standard International Trade Classification (SITC, revision 2) provided by UN COMTRADE.

Table C.7. displays the results based on the conservative classification[42]; columns (1) to (6) show that digital connectedness has a positive and statistically significant effect on exports of differentiated goods, while the impact on the homogenous goods remains not significant. This result is consistent with the literature and meets our expectation inasmuch as differentiated goods are characterized by higher search cost and are intensive in information. When it comes to the heterogeneity analysis, column (7) indicates that the beneficial effect on digital connectedness on exports of differentiated goods is statistically significant at 1% level and in magnitude larger in sub-Saharan Africa than anywhere else—no significant effect is found in MENA countries. Column (8) shows that, organized exchanges are not left out, a positive effect of the digital connectedness being recorded in SSA and the two Asian regions.

[42]Estimates based on the liberal classification are available in Table C.8. in the appendix in 2.

Table 6: 2SLS fixed-effect estimates – The absorptive capacity channel

Dep var: ECI	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Absorptive capacity var:	**Internet penetration**			**1ary enrolment rate**			**2ary enrolment rate**			**3ary enrolment rate**		
	1995–2017		**2006–2015**	**1995–2017**		**2006–2015**	**1995–2017**		**2006–2015**	**1995–2017**		**2006–2015**
(A) Connectedness (con)	0.0425	0.000369	0.147	-2.932***	-2.552**	-1.900	-0.357	-0.436	-0.292	-0.0947	-0.136	-0.0859
	(0.0758)	(0.0584)	(0.137)	(1.012)	(1.008)	(2.763)	(0.284)	(0.280)	(0.502)	(0.130)	(0.117)	(0.307)
(B) Con x internet	0.00290***	0.00385***	0.00284*									
	(0.00076)	(0.00062)	(0.0016)									
(B) Con x e.r.				0.0297***	0.0257**	0.0210	0.00620*	0.00657*	0.00660	0.00640*	0.00669**	0.00918
				(0.00990)	(0.00997)	(0.0257)	(0.00364)	(0.00367)	(0.00573)	(0.00352)	(0.00325)	(0.00726)
(C) Con x SSA		0.343	0.634*		-28.85**	-2.676		-0.727	0.487		-0.358	-0.505
		(0.289)	(0.343)		(11.68)	(23.94)		(2.191)	(3.641)		(0.942)	(2.175)
(D) Con x SSA x internet		-0.0480***	-0.0233									
		(0.0176)	(0.0280)									
(D) Con x SSA x e.r.					0.281**	0.0304		0.0131	0.000750		0.0141	0.0257
					(0.113)	(0.229)		(0.0264)	(0.0427)		(0.0259)	(0.0538)
Additional controls												
SSA x internet		0.588***	0.214									
		(0.173)	(0.318)									
SSA x e.r.					-0.0119	0.0112		-0.0147	-0.00647		0.0784	0.0251
					(0.0451)	(0.0503)		(0.0647)	(0.0626)		(0.159)	(0.139)
Enrollment rate (e.r.)				-10.40***	-10.46***	14.11**	3.581***	3.299***	-2.120***	5.011***	4.410***	-18.45***
				(1.400)	(1.413)	(5.643)	(0.517)	(0.523)	(0.772)	(0.716)	(0.756)	(6.709)
Internet user (% pop)	-0.0495	-0.0126	-0.0741	0.00241	0.0358	-0.0401	0.0122	0.0395	-0.0405	0.0117	0.0500	-0.0375
	(0.0373)	(0.0439)	(0.0706)	(0.0387)	(0.0364)	(0.0674)	(0.0372)	(0.0369)	(0.0687)	(0.0373)	(0.0402)	(0.0682)
	First-stage estimations											
F-stat (A)	53.98	37.53	27.32	60.15	34.31	16.52	30.66	36.02	34.78	30.81	39.96	41.81
F-stat (B)	97.12	58.14	67.52	59.18	34.8	16.91	30.59	38.24	41.57	30.94	41.12	51.24
F-stat (C)		25.42	33.87		26.86	28.37		25.68	22.99		27.7	23.36
F-stat (D)		7.64	7.63		26.8	28.7		24.38	22.54		23.49	21.04
Cragg-Donald F-stat	122.986	139.992	56.312	131.977	270.721	53.755	186.542	274.393	76.958	185.623	262.082	84.706
LM-stat	26.491***	2.930***	3.524*	29.340***	35.727***	15.763***	27.687***	32.018***	16.930***	27.593***	29.575***	18.200***
X_{it}, country & year FEs	Yes											
N	1150	1150	528	1150	1150	528	1150	1150	528	1150	1150	528
R^2	0.660	0.657	0.698	0.652	0.663	0.702	0.656	0.665	0.703	0.656	0.665	0.703

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table.

2. Digital connectedness and value chain participation

To fully understand the mechanism at play in sub-Saharan Africa, we continue our empirical investigation focusing on global value chain participation. For this purpose, we use the UNCTAD-Eora global value chains data from Casella et al. (2019). Using the EORA Multi-Region Input-Output (MRIO) data set, and following Koopman et al. (2014)'s gross export decomposition, these authors compute various trade-value indicators including the foreign value-added content of exports (FVA) and the indirect value-added exports (DVX). The former measures the part of exports from a country incorporating-value added previously imported from abroad and is widely used as a proxy of the backward GVC participation. The latter captures forward GVC participation and is computed as the portion of gross exports produced in the country that enters as an intermediate input in the value-added exported by other countries including re-imported value-added.

In Table C.9. (in the Appendix 3), columns (1) and (2) show that digital connectedness induces greater participation in global value chains and that the impact is much stronger in terms of magnitude on backward participation than on forward participation. Regarding the heterogeneity of the effect, column (5) suggests that digital connectivity increases backward participation in all regions except MENA countries. Moreover, the effect is much larger for sub-Saharan African countries, confirming the catch-up effect documented earlier in the sense that more intermediate goods are needed to produce complex goods. The same conclusion applies to a lesser extent when it comes to forward participation, except for MENA and South-East Asia countries where the effect is not significant.

3. Alternative export upgrading variables

This section focuses on the sensitivity of results to alternative measure of export basket sophistication. The results in Table C.10. (in the Appendix 4) are based on ECI+, an augmented version of ECI that considers the difficulty of exporting each product. ECI+ is deemed equivalent to the fitness index proposed by Tacchella et al. (2012) and outperforms ECI when used to predict future economic growth (Albeaik et al., 2017).

The estimates of columns (1) to (4) show that using of an alternative measure does not change our results. In Table C.11. (in the Appendix 4) we introduce EXPY as an alternative indicator of sophistication. As defined by Hausmann et al. (2007), EXPY indicates the level of productivity associated with a country's pattern of specialization. Compared to the ECI index, EXPY has two limitations (Valette, 2018). First, it includes GDP per capita and is de facto correlated with it. Second, it does not take into account the proximity between products.

Despite these limitations, the estimates leave our conclusions about the positive role of digital connectedness in export sophistication and the negative role of maritime distance unchanged. However, the sub-Saharan Africa exception does not hold anymore, in the usual significance levels.

V. Conclusion

This paper focuses on the implications of the recent and rapid deployment of SMCs along African coasts for African trade patterns and makes three contributions to the empirical literature. First, we highlight a new dimension of the SMC infrastructure deployment, termed 'digital connectedness', reflecting a country's digital proximity to world markets. Second, we assess its impact on export sophistication using the economic complexity index. Third, we address possible reverse causality between the shape of the SMC network and countries' integration in world markets, using the number of (indirect) second-order SMC connections as instrument.

From a sample of 60 developing countries, including 23 sub-Saharan African countries covering the period 1995–2017, our results show that, while digital connectivity significantly increases the complexity of the export basket in all countries, there is geographic and temporal heterogeneity within our sample. Indeed, the effect of digital connectivity on export complexity is particularly strong in the period 2006–2015, indicating a catching-up of sub-Saharan African countries. Compared to the rest of the world, a 10pp increase in the share of world GDP reached by SSA countries' direct SMC connections leads to an additional increase ranging from 4.6 index points (FE estimates) to 5.3 index points (IV estimates). The overall increase in SSA's export

complexity resulting from a 10pp increase in its connectedness equals 8.5pp, corresponding to 47% of the ECI sample standard deviation. The results also show that the positive effect of connectedness declines with both geographic and maritime distance to world markets, except for SSA, where these two types of distance actually increase the benefits of digital connectedness. For example, a 3,000 km increase in sea distance (roughly one standard deviation) reduces the positive effect of connectedness on export complexity by 47% in non-SSA countries but increases the positive effect of connectedness on export complexity by 75% in SSA.

Focusing on the additional channels through which digital connectivity operates, we document a mediating effect of Internet penetration and human capital, that is not specific to SSA countries. Finally, in exploring how digital connectedness materializes in exports upgrading, we found that digital connectedness increases exports of differentiated goods — goods for which the search costs are higher— and promotes both backward and forward participation in global value chains.

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Appendix to Chapter 3

Appendix 1: Sample and data

Table C.1. Sample composition

Country	Region	Obs	Country	Region	Obs
AGO	Sub-Saharan Africa	15	KAZ	Eastern Europe and post-Soviet Union	23
CIV	Sub-Saharan Africa	23	BOL	Latin America	23
CMR	Sub-Saharan Africa	22	BRA	Latin America	23
COD	Sub-Saharan Africa	13	CHL	Latin America	23
COG	Sub-Saharan Africa	11	COL	Latin America	23
GAB	Sub-Saharan Africa	16	CRI	Latin America	23
GHA	Sub-Saharan Africa	23	DOM	Latin America	23
GIN	Sub-Saharan Africa	18	ECU	Latin America	23
KEN	Sub-Saharan Africa	23	GTM	Latin America	23
LBR	Sub-Saharan Africa	3	HND	Latin America	23
MDG	Sub-Saharan Africa	23	MEX	Latin America	23
MLI	Sub-Saharan Africa	3	PER	Latin America	23
MOZ	Sub-Saharan Africa	21	PRY	Latin America	23
MRT	Sub-Saharan Africa	13	SLV	Latin America	22
MUS	Sub-Saharan Africa	3	URY	Latin America	23
NGA	Sub-Saharan Africa	23	VEN	Latin America	19
SEN	Sub-Saharan Africa	22	DZA	North Africa & the Middle East	9
TGO	Sub-Saharan Africa	17	EGY	North Africa & the Middle East	22
TZA	Sub-Saharan Africa	23	IRN	North Africa & the Middle East	13
UGA	Sub-Saharan Africa	3	ISR	North Africa & the Middle East	23
ZAF	Sub-Saharan Africa	22	JOR	North Africa & the Middle East	18
ZMB	Sub-Saharan Africa	23	MAR	North Africa & the Middle East	23
ZWE	Sub-Saharan Africa	13	OMN	North Africa & the Middle East	23
CHN	East Asia	18	QAT	North Africa & the Middle East	18
KOR	East Asia	23	SAU	North Africa & the Middle East	23
IDN	South-East Asia	23	TUN	North Africa & the Middle East	22
KHM	South-East Asia	20	TUR	North Africa & the Middle East	8
PHL	South-East Asia	23		**Total**	**1150**
SGP	South-East Asia	23			
THA	South-East Asia	18			
BGD	South-East Asia	21			
IND	South-East Asia	23			
LKA	South-East Asia	17			

Table C.2. Correlation table

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
(1) ECI	1.000																							
(2) Connectedness	0.520	1.000																						
(3) 2nd order	0.305	0.675	1.000																					
(4) log (GDP p.c.)	0.629	0.365	0.309	1.000																				
(5) Trade (% of GDP)	0.287	0.186	0.110	0.279	1.000																			
(6) Internet users	0.483	0.449	0.551	0.618	0.216	1.000																		
(7) Remoteness	-0.081	-0.281	-0.338	-0.132	-0.039	-0.153	1.000																	
(8) Sea distance	-0.316	-0.308	-0.066	-0.098	-0.174	-0.155	0.234	1.000																
(9) Shipping connectivity index	0.599	0.724	0.501	0.433	0.247	0.509	-0.198	-0.179	1.000															
(10) Natural rents	-0.298	-0.090	-0.034	0.171	0.029	-0.058	-0.130	0.367	-0.171	1.000														
(11) Electricity (access)	0.605	0.497	0.365	0.814	0.123	0.507	-0.205	-0.350	0.438	-0.065	1.000													
(12) log (Population)	0.139	0.376	0.269	-0.220	-0.370	-0.040	-0.110	-0.019	0.431	-0.208	-0.009	1.000												
(13) FDI inflows	0.089	-0.001	0.067	0.064	0.542	0.103	0.093	-0.001	0.051	0.049	-0.047	-0.223	1.000											
(14) log (REER)	-0.091	-0.026	0.010	-0.042	-0.061	0.036	0.108	0.002	-0.008	-0.026	-0.034	0.028	-0.046	1.000										
(15) Internet penetration	0.483	0.449	0.551	0.618	0.216	1.000	-0.153	-0.155	0.509	-0.058	0.507	-0.040	0.103	0.036	1.000									
(16) 1ary enrollment rate	0.083	0.319	0.582	0.095	0.076	0.478	-0.105	-0.016	0.068	0.143	0.116	0.064	0.145	0.056	0.478	1.000								
(17) 2ary enrollment rate	0.043	0.255	0.614	0.125	0.033	0.645	-0.113	-0.005	0.176	0.037	0.153	0.073	0.115	0.124	0.645	0.775	1.000							
(18) 3ary enrollment rate	0.045	0.273	0.623	0.123	0.040	0.646	-0.114	-0.002	0.175	0.053	0.151	0.073	0.131	0.126	0.646	0.805	0.975	1.000						
(19) Oil rents (%GDP)	-0.154	0.041	0.046	0.368	0.047	0.017	-0.212	0.211	-0.063	0.914	0.172	-0.185	-0.033	-0.031	0.017	0.086	-0.008	0.005	1.000					
(20) FVA pc	0.402	0.276	0.197	0.348	0.788	0.344	-0.005	-0.162	0.446	-0.116	0.159	-0.143	0.440	0.004	0.344	0.056	0.065	0.065	-0.066	1.000				
(21) DVX pc	0.449	0.282	0.277	0.610	0.637	0.555	-0.142	-0.078	0.390	0.142	0.311	-0.251	0.305	-0.010	0.555	0.159	0.163	0.167	0.201	0.802	1.000			
(22) Diff exp. Pc	0.425	0.270	0.206	0.411	0.793	0.394	-0.040	-0.150	0.429	-0.061	0.187	-0.168	0.424	-0.006	0.394	0.078	0.080	0.081	-0.013	0.935	0.834	1.000		
(23) OE exp. Pc	0.117	0.080	0.102	0.561	0.194	0.334	-0.152	0.194	0.019	0.644	0.272	-0.338	0.068	-0.012	0.334	0.151	0.106	0.115	0.672	0.148	0.607	0.244	1.000	
(24) Ref Pr.exp.pc	0.296	0.152	0.172	0.456	0.553	0.405	-0.086	-0.031	0.218	0.138	0.189	-0.250	0.273	-0.007	0.405	0.096	0.098	0.099	0.159	0.649	0.872	0.664	0.561	1.000

Table C.3. Dependent and control variables, expected sign, and associated literature

Variable	Definition	Source
ECI	Economic Complexity Index.	Observatory of Economic Complexity (OEC, MIT).
ECI+	Augmented Economic complexity Index taking into account the difficulty of exporting each product.	
Connectedness	Cumulative share of the world GDP reached by direct—that is, first-order—cable connections.	Author's computation using SMC network worldwide.
Trade (% of GDP)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	WDI
Internet users (% of pop)	Internet users are individuals who have used the Internet (from any location) in the last three months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV, etc.	WDI
Remoteness	Remoteness from world markets, adjusted for landlocked-ness is the trade weighted average distance from world markets.	UN-CDP and FERDI's retrospective EVI series.
Sea distance	Average sea distance of country to its 10 main imports and exports trade partners	Author's computation using CERDI-Sea Distance Database (Bertoli et al., 2016).
Shipping connect index	Liner Shipping Connectivity Index score indicates how well countries are connected to global shipping networks based on the status of their maritime transport sector.	UNCTAD
Natural rents	Total natural resources rents (% of GDP) are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	WDI
Polity 2	Polity2 is a revised and combined version of the POLITY score indicator, which captures the spectrum of political regime authority on a scale of -10 (hereditary monarchy) to 10 (consolidated democracy).	QOG
Electricity access (% of pop)	Access to electricity is the percentage of population with access to electricity.	WDI
FDI inflows (% of GDP)	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor.	WDI
REER	The Real Effective Exchange Rate is calculated as the weighted geometric average of the nominal exchange rate indices vis-a-vis the ten main partners, total imports and exports excluding oil of the country under consideration adjusted for relative prices.	FERDI's Sustainable Competitiveness Observatory (SCO) data.
FVA pc	Foreign Value-Added per capita used as indicator of backward participation in GVCs.	UNCTAD-Eora global value chain data from Casella et al. (2019).
DVX pc	Indirect ValueAdded per capita widely used as indicator of forward participation in GVCs.	
Diff exp pc	Per capita exports of differentiated goods	Author''s computation using UN COMTRADE Database and following Rauch (1999)'s classification.
OE exp pc	Per capita exports of Organized Exchange goods.	
RefPr exp Pc	Per capita exports of reference price goods.	

Remoteness from world markets. Transportation costs and geographic distance have a crucial impact on international trade (Falvey, 1976; Hummels, 2007). Several empirical studies of bilateral trade have emphasized the negative relationship between distance and trade flows (Brun et al., 2005; Disdier & Head, 2008; Krautheim, 2012; Carrere et al., 2013) —and diversification is not an exception. Dennis and Shepherd (2011) found that a reduction in export or international transport costs is associated with a gain in export diversification. In line with results from Parteka and Tamberi (2008) that positing remoteness form major markets as a robust determinant of export diversification, we resort to Remoteness Index for our empirical investigation. This index, sub-component of the United Nations' Economic Vulnerability Index (EVI) (Cariolle et al., 2016), is the normalized minimum average distance to 33% of the world markets.[43] We expect export complexity to decrease with greater remoteness from world markets, but to account to eventual threshold effect in this variable, we also control for its squared value.

Country size and development level. Country size and development level, in particular through human capital development, are favourable to the enhancement of the size of export basket and the countries' diversification possibilities (Hummels & Klenow, 2005; Parteka & Tamberi, 2008; Starosta de Waldemar, 2010). To capture the role played by a large domestic market in increasing product variety and quality, we control for the logarithm of the population. We also use the logarithm of GDP per capita as a global proxy of the level of development. We expect these factors to exert a positive effect on export complexity.

Natural rents. While natural resource abundance was once considered a source of development Rostow (1990), a vast literature on "resource curse" has highlighted the negative impact of natural resources on economic growth (Frankel, 2012; van der Ploeg, 2011; Ross, 2015; Venables, 2016). An abundance of natural rents and a low level of economic diversification characterize resource-rich countries. Indeed, natural resources dominate export earnings and government revenues (Ross, 2017; Bahar & Santos, 2018). This results in a low level of economic diversification, making them vulnerable to economic shocks and conflicts (Ross, 2004; Venables, 2016). To account for the role of natural resources on the economic complexity, we include an indicator of total natural

[43] See https://www.un.org/development/desa/dpad/least-developed-country-category/evi-indicators.html and also CDP Secretariat. Note on measuring remoteness for the identification of LDCs. August 2015.

resources rents expressed as a share of GDP, provided by the WDI (and also rely on a decomposition of this indicator into oil, gas, mineral, and forest rents). We expect a negative sign for this variable.

FDI inflows. Export complexity is more likely to be affected by FDI. By facilitating the transfer of knowledge, technology and managerial skills, FDI may promote the production and the export of more complex goods and services (Hausmann, 2016). We draw upon FDI inflows retrieved from World Development Indicators. We expect this variable to have a positive impact on export complexity.

Trade openness is often associated with greater specialization (Imbs, 2004), diversification (Dennis & Shepherd, 2011; Makhlouf et al., 2015), or greater complexity in export structure (Keller, 2010). We use trade as a percentage of GDP, derived from the World Bank's WDI, as a measure of openness. Since the literature show that countries that are more open benefit most from technology diffusion, we expect a positive effect of openness on complexity.

Institutional quality. Institutions are important for the sophistication and complexity of the economy (Makhlouf et al., 2015; Saadi, 2020). To capture this impact, we use the Freedom House imputed polity 2 index provided by the Quality of Government Institute (QOG) and deemed to perform better in terms of validity and reliability (Hadenius & Teorell, 2005). The index ranges from 0 to 10, 0 characterizing a less democratic country and 10 for the most democratic. We expect that an increase in the Polity 2 index will improve the complexity of the export.

Internet and energy access are central for exports sophistication (Cristelli et al., 2018). We control for internet users (Lapatinas, 2019) and access to electricity. Both data are derived from the World Bank's WDI database and are expected to influence positively exports complexity.

Real Effective Exchange Rate. The exchange rate is at the heart of the diversification strategy in developing countries. Studying export surges in developing countries, Freund and Pierola (2012) show that export accelerations are preceded by episode of large real devaluations and a reduction in exchange rate volatility. Thus, exchange rate depreciation increases entry into new products and markets and these new flows account for 25% of growth during surges. In the same vein, Iacovone and Javorcik (2008) find that devaluations precede export "breakthroughs" in Mexican firms, while Tang and Zhang

(2012) highlight the negative impact of exchange rate appreciation on firms' extensive margin. To account for the role of REER on complexity, we draw upon FERDI's Sustainable Competitiveness Observatory (SCO) data. The REER index is calculated as the weighted geometric average of the nominal exchange rate indices vis-a-vis the 10 main partners, total imports, and exports excluding oil of the country under consideration adjusted for relative prices. The weights are calculated according to the relative share of the partners over the period 2009–2013. A change below 100 reflects a real depreciation, and thus a tendency to undervaluation. In line with Freund and Pierola (2012) findings, we expect the REER to affect negatively the complexity of the export basket.

Table C.4. Descriptive statistics – Baseline sample: 1,150 observations

	Mean	Std.Dev.	Min	Max	Source
Dependent variable					
ECI	38.25	17.81	0.00	90.84	MIT's OEC
Interest variable					
Digital connectedness	18.10	21.27	0.00	75.59	Authors
Instrumental variable					
2nd order cable connections	32.00	27.84	0.00	102.00	Authors. telegeography
Control variables					
Log (GDP p.c.)	8.09	1.21	5.53	11.15	WDI
log (Population)	16.88	1.41	13.29	21.05	WDI
FDI inflows	3.67	4.52	-6.06	39.46	WDI
Trade (% of GDP)	73.49	48.74	15.64	437.33	WDI
Internet users	17.90	22.19	0.00	97.39	WDI
log (REER)	4.68	0.40	3.04	14.65	FERDI
Remoteness index	53.56	23.19	0.00	100.00	FERDI
Natural rents	9.01	11.24	0.00	58.65	WDI
Polity2	5.81	2.68	0.00	10.00	QOG
Electricity (access)	73.26	30.33	3.44	100.00	WDI
Sea distance	7678.01	2935.01	2494.37	18646.79	CERDI
Shipping connectivity index	26.91	23.30	0.80	141.58	UNCTAD
Absorptive capacity channel					
Internet penetration	17.90	22.20	0.00	97.39	WDI
1ary enrolment rate	102.31	2.63	95.97	105.32	WDI
2ary enrolment rate	78.39	6.65	67.79	90.21	WDI
3ary enrolment rate	34.23	7.26	22.16	47.70	WDI
Value chain participation					
FVA pc	0.79	4.21	0.00	43.10	UNCTAD-Eora
DVX pc	0.46	1.13	0.00	9.96	UNCTAD-Eora
Rauch's exports					
Diff exp. pc	1.23	5.21	0.00	51.43	UN COMTRADE
OE exp. pc	0.78	1.86	0.00	17.94	UN COMTRADE
Ref Pr.exp.pc	0.79	3.38	0.00	39.57	UN COMTRADE

Note: Variable's definitions and related literature are reported in Table C.3. (in the appendix).

Table C.5. Inoue and Solon (2006) LM-test on residuals

Lags	IS-stat	p-value	N	Max T
K=1	44.16	0.003	60	23
K=2	52.76	0.146	60	23

Notes: H0: No auto-correlation of any order. Ha: Auto-correlation up to order k.

Source: Inoue, A. and G. Solon. 2006. "A portmanteau test for serially correlated errors in fixed effects models". *Econometric Theory*, 22(5): 835–51.

Table C.6. Multi-instruments set-up

Period: 2005–2017. Var dep: ECI	**(1)**	**(2)**	**(3)**	**(4)**
(A) Connectedness (con)	0.304***	0.202*	0.300**	1.549***
	(0.114)	(0.115)	(0.132)	(0.308)
(B) SSA x con		0.416*	0.290	0.000347***
		(0.222)	(0.287)	(0.000111)
(C) Lat Am x con			-0.438*	
			(0.253)	
(D) MENA x con			-0.00930	
			(0.211)	
(E) South-East Asia x con			0.0524	
			(0.152)	
(F) South Asia x con			-0.340**	
			(0.167)	
(G) Con x sea distance				-0.000230***
				(0.0000548)
(H) Con x SSA x sea dist.				0.000347***
				(0.000111)
Additional controls				
Sea distance				0.00213***
				(0.000819)
Sea distance x SSA				-0.00166**
				(0.000828)
		First-stage statistics		
F-test (A)	67.56***	110.57***	105.43****	43.44***
F-test (B)		103.17***	93.45***	42.46***
F-test (C)			2.67**	
F-test (D)			2.51**	
F-test (E)			183.22***	
F-test (F)			240.83***	
F-test (G)				93.36***
F-test (H)				85.14***
Cragg-Donald F-stat	74.249	312.249	18.974	79.47
LM-stat	11.385***	24.673***	8.115***	11.65***
Hansen test p-val	0.69	0.12	0.20	0.35
Controls, country & year FEs	Yes	Yes	Yes	Yes
N	633	633	633	633
R^2	0.643	0.660	0.698	0.690

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table. The baseline instrument set (column 1) is: the number of first-order cable connections, the number of second-order cable connections, and the product of the two instruments. Instrument set in column (2) to column (4): conditional variables are interacted with the number of second-order cable connections and added to the number of first-order cable connections and the product of the two instruments in the set of instruments.

Appendix 2: Rauch's exports

Table C.7. 2SLS fixed-effect estimates – Digital connectedness and Rauch's exports – Conservative classification

Period: 2005-2017	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. Var:	**Diff exp. pc**	**OE exp. pc**	**Ref Pr. exp. pc**	**Diff exp. pc**	**OE exp. pc**	**Ref Pr. exp. pc**	**Diff exp. pc**	**OE exp. pc**	**Ref Pr. exp. pc**
(A) Connectedness (con)	0.256**	0.0272	0.0443	0.131*	0.0117	0.0160	-0.193**	-0.0231	-0.0296
	(0.112)	(0.0204)	(0.0368)	(0.0728)	(0.00802)	(0.0164)	(0.0941)	(0.0143)	(0.0357)
(B) SSA x con				0.235	0.0287	0.0526	0.584***	0.0570*	0.118
				(0.165)	(0.0237)	(0.0439)	(0.214)	(0.0317)	(0.0948)
(B) Lat Am x con							0.497**	0.0280	0.00920
							(0.252)	(0.0278)	(0.0486)
(C) MENA x con							0.0141	-0.00718	0.0115
							(0.145)	(0.0162)	(0.0336)
(D) South-East Asia x con							0.272**	0.0344**	0.0403
							(0.128)	(0.0158)	(0.0410)
(E) South Asia x con							0.416***	0.0283*	0.0639
							(0.138)	(0.0145)	(0.0618)
Ref Pr. exports per capita	0.824**		0.236**	0.792**		0.228**	0.694**		0.200**
	(0.333)		(0.107)	(0.332)		(0.0998)	(0.288)		(0.0860)
OE exports per capita	-0.322*	0.0583***		-0.336*	0.0565***		-0.350*	0.0524***	
	(0.179)	(0.00588)		(0.177)	(0.00490)		(0.193)	(0.00818)	
Diff exports per capita		0.0511***	-0.0886		0.0513***	-0.0877		0.0469***	-0.102
		(0.0110)	(0.110)		(0.00984)	(0.108)		(0.0103)	(0.123)
					First-stage statistics				
Cragg-Donald F-stat	58.447	57.215	57.357	195.632	195.335	195.205	19.759	19.699	19.501
LM-stat	10.524***	9.375***	9.595***	21.068***	20.915***	20.977***	14.628***	14.292***	13.758***
Controls, country & year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	773	773	773	773	773	773	773	773	773
R^2	0.816	0.318	0.252	0.847	0.349	0.276	0.857	0.363	0.286

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table.

Table C.8. 2SLS fixed-effect estimates – Digital connectedness and Rauch's exports –Liberal classification

Period: 2005-2017	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. Var:	Diff exp. pc	OE exp. pc	Ref Pr. exp. pc	Diff exp. pc	OE exp. pc	Ref Pr. exp. pc	Diff exp. pc	OE exp. pc	Ref Pr. exp. pc
(A) Connectedness (con)	0.143**	0.0303	0.114*	0.0684	0.0129	0.0591	-0.122*	-0.0233	-0.0785
	(0.0707)	(0.0211)	(0.0625)	(0.0462)	(0.00854)	(0.0402)	(0.0722)	(0.0148)	(0.0483)
(B) SSA x con				0.138	0.0321	0.104	0.352**	0.0609*	0.267**
				(0.114)	(0.0241)	(0.0656)	(0.152)	(0.0323)	(0.133)
(B) Lat Am x con							0.336*	0.0308	0.129
							(0.172)	(0.0295)	(0.0885)
(C) MENA x con							-0.0304	-0.00788	0.0545
							(0.0988)	(0.0165)	(0.0729)
(D) South-East Asia x con							0.146*	0.0361**	0.133*
							(0.0847)	(0.0168)	(0.0768)
(E) South Asia x con							0.267***	0.0289*	0.164*
							(0.104)	(0.0153)	(0.0844)
Ref Pr. exp. per capita	-0.00288	0.0611***		0.00717	0.0631***		-0.0472	0.0569***	
	(0.357)	(0.00860)		(0.365)	(0.00639)		(0.349)	(0.00775)	
OE exp. per capita	0.608***		0.388***	0.582***		0.373***	0.546***		0.328***
	(0.212)		(0.122)	(0.208)		(0.118)	(0.200)		(0.108)
Diff exp. per capita		0.0562***	0.0155		0.0548***	0.0124		0.0518***	-0.0150
		(0.0127)	(0.201)		(0.0117)	(0.197)		(0.0117)	(0.210)
					First-stage estimates				
F-stat (A)	10.39***	10.12***	11.03***	55.07***	51.06***	53.44***	52.52***	58.40***	58.33***
F-stat (B)				20.86***	21.04***	20.88***	26.54***	28.50***	28.77***
F-stat (C)							2.78**	2.64**	2.79**
F-stat (D)							2.55**	2.56**	2.52**
F-stat (E)							62.83**	62.58***	59.44***
F-stat (F)							279.85**	270.43***	273.52***
Cragg-Donald F-stat	56.536	56.806	59.392	192.569	194.370	197.599	19.830	19.724	19.462
LM-stat	10.539***	9.569***	10.014***	21.255***	21.033***	21.029***	14.292***	14.353***	13.814***
Controls, country & year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	773	773	773	773	773	773	773	773	773
R^2	0.805	0.328	0.620	0.824	0.365	0.654	0.832	0.379	0.664

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table.

Appendix 3: Digital connectedness and value chain participation

Table C.9. 2SLS fixed-effect estimates – Digital connectedness and value chain participation

Period: 2005–2017 Dep. Var:	(1) FVA pc	(2) DVX pc	(3) FVA pc	(4) DVX pc	(5) FVA pc	(6) DVX pc
(A) Connectedness (con)	0.202**	0.0398**	0.126*	0.0232*	-0.165*	-0.0237
	(0.0906)	(0.0174)	(0.0661)	(0.0128)	(0.0882)	(0.0198)
(B) SSA x con			0.127	0.0277	0.419**	0.0720*
			(0.102)	(0.0189)	(0.184)	(0.0375)
(C) Lat Am x con					0.344*	0.0641*
					(0.178)	(0.0334)
(D) MENA x con					0.0551	-0.00161
					(0.116)	(0.0256)
(E) South-East Asia x con					0.276**	0.0445
					(0.129)	(0.0276)
(F) South Asia x con					0.322**	0.0492*
					(0.131)	(0.0275)
	First-stage estimates					
Cragg-Donald F-stat	86.835	86.835	322.281	322.281	28.202	28.202
LM-stat	13.40***	13.40***	25.084***	25.084***	10.541***	10.541***
Controls, country FE, year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	855	855	855	855	855	855
R^2	0.795	0.819	0.826	0.850	0.838	0.865

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table.

Appendix 4: Augmented Economic complexity index and Export sophistication index

Table C.10. ECI+ index

Period: 2005–2017 **Var dep: ECI+**	**(1)**	**(2)**	**(3)**	**(4)**
	2nd stage estimations			
(A) Connectedness (con)	0.996*	0.338**	0.172	1.168***
	(0.560)	(0.135)	(0.299)	(0.383)
(B) SSA x con		0.855*	1.124*	-2.946***
		(0.450)	(0.613)	(1.144)
(C) Lat Am x con			0.116	
			(0.560)	
(D) MENA x con			0.598	
			(0.560)	
(E) South-East Asia x con			0.293	
			(0.238)	
(F) South Asia x con			0.0952	
			(0.240)	
(G) Con x sea distance				-0.000191***
				(0.0000670)
(H) Con x SSA x sea dist.				0.000485***
				(0.000142)
Additional controls				
Sea distance				0.00284**
				(0.00113)
Sea distance x SSA				-0.00329***
				(0.000838)
	First-stage statistics			
F-test (A)	4.69**	49.66***	116.72***	17.06***
F-test (B)		48.68***	30.36***	30.52***
F-test (C)			5.68***	
F-test (D)			2.07*	
F-test (E)			144.61***	
F-test (F)			845.20***	
F-test (G)				19.66***
F-test (H)				39.45***
Cragg-Donald F-stat	21.053	116.295	6.332	31.58
LM-stat	5.049**	17.410***	10.600***	8.827***
Controls, country & year FEs	Yes	Yes	Yes	Yes
N	521	521	521	521
R^2	0.595	0.811	0.805	0.838

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table.

Table C.11. Export sophistication index (EXPY)

Period: 2005–2017 **Var dep: EXPY score**	**(1)**	**(2)**	**(3)**	**(4)**
	2nd stage estimations			
(A) Connectedness (con)	0.255*	0.0422	0.200*	1.074***
	(0.134)	(0.113)	(0.115)	(0.348)
(B) SSA x con		0.326	-0.0806	0.184
		(0.232)	(0.209)	(0.554)
(C) Lat Am x con			-0.771***	
			(0.192)	
(D) MENA x con			-0.121	
			(0.127)	
(E)South-East Asia x con			-0.0700	
			(0.113)	
(F) South Asia x con			-0.545***	
			(0.124)	
(G) Con x sea distance				-0.000159***
				(0.0000612)
(H) Con x SSA x sea dist.				0.0000588
				(0.0000642)
Additional controls				
Sea distance				0.00195**
				(0.000957)
Sea distance x SSA				0.0000316
				(0.000742)
	First-stage statistics			
F-test (A)	13.08***	74.21***	72.77***	26.00***
F-test (B)		56.11***	34.90***	41.65***
F-test (C)			3.78***	
F-test (D)			2.81**	
F-test (E)			60.83***	
F-test (F)			275.87***	
F-test (G)				36.57***
F-test (H)				41.97***
Cragg-Donald F-stat	74.249	312.249	18.974	68.287
LM-stat	11.385***	24.673***	8.115***	14.444***
Controls, country & year FEs	Yes	Yes	Yes	Yes
N	801	801	801	681
R^2	0.855	0.875	0.923	0.916

Notes: Standard errors are robust to heteroscedasticity and clustered by country. *** p<0.01, ** p<0.05, * p<0.1. Control estimates are not reported in the table. The export sophistication index is a normalized version (between 0 and 100) of the index proposed by Hausmann et al. (2007).

General conclusion:

Poor nations could find happiness in their own way.

Key takeaways

This thesis, spanning three chapters, thoroughly examines competitiveness and export performance in Africa. The initial chapter revisits the perennial debate on the competitiveness of the CFA franc by addressing the challenge of assessing price competitiveness. The second chapter meticulously explores how exchange rate undervaluation propels export surges for African products. Shifting the focus to non-price competitiveness, the third chapter investigates the implications of the swift deployment of submarine cables (SMC) along the African coasts for the sophistication of the African export basket.

In summary, the analyses reveal that while competitiveness remains a central concept in economics, its measurement depends on the study's objective and the data and techniques employed. For the CFA franc zone, differences between monetary unions, sub-periods, and countries emerge. Towards the end of the period, deviations from the equilibrium exchange rate do not necessitate a parity readjustment. Focusing on exported products, the analysis in chapter 2 indicates that product-specific exchange rate misalignments stimulate export surges. However, the official exchange rate, being a generic tool, may not meet specific product market expectations. Identifying product-specific exchange rate misalignments is crucial before aligning country-product pairs with appropriate industrial policy instruments. The empirical analysis highlights that optimal policy tools vary and must be customized based on each country's characteristics and development goals. While the nominal exchange rate is crucial, it is just one of several economic policy instruments contributing to product-specific undervaluation. The findings suggest that product-specific undervaluation stimulates export surges, may or may not result from changes in the nominal exchange rate, and potentially collaborates with other elements of vertical industrial policy and territorial attractiveness.

Lastly, when examining non-price competitiveness and the implications of submarine cable deployment along the African coasts, we found that digital connectedness generally enhances export complexity, with Sub-Saharan Africa experiencing an additional increase in economic complexity during a catch-up phase on the 2006-2015 period. However, the positive impact of digital connectedness diminishes with increasing geographical and maritime distance from global markets, except in Sub-Saharan Africa, where these distances amplify its benefits. The analysis of transmission channels indicates that digital connectedness promotes both upstream and downstream participation in global value chains and increases the exports of differentiated goods i.e., those with the higher information search costs.

Directions for future research

An imaginable extension of the first chapter could involve examining the effects of exchange rate regimes and their tendencies towards misalignments on the export performance of countries. Building upon the insights from the second chapter on export accelerations, further exploration could focus on studying the entire export basket of African countries, considering an extensive margin based on the export of new products. This might lead to a typology of products experiencing acceleration, defined by the duration of the acceleration period, the complexity of the products, and their proximity to existing products—those for which countries have a long-standing comparative advantage. It would also be interesting to investigate the structural transformations occurring in the economy during surge periods. Do these surges periods create significant changes in the production environment? An equally relevant question that could garner interest is examining the impact of climate change on the structure of African countries' export baskets.

The third chapter, which delves into the impact of deploying Submarine cables (SMC) on the complexity of exported products, could potentially spawn a series of research papers on transmission channels. This could involve exploring, through a gravity model, how direct SMC connections between two countries affect the diffusion of knowledge and thus production structure between connected country. Another avenue for exploration could be studying the rise of mobile money adoption and its impact on the structure of intra-African trade.

Résumé extensif en français

Le principe d'Anna Karenine en économie du développement

En 1873, alors que Léon Tolstoï entamait son chef-d'œuvre "Anna Karenine" avec l'affirmation selon laquelle "Toutes les familles heureuses se ressemblent ; chaque famille malheureuse l'est à sa manière", il n'imaginait guère que cette métaphore transcenderait le domaine de la littérature et résonnerait à travers divers champs des siècles plus tard. Le principe d'Anna Karenine, issu de cette déclaration fondamentale, se déploie comme une lentille métaphorique à travers laquelle le succès est envisagé comme dépendant de l'accomplissement simultané d'une myriade de conditions indispensables, une notion largement appliquée dans des disciplines telles que l'économie. Dans le domaine de l'économie du développement, le principe Karenine se transpose en "toutes les économies riches se ressemblent ; chaque économie pauvre est pauvre à sa manière" et postule que le succès dans le développement économique découle de la satisfaction méticuleuse d'un ensemble spécifique de critères, reflétant le concept selon lequel les familles heureuses (c'est-à-dire les pays développés) partagent des attributs communs. En revanche, l'échec dans ce contexte découle de l'insuffisance ou de la non-satisfaction de l'une de ces conditions essentielles, se manifestant par un éventail d'inadéquations distinctes. Cette application métaphorique du principe d'Anna Karenine a gagné en importance dans diverses disciplines académiques, soulignant l'impératif de traiter de multiples facettes pour atteindre le succès. Elle sert de rappel poignant que les chemins de l'échec sont divers et complexes, tandis que le succès suit souvent une trajectoire discernable où de nombreux éléments critiques convergent harmonieusement. Cependant, le principe d'Anna Karenine s'applique différemment d'un domaine à l'autre et n'est pas une panacée. Dans son best-seller "De zéro à un : Comment construire le futur", Peter Thiel offre une perspective contrastée en ce qui concerne les entreprises. En effet, il postule que "toutes les entreprises heureuses sont différentes : chacune gagne un monopole en résolvant un problème unique. Toutes les entreprises malheureuses se ressemblent : elles n'ont pas réussi à échapper à la concurrence." Thiel suggère que les entreprises à succès se distinguent en relevant des défis distinctifs et en établissant un monopole dans leurs niches respectives. En revanche, les entreprises malheureuses partagent une

caractéristique commune - elles n'ont pas réussi à se libérer des contraintes de la concurrence.

L'interminable débat sur la compétitivité

La compétition reste un concept central en économie depuis qu'Adam Smith l'a introduit comme une force fondamentale sur les marchés, renforcée par la théorie de l'avantage compétitif de David Ricardo. Ce sujet attire une attention significative et hégémonique parmi les économistes, les décideurs politiques et les médias en raison de son rôle crucial dans le développement économique, devenant parfois une "obsession dangereuse". L'intérêt considérable pour le concept de compétitivité internationale est apparent à travers les plus de 6,5 millions de résultats générés par une recherche Google (Olczyk, 2016). L'intérêt croissant pour les classements de compétitivité, en particulier au niveau des pays, renforce cette tendance (Hassett, 2012). Malgré sa persistance hégémonique dans le débat, le concept n'est pas bien défini dans la littérature économique. Lachmann (2001) identifie plusieurs facteurs contribuant au manque d'une définition et d'une théorie largement acceptées de la compétitivité internationale, y compris la nature large du concept, les idées fausses sur le niveau d'analyse et l'absence de consensus sur une base théorique. D'un point de vue microéconomique, la concurrence crée un environnement dynamique où les entreprises moins compétitives risquent de perdre des parts de marché, de faire faillite ou de sortir du marché, tandis que les entreprises plus compétitives ont le potentiel de gagner des parts de marché et de connaître une croissance (Hibbs, 1983 ; Bristow, 2005 ; Kitson et al., 2004 ; Porter, 1990 et 1998 ; Falciola et al., 2020). Cependant, lorsqu'on considère la concurrence au niveau macroéconomique, la situation devient plus complexe. Pour paraphraser Krugman (1994), les nations - contrairement aux entreprises - n'ont pas l'option de se retirer du marché. Porter (1998) et Krugman, cité dans Kurtzman (1998), soutiennent que ce sont les entreprises, et non les nations, qui se concurrencent sur les marchés internationaux. Cette perspective souligne que les pays ne participent pas à l'achat et à la vente de biens à l'étranger ; ce sont plutôt des entreprises individuelles qui le font. En d'autres termes, le concept de compétitivité au niveau national n'est pas aussi simple que pour les entreprises. C'est plutôt un concept évanescent pour lequel il n'existe pas de théorie universellement acceptée.

Mulatu (2016), dans sa typologie, catégorise le concept de compétitivité nationale en trois écoles de pensée, à savoir l'école de pensée économique néoclassique, l'école de pensée de la quasi-compétitivité et l'école de la compétitivité. L'école de pensée économique néoclassique affirme que le concept de compétitivité est bien défini au niveau de l'entreprise, où le succès dépend de la performance relative. Étendre le concept aux nations soulève cependant des questions sur les dépendances à l'égard de facteurs tels que la structure des coûts, la productivité et les taux de change. Les critiques de la vue néoclassique pointent les inefficacités des marchés libres ou du libre-échange en raison des défaillances du marché et de la non-exogénéité de l'avantage comparatif. Ils soulignent également l'importance de traiter des questions telles que les externalités, les économies d'échelle, l'information imparfaite et la distribution des revenus. L'école de la quasi-compétitivité, représentée entre autres par Boltho, Fagerberg et Cantwell, reconnaît un rôle limité mais significatif pour la compétitivité et insiste sur son utilisation comme mesure de la performance économique nationale. En mettant l'accent sur des problèmes à court terme tels que les taux de change réels et les déficits du compte courant, la compétitivité est considérée comme un outil pour relever des défis économiques spécifiques, tout en plaidant pour la priorité de la productivité sur la compétitivité. En revanche, l'école de la compétitivité soutient que la compétitivité est une partie intégrante de la stratégie de développement pour les pays, allant au-delà de l'efficacité des entreprises pour mettre l'accent sur l'engagement et l'efficacité dans les secteurs à forte valeur ajoutée. Cette perspective préconise des politiques stratégiques, y compris des subventions ou des tarifs, qui remettent en question l'approche totalement libérale, en particulier dans les secteurs de haute technologie, pour promouvoir l'innovation et augmenter la performance économique globale et les revenus d'une nation.

La compétitivité, que ce soit au niveau national ou au niveau de l'entreprise, englobe diverses définitions (voir Aiginger et al., 2013 ; Falciola et al., 2020 ; Buitrago et al., 2021). Moon et al. (1998) définissent la compétitivité au niveau de l'entreprise comme "la capacité des entreprises engagées dans des activités à valeur ajoutée dans un secteur spécifique dans un pays particulier à maintenir cette valeur ajoutée sur des périodes prolongées malgré la concurrence internationale." Falciola et al. (2020) contribuent à cette notion en soulignant que les entreprises compétitives doivent non seulement répondre aux demandes des consommateurs, mais le faire de manière durable, en s'adaptant aux

changements environnementaux et en restant constamment informées des dernières tendances du marché. Au niveau national, l'Organisation de coopération et de développement économiques (OCDE, 1992) perçoit la compétitivité comme la capacité d'un pays à produire des biens et des services répondant aux exigences du marché international dans des conditions de marché équitable et de libre-échange, favorisant des gains durables et croissants pour les individus à long terme. Le Forum économique mondial (WEF), évaluant activement la compétitivité à travers l'« Indice mondial de compétitivité » depuis la fin des années 1970, la définit comme « l'ensemble des institutions, des politiques et des facteurs qui déterminent le niveau de productivité d'un pays ». Parmi les innombrables définitions trouvées dans la littérature économique, cette thèse s'aligne étroitement sur celle de Berger (2008), qui énonce quatre définitions théoriques essentielles de la compétitivité nationale. La première définition met en lumière la capacité commerciale d'une nation, couvrant à la fois la compétitivité basée sur les prix et celle non basée sur les prix. La deuxième met l'accent sur l'importance de réaliser des gains de productivité. La troisième se concentre sur la capacité d'adaptation de la nation aux changements externes, impliquant la promotion de l'innovation et le maintien de la flexibilité. Enfin, la quatrième définition concerne la capacité de la nation à attirer des ressources en capital et en main-d'œuvre.

Problématique et objectif de cette thèse :

Malgré sa population dépassant 1,4 milliard d'habitants, ce qui en fait le deuxième continent le plus peuplé au monde après l'Asie, l'Afrique occupe une position relativement modeste sur la scène du commerce mondial. L'analyse de la littérature économique sur la marginalisation des économies africaines dans le commerce mondial révèle une interaction complexe de facteurs. Parmi ceux-ci figurent les défis liés à l'infrastructure, les barrières commerciales et les tarifs, la faible diversification économique et la sophistication limitée des biens exportés, les lacunes institutionnelles, le manque d'accès au financement, l'instabilité politique, le déficit de compétences, les déséquilibres de pouvoir dans le commerce mondial, ainsi que l'intégration régionale limitée et la coopération économique insuffisante entre les nations africaines. Ces facteurs, qui font écho au principe d'Anna Karenine, entravent la création de marchés plus vastes et plus attrayants pour le commerce international et limitent les économies d'échelle. De plus, les défis liés au changement climatique et à l'environnement viennent

s'ajouter aux obstacles. S'inspirant de la littérature existante sur les défis qui entravent l'intégration commerciale mondiale des pays africains et reconnaissant l'absence d'une approche unique en raison des divers obstacles rencontrés, cette thèse explore le potentiel de la compétitivité prix et hors prix en tant que moyens pour l'Afrique de prospérer par le biais d'une intégration accrue dans le commerce international.

La valeur ajoutée et le principal résultat de la thèse

Cette thèse est structurée autour de trois chapitres, se concentrant principalement sur la compétitivité prix et la compétitivité hors prix en Afrique. Dans le premier chapitre, nous abordons la question de la mesure de la compétitivité prix. Pour ce faire, nous relançons le débat perpétuel sur la compétitivité du franc CFA à travers les prismes du Taux de Change d'Équilibre Comportemental (BEER) et de la Parité de Pouvoir d'Achat (PPP). Pour mener cette analyse, nous utilisons un panel de 99 pays de différents niveaux de développement sur la période 1990-2016. Les mésalignements comportementaux (BEER) sont estimés en utilisant des méthodes de cointégration de panel (Pool Mean Group - PMG), tandis que les désalignements en PPA sont dérivés d'une régression OLS standard. Une contribution significative de ce chapitre est la prise en compte des rentes naturels, qui ne sont généralement pas inclus dans les fondamentaux du taux de change d'équilibre mais constituent un facteur important des mésalignements dans les pays africains principalement dépendants des ressources naturelles. Les deux critères d'analyses adoptés ont révélé des disparités entre les unions monétaires, les sous-périodes et les pays considérés. En particulier, le modèle BEER favorise l'UEMOA, tandis que le critère de la PPA favorise la CEMAC. Ces résultats restent robustes, les mésalignements se révélant insensibles aux variations des mesures de productivité et de la composition de l'échantillon. Vers la fin de la période (2014-2016), les écarts par rapport au taux d'équilibre ne semblent pas nécessiter un réajustement de la parité. Cependant, au sein du groupe de 14 membres, la République centrafricaine a manifestement présenté une surévaluation substantielle découlant de vulnérabilités et d'une fragilité politique, avec des conséquences dépassant le cadre d'un simple ajustement nominal du taux de change.

Le deuxième chapitre examine en détail l'impact de la sous-évaluation du taux de change sur la stimulation des exportations de produits africains. S'appuyant sur les recherches fondamentales de Freund et Pierola (2012), ce chapitre étend l'analyse à une large gamme

de produits d'exportation clés, tant primaires que manufacturés. Ce qui distingue ce chapitre, c'est son approche innovante, qui introduit une dimension microéconomique de la compétitivité prix adaptée à chaque produit d'exportation, en tenant compte de l'environnement macroéconomique des principaux pays concurrents exportant un bien similaire. Sur la période 1995-2017, 96 épisodes sont identifiés pour 41 pays africains, couvrant 149 produits (code HS à 4 chiffres). Les résultats que montrent la sous-évaluation stimule significativement la compétitivité et déclenche des accélérations d'exportation. En utilisant un modèle log-log complémentaire (cloglog), les résultats restent robustes à diverses considérations, confirmant l'influence de la sous-évaluation au niveau du produit sur les épisodes d'accélération d'exportation. En substance, le chapitre 2 fournit des indications précieuses sur l'interaction complexe entre la sous-évaluation des monnaies, la compétitivité de prix au niveau des produits et les accélérations d'exportation qui en résultent dans les économies africaines. L'analyse nuancée des biens primaires et manufacturés fournit une compréhension globale des dynamiques du marché mondial.

Le troisième chapitre se concentre sur la compétitivité hors prix et explore les implications du déploiement récent et rapide du câble sous-marin le long des côtes africaines pour la sophistication du panier d'exportation africain. La contribution de ce chapitre est triple. Premièrement, il met en lumière une nouvelle dimension du déploiement du câble sous-marin appelée "interconnectivité numérique", reflétant la proximité numérique d'un pays avec les principaux marchés mondiaux et évalue son impact sur la sophistication des exportations. Deuxièmement, la sophistication est mesurée par des indicateurs de la complexité du panier d'exportation, principalement basés sur l'Indice de Complexité Économique (Hidalgo, 2021). Troisièmement, un instrument innovant, le nombre de connexions indirectes de câbles sous-marins (connexions de second ordre), est calculé pour traiter une éventuelle causalité inverse entre l'interconnectivité numérique et la complexité des exportations. Tirant parti d'un échantillon de pays en développement, comprenant 23 pays d'Afrique subsaharienne (ASS), couvrant la période 1995-2017, les résultats montrent que la connectivité numérique a globalement amélioré la complexité des exportations. Cependant, il existe une hétérogénéité géographique et temporelle. En comparaison avec le reste du monde, l'Afrique subsaharienne (ASS) a connu une augmentation supplémentaire de la

complexité économique, notamment pendant la période 2006-2015, ce qui indique une phase de rattrapage pour la région. L'impact positif de l'interconnectivité numérique diminue à mesure que les distances géographiques et maritimes par rapport aux marchés mondiaux augmentent, sauf en ASS, où ces distances amplifient les avantages de la connectivité numérique. En examinant les mécanismes sous-jacents au processus de sophistication des exportations grâce à l'interconnectivité numérique, les résultats indiquent qu'elle améliore l'exportation de biens différenciés - ceux avec des coûts de recherche d'informations plus élevés - et favorise la participation à la fois en amont et en aval aux chaînes de valeur mondiales.