International Economics 169 (2022) 71–88

Contents lists available at ScienceDirect

International Economics

journal homepage: www.elsevier.com/locate/inteco

Does foreign aid impede economic complexity in developing countries?

Brice Kamguia [a], Sosson Tadadjeu [a], Clovis Miamo [b], Henri Njangang [b,*]

[a] The Dschang School of Economics and Management, University of Dschang, Cameroon
[b] LAREFA, Faculty of Economics and Management, University of Dschang, Cameroon

ARTICLE INFO

JEL classification:
O23
F21
C23

Keywords:
Foreign aid
Economic complexity
Panel data
Developing countries

ABSTRACT

Foreign aid is one of the most important policy tools that developed countries use to help poor countries improve population well-being and facilitate economic and institutional development. However, the effectiveness of aid as an instrument of development has been questioned several times, especially for its deleterious effects on governance. This study examines the effect of foreign aid on economic complexity in 78 developing countries over the period 1990–2017. We combine different identification strategies and the following results are established. First, we find evidence that foreign aid reduces economic complexity. Second, we show that the effect of foreign aid on economic complexity is heterogeneous to the level of economic complexity and to the nature of aid received. More specifically, we show that while foreign aid reduces economic complexity in countries with lower levels of economic complexity, the effect is positive in countries with higher levels of economic complexity. Additionally, we show that while foreign aid in the energy and education sectors increases economic complexity, the effect is negative for agricultural and humanitarian aid. Three, we further find a U-shaped relationship between foreign aid and economic complexity. Finally, the empirical results of this paper show that democracy mitigates the negative effect of foreign aid on economic complexity. Thus, in order to benefit from the effects of foreign aid for better economic complexity, the governments of developing countries would benefit from putting more effort into improving democracy.

1. Introduction

For decades, theories of economic growth have tried to understand why some economies grow faster than others. In the 1970s, several studies placed industrialization at the heart of development economics (Raffer and Singer, 2001; Ocampo and Ros, 2011). Prebisch-Singer's thesis focuses on the difference in income elasticity of demand between commodities and manufactures, highlighting the risk of specializing in commodities. Hirschman's unbalanced growth model and Kaldor's growth laws highlight the special properties of manufacturing. After the neoclassical paradigm shift in development economics between the 1970s and the 1990s (which is represented by homogeneity of production, neutrality of the trade regime, allocative efficiency and industrialization), many economists have re-emphasized this issue over the last two decades.

A recent growing literature has revived those ideas and resettled structural transformation and industrialization at the forefront of

* Corresponding author.
E-mail addresses: kamguiadj@yahoo.fr (B. Kamguia), stadadjeu@yahoo.fr (S. Tadadjeu), c_miamo_w@yahoo.fr (C. Miamo), ndieupahenri@yahoo.fr (H. Njangang).

https://doi.org/10.1016/j.inteco.2021.10.004
Received 12 May 2021; Received in revised form 11 October 2021; Accepted 25 October 2021
Available online 28 October 2021

understanding economic growth and explained economic development as a process of learning how to produce and export more complex products (Hausmann et al. 2007, 2014; Spatafora et al., 2012; Hartmann et al., 2017). Specifically, economic complexity measures the sophistication of a country's productive structure by combining information on the diversity of a country (the number of products it exports), and the ubiquity of its products (the number of countries that export that product) (Hidalgo and Hausmann, 2009). Hausmann et al. (2007) argue that if a country exports a basket of products with a higher share of technologically and productively more sophisticated or higher value-added products, then this country is considered having more sophisticated exports.

Increasing the productivity of exports is an issue of great importance for developing economies. However, according to Hausmann et al. (2007), "*it is not how much but what you export that matters*". Developing countries face more difficulties in improving their export baskets (Harding and Javorcik, 2011). Therefore, it becomes very important to understand the factors that determine the country's economic sophistication. Since the seminal work of Hausmann et al. (2007) on export sophistication,[1] recent studies have made major inroads into documenting the determinants of countries' export sophistication. Gala et al. (2018) investigate the relationship between sophisticated jobs and economic complexity and show that in the long-run, economic complexity depends on the efforts and the ability of countries to generate employment in manufacturing and sophisticated services sectors. Lapatinas and Litina (2019) suggest a positive correlation between the level of collective intelligence of a country and the level of economic sophistication. Other authors (Kannen (2020), Khan et al., 2020; Kannen (2020); Antonietti and Franco, 2021) emphasize the role of foreign direct investment (FDI) in explaining economic complexity. According to Valette (2018) migration from developing to developed countries is associated with a transfer of productive knowledge and an increase in the level of economic complexity. Recently, Bahar et al. (2020) corroborate this view and show that countries with a high level of migration diversity have a high level of economic complexity. Saadi (2020) reveals that remittances, and particularly remittances used for investment, increase export complexity. For Lapatinas (2019), access to the internet accelerates the productive capacity and level of sophistication of an economy. Nguyen et al. (2020) show that while patent is positively associated with economic complexity, as in Sweet and Eterovic (2019), the effect of financial development on economic complexity is mitigated. Only financial efficiency increases economic complexity. This result was generalized by Chu (2020) and Njangang et al. (2021) who showed that financial development in general is positively correlated with economic complexity. Vu (2019) shows that institutions influence economic complexity by inducing the accumulation of human capital and increasing incentives for innovative activities. Recently, Keneck-Massil and Nvuh-Njoya (2021) show that high mortality among settlers led to less present economic complexity in former colonies.

However, work on the determinants of export sophistication is still insufficient, particularly for developing countries, and needs to be methodologically improved (Zhu and Fu, 2013). Export sophistication is considered the most relevant marker of the productive transformation of economies (Hausmann et al., 2007). According to Lectard and Rougier (2018), sophistication and diversification signal the emergence of new, more capital-intensive industries that are competitive enough to become exporters. More recent work provides evidence that economic complexity also brings a substantial advantage to countries in increasing production stability (Koren and Tenreyro, 2007; Camanho and Romeu, 2011), promoting democracy (Cuberes and Jerzmanowski, 2009; Kolstad and Wiig, 2014), improving economic growth (Zhu and Li, 2017), reducing income inequality (Hartmann et al., 2017), and mitigating the resource curse (Canh et al., 2020).

Despite this new, emerging, and persistent literature on both the effects and, above all, the determinants of economic complexity, the role of aid has so far not been the subject of empirical study. Yet development aid, which has been steadily increasing since 2000, is now the third largest source of external financing for developing countries after foreign direct investment and migrant remittances (World Bank, 2021). For example, in 2019, development aid provided by the donors in the OECD Development Assistance Committee (DAC) was 152.8 billion US dollars, increased by 1.4% in real terms compared to 2018,[2] and by 111% from 2000. This growing increase in aid to developing countries has raised the question of the effectiveness of this aid regarding the economic performance of the receiving countries (Boone, 1996; Hansen and Tarp, 2000; Chong et al., 2009; Asongu, 2012; Riddell and Niño-Zarazúa, 2016).

There are two opposing views on the effectiveness of development aid: optimists and sceptics. From an optimistic view, several studies have shown that foreign aid enhances economic growth (Easterly 2003; Dalgaard et al., 2004; Clemens et al., 2012; Brückner, 2013; Arndt et al., 2015; Galiani et al., 2017), reduces the extreme poverty (Collier and Dollar, 2002; Alvi and Senbeta, 2012; United Nations, 2016), reduces gender disparities (United Nations, 2016), reduces the supply of terrorist attacks by recipient countries (Azam and Thelen, 2008), improves the global health issues (United Nations, 2016), and education (Riddell and Niño-Zarazúa, 2016). For the sceptics, foreign aid is negatively associated with economic and political performances. More precisely, dependence on aid reduce economic growth (Avom et al., 2021a; Morrissey 2015; Moyo 2009), extends civil war (Nunn and Qian 2014), increases net imports and total consumption (Temple and Van de Sijpe 2014), and increase corruption (Asongu, 2012). Knack (2009) shows that higher aid levels erode the quality of governance, weakening accountability, reduce government incentives to collect taxes or its efforts to attract foreign investment, encouraging rent-seeking and corruption. Corruption, in turn, has the implications of discouraging entrepreneurs and investment, misallocation of talents, enhancing brain drain. Several studies have evidenced that aid is fungible at general and aggregate level (Ouattara 2006; Van de Sijpe 2013). Moyo (2009) argues that aid does not lead to development, but creates problems including

[1] The analysis of complexity seems to be a good way to assess the production system, given that exports make up that part of the system that is entirely subject to international competition. In other words, exports, by reflecting comparative advantages, demonstrate a country's capacity to add value to its productive system on international markets.

[2] For more information, see https://www.oecd.org/dac/financing-sustainable-development/development-finance-data/ODA-2019-detailed-summary.pdf.

corruption, dependency, limitations on exports and Dutch disease, which negatively affect the economic growth and development of most African countries and other poor countries across the globe.

This paper takes a fresh look and contributes to the literature on the effectiveness of foreign aid on at least four points. **First**, to the author's knowledge, we are not aware of any empirical studies which investigate the direct effect of foreign aid on economic complexity. Thetwo lines of research discussed above offer two different views about the determinants of comparative prosperity across countries. Hence, they have been generally examined separately as competing alternatives. This paper goes beyond the current literature by bringing them together. Therefore, this is the first study that empirically examines the effect of foreign aid on economic complexity. **Second**, this study analyses the effect of external aid on economic complexity by considering the type of aid. As humanitarian aid does not have the same objective as, for example, education aid, this article examines the effectiveness of development aid according to its type. More specifically, we analyze the effect of education aid, humanitarian aid, energy aid, agriculture aid and health aid on economic complexity. **Third**, this study, besides examining the linear relationship between foreign aid and economic complexity, analyses the existence of a non-linear relationship. Moreover, institutional theories highlight the role of political institutions in creating different incentives for democratic leaders to make better use of foreign aid for poverty reduction and improved economic growth (Svensson, 1999).[3] In this perspective, this study examines the interaction between foreign aid and democracy to see if foreign aid is potentially less harmful to economic complexity in democratic countries. **Four,** this study accounts for endogeneity by using appropriate econometric methods. For that purpose, this study makes use of two alternative empirical strategies, namely the two-step system Generalized Method of Moments (GMM), which has the advantage of using internal instruments, and the two-stage Least-square instrumental variable (2SLS-IV) approach, which uses external instruments. To sum up, using a panel dataset of 78 developing countries over the period 1990–2017, the results show that foreign aid affects negatively and significantly economic complexity. Moreover, the effect of aid on economic complexity varies according to the type of the aid and democracy mitigates the negative effect of aid.

The remainder of this paper is organized as follows. Section 2 discuss the theoretical mechanism underlying the relationship between foreign aid and economic complexity. Section 3 briefly presents the measurement of economic complexity. Section 4 describes the data and presents the empirical strategy. Section 5 presents the empirical results, and Section 6 concludes.

2. Theoretical background

We present two of potential channels through foreign aid could affect economic complexity: the quality of institutions and human capital.

2.1. Foreign aid, institutional quality and economic complexity

There is a pessimistic line of thought that development aid has a detrimental effect on institutions (Djankov et al., 2008; Rajan and Subramanian, 2007; Busse and Gröning, 2009; Deaton, 2013). These authors argue that aid dependency can undermine the quality of institutions, weaken accountability, encourage rent-seeking, foment conflict over the internal control and distribution of aid funds, and lessen pressure to reform inefficient policies and institutions (Knack, 2001). Busse and Gröning (2009) note that the "moral hazard" and rent-seeking associated with high levels of aid could lead to a negative impact of aid on governance. Similarly, Moss et al. (2006) argue that governments dependent on external sources of revenue tend to be less accountable to their citizens and have less incentive to support effective public institutions. In contrast, an emerging literature suggests that institutional quality is an important determinant of economic complexity. Sweet and Maggio (2015) show that stronger intellectual property systems lead to higher levels of economic complexity. Recently, Vu (2019) has shown that institutional quality exerts a positive and robust effect on economic complexity. The author finds institutions affect economic complexity by inducing human capital accumulation and enhancing incentives for innovative activities. Therefore, we can hypothesizing that development aid by deteriorating the quality of institutions in recipient countries will affect negatively economic complexity.

2.2. Foreign aid, human capital and economic complexity

A second channel for explaining why development aid negatively influences economic complexity is human capital. Although there is no consensus, there is a literature showing that countries dependent on foreign aid are associated with low levels of human development (e.g., Boone, 1996; Azarnert, 2008). Azarnert (2008) analyze the effect of humanitarian aid on fertility and human capital accumulation in aid-dependent countries. The authors show that foreign aid increases fertility, reduces human capital accumulation, and delays the onset of the demographic transition. The analysis suggests that the greater the foreign aid as a source of income, the slower the decline in fertility and the lower the level of education. However, human capital is essential for a country to build productive capacity (Vu, 2019). Indeed, countries with better human capital learn and master complex production tasks faster (Zhu and Li, 2017). Thus, a more educated workforce promotes the ability to produce complex products (Vu, 2019). Looking at the relationship between human capital and economic complexity, Zhu and Fu (2013) find that human capital has a positive effect on export sophistication. Hausmann et al. (2014) also show a positive relationship between human capital and economic sophistication. Gala et al. (2018) show that economic complexity depends on the efforts and capacity of countries to generate jobs in sophisticated manufacturing and service

[3] For example, Burnside and Dollar (2000) find that aid has a positive impact on economic growth in recipient countries with reformed policies and institutions. In the same vein, Svensson (1999) finds that aid contributes to economic growth in more democratic countries.

sectors, which are linked to the quality of human capital. Therefore, development aid, by weakening human capital, contributes to a low level of economic complexity.

2.3. Does type of foreign aid matter?

Although aggregate aid may negatively affect economic complexity through the transmission channels mentioned above, it is possible that different types of aid affect economic complexity differently. Indeed, because aid from each sector, including health, education, agriculture, energy, and humanitarian aid, has specific objectives, aid from these sectors might have divergent effects on the production of complex products. For example, appropriate use of education aid increases school enrollment rates, which in turn helps workers take up high-paying jobs that require higher levels of knowledge (Dreher et al., 2008). Therefore, aid to education has long-term and permanent effects on human capital accumulation, which would increase the production of more complex products. Similarly, energy aid contributes to improved access to electricity and energy efficiency (Murata and Banerjee, 2020). This improvement in energy efficiency and access to electricity promotes improvements in human capital (Banerjee et al., 2021), which will increase economic complexity, all else being equal. Theoretically, one could assume that health aid, by improving health outcomes enables people to continue their education, which will promote innovation and thus economic complexity. However, empirical studies are not unanimous on the effectiveness of health aid in improving health outcomes given the poor institutional quality in recipient countries or the fungible nature of health aid (Mukherjee and Kizhakethalackal, 2013; Dieleman et al., 2013). Regarding agricultural aid, despite the lack of consensus, several studies show that agricultural aid improves agricultural productivity, reduces undernourishment, and promotes food security (see for example, Mary et al., 2020). We assume that it is very unlikely that agricultural aid will promote economic complexity because it will contribute to increasing agricultural productivity, which has very little positive externality for innovation. Similarly, given that humanitarian aid is allocated to populations in situations of insecurity due to, for example, political instability, conflict, or natural disasters, it is very unlikely that this aid will promote economic complexity.

3. The measurement method of economic complexity

To measure economic complexity, we build on the measure proposed by Hidalgo and Hausmann (2009). Based on the idea that modern societies are characterized by the diversity of knowledge among individuals and their capability to synthesize the knowledge through complicated social interactions. The intuition is that all members of a society have some productive knowledge, which can be called as capability. Products are combinations of a large number of productive knowledge and countries can make products if they have all the required capabilities. Hausmann et al. (2007) create economic complexity index by analyzing these capabilities and productive knowledge among countries.

The intuition behind the economic complexity is based on two concepts: diversity and ubiquity. Diversity indicates the number of products a country exports and ubiquity refers to the number of countries that export the same product (Hidalgo and Hausmann, 2009). Diversity could be one of the strongest words that could describe today's economic structure around the world. Hidalgo and Hausmann (2009) state that producing a diverse set of goods implies that a country has many capabilities.[4] Nonetheless, by itself, this is not enough. The diversity of countries must be corrected with ubiquity of products and vice versa. Ubiquity can be thought of an indicator for sophistication. Sophistication of economies can evolve by either increasing the quality of produced goods or switching to new, modern or more sophisticated products (Maggioni et al., 2016). Thus, through the concepts of diversity and ubiquity, economic complexity searches a way for countries to transform their productive structure.

The method of correcting diversity by ubiquity and vice versa is called the method of reflections. Hausmann et al. (2011) generalizes the method of reflections to calculate ECI for all countries. To analyze the mathematical calculation, following Hausmann et al. (2011), let's define a matrix called M_{ab} and assume that an element of this matrix equals to 1 if country a exports product b with a revealed comparative advantage[5] (RCA >1) and 0 otherwise. Then diversity and ubiquity can be computed by adding the rows and columns of the matrix together:

$$Diversity = k_{a,0} = \sum\nolimits_b M_{ab} \tag{1}$$

$$Ubiquity = k_{b,0} = \sum\nolimits_a M_{ab} \tag{2}$$

Then, to acquire a better measure, Hausmann et al. (2011) use diversity and ubiquity to correct each other. Calculating the diversity and ubiquity measures iteratively to get a weighted average ubiquity for a country's exports and weighted average diversity of countries based on their exports gives equations (3) and (4) below, where n represents number of iterations.

$$k_{a,N} = (1 \,/\, k_{a,0}) \sum\nolimits_b M_{a,b}.k_{b,N-1} \tag{3}$$

[4] More complex products, then, are defined as those requiring a specific set of diverse capabilities. As a consequence, they are not easily reproducible everywhere and are generally produced by a few countries endowed with a large set of diverse capabilities and with the ability to suitably combine them (Maggioni et al., 2016).

[5] The Revealed Comparative Advantage (RCA) of a country c in a product p is: $RCA_{ab} = \frac{X_{ab}/\sum_{b'} X_{ab'}}{\sum_{a'} X_{a'b}/\sum_{a'b'} X_{a'b'}}$, where X_{ab} is the total export of country a in product b.

$$k_{b,N} = (1 \,/\, k_{b,0}) \sum\nolimits_{a} M_{a,b}.k_{a,N-1} \tag{4}$$

If we substitute the latter into the former, we get,

$$k_{a,N} = (1 \,/\, k_{a,0}) \sum\nolimits_{b} M_{a,b} (1 \,/\, k_{b,0}) \sum\nolimits_{a'} M_{a',b}.k_{a',N-2} \tag{5}$$

And this can be written as,

$$k_{a,N} = \sum\nolimits_{a'} M_{a',b}.k_{a',N-2} \sum \frac{MabMa'b}{ka,0kb,0} \tag{6}$$

We can rewrite this as,

$$k_{a,N} = \sum\nolimits_{a'} M_{aa'} k_{a',N-2} \tag{7}$$

Where,

$$M'_{aa'} = \sum \frac{MabMa'b}{ka,0kb,0} \tag{8}$$

Equation (7) is satisfied when $k_{a,N} = k_{a,N-2} = 1$, which is the eigenvector of $M'_{aa'}$. However, this is not informative because it constitutes just the vector of ones. Hausmann et al. (2011) look for the eigenvector associated with the second largest eigenvalue. This yields the measure of economic complexity.

Finally,

$$\text{ECI} = \frac{\overset{\nu}{k} - avg\left(\overset{\nu}{k}\right)}{\sigma\left(\overset{\nu}{k}\right)} \tag{9}$$

where *avg* represents average, σ stands for standard deviation, and $\overset{\nu}{k}$ is the eigenvector of $M_{aa'}$ associated with the second largest eigenvalue.

More recently, using a similar theoretical background and trade network data but different mathematical methodologies, other indexes similar to ECI are proposed as well.[6]

4. Data and empirical strategy

4.1. Data

We study the effect of foreign aid on economic complexity focusing on an unbalanced panel of 78 developing countries with data spanning from 1990 to 2017. Data are collected from various source: the Observatory of Economic Complexity (OEC), the World Bank: World Development Indicators (WDI), Organisation for Economic Co-operation and Development (OECD), Polity and Tacchella et al. (2012). Data availability dictates the sample and periodicity. Variables definition and data sources and the complete list of countries are provided in the appendix. The full description of data is as follows.

4.1.1. Dependent variable

The dependent variable is the Economic Complexity Index (ECI), obtained from the Observatory of Economic Complexity.[7] As stated before, this index reflects the sophistication of a country's economicstructure. In particular, this indicator measures the availability of productive capabilities thatallow countries to produce complex products. The number of productive capabilities in acountry is dictated by information on the diversity of products it exports and the ubiquity of itsproducts the number of countries exporting a product (Hidalgo and Hausmann, 2009). The choice of this indicator is guided by the growing literature on the determinants of economic complexity (Nguyen et al. (2020), Lectard and Rougier (2018); Lapatinas (2019); Saadi (2020): Nguyen et al. (2020; Avom et al., 2021b). This indicator helps to correct the criticism of the export sophistication index. Fig. 1 shows the evolution of economic complexity over time. The ends of each box represent the minimum values and the values of each distribution, i.e. the ECI values for each year. Each box is composed of three horizontal lines: the lower line provides the value of the first quartile, the line within the box provides the value of the second quartile (or median value), the upper line provides the third quartile value. The dots represent extreme values. Data on the ECI are taken from the Atlas of Economic Complexity issued by The Observatory of Economic Complexity, a joint initiative of the MIT Media Lab and the Harvard Centre for International Development.

[6] See Hartmann et al. (2017), Albeaik et al. (2017a; 2017b), Tacchella et al. (2012) for more detailed description about these indexes.

[7] These data can be accessed here http://atlas.media.mit.edu.

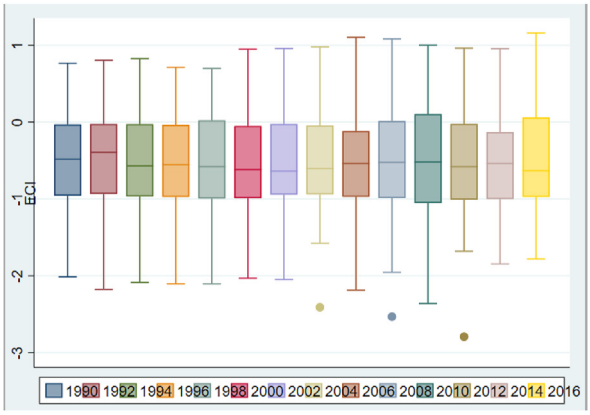

Fig. 1. ECI over time.
Source: MIT's Observatory of Economic Complexity and author' estimates.

For robustness purposes, this paper uses two alternative measures of economic complexity. The first alternative index is the improved economic complexity index (ECI+) by Albeaik et al. (2017) and the second is the economic fitness proposed by Tacchella et al. (2012, 2013). ECI + measures the diversity and sophistication of a country's export structure corrected by how difficult it is to export each product. It combines information on the diversity of a country, i.e. the number of products it exports, and the ubiquity of its products, i.e. the number of countries that export these products (Hidalgo and Hausmann 2009). ECI+ is estimated from data connecting countries to the products they export and is freely available at MIT's Observatory of Economic Complexity. Economic fitness has the advantage of being simple to calculate. It measures the total exports of an economy and adjusts them to the difficulty of exporting each product. Our second measure is obtained from Tacchella et al. (2012, 2013) who propose economic fitness as an alternative to the economic complexity index. This indicator measures, on the one hand, a country's diversification and, on the other hand, its capacity to produce complex goods in a globally competitive manner. It is calculated using a non-linear and iterative approach that effectively highlights the natural link between the basket of goods exported by different countries and their industrial competitiveness.

4.1.2. Main explanatory variable

According to the literature, foreign aid is measured by the "official development assistance" (ODA) from the World Bank: WDI. Following the literature, the analysis primarily uses aid as a share of gross national income (Collier and Dollar 2002; Knack 2009; Galiani et al., 2017). Aid includes grants and loans with a grant element of more than 25%. This definition excludes most IMF lending, and a substantial share of World Bank lending, which goes to middle-income borrowers charged near-market rates of interest. Military aid is also excluded from the definition of ODA (Knack 2009). For robustness check, we use aid commitment as an alternative measure of foreign aid. Aid commitments reflect firm obligations, expressed in writing and backed by the necessary funds, by an official donor to provide specific assistance to a recipient country or multilateral organization. In Fig. 2, we plot the relationship between foreign aid and ECI. As we can see, there is a negative relationship between these two variables. This means that an increase in foreign aid is associated

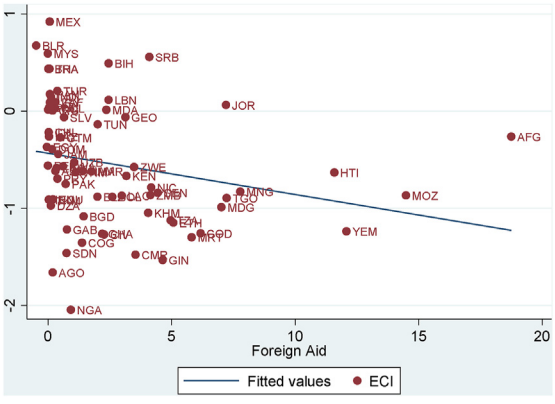

Fig. 2. Foreign aid and ECI (78 countries: 1990–2017).
Source: author's construction

Table 1
Descriptive statistics.

Variables	Obs	Mean	Std. Dev.	Min	Max
ECI	2089	−0.531	0.653	−2.791	1.16
ECI +	1934	−0.496	0.844	−3.532	1.221
Economic fitness	1435	0.4967	0.66239	0	4.3956
Foreign_Aid	2064	4.314	6.938	−0.675	72.06
Aid energy*	1140	1.323	2.626	−9.827	6.575
Aid Humanitarian*	1170	1.779	2.583	−8.022	7.642
Aid Agriculture*	1175	1.982	1.902	−6.773	6.391
Aid health*	1171	2.176	1.777	−4.403	5.655
Aid education*	1181	3.495	1.199	−1.706	5.951
Financial development	2004	32.606	28.467	0.491	166.504
Internet	1880	14.531	19.41	0	83.559
Remittances	1916	3.914	5.559	0	48.195
FDI	2099	3.499	4.97	−37.155	55.076
GFCF	1963	22.503	7.162	0	60.018
Population	2184	1.834	1.241	−9.081	8.791
Inflation	1832	51.578	621.761	−11.686	23773.132
Government cons.	1988	104.754	13.769	57.699	167.04
Democracy	2184	0.512	0.5	0	1

Note: *These variables are expressed in logarithm. Data on the Economic Fitness Index are available for the period 1995–2015. Data on the different types of aid are available from 2002 in the OECD database.

with a decrease in economic complexity. However, as correlation does not mean causality, this relationship will be investigated empirically in the next section.

4.1.3. Control variables

To substantiate on the relationship between foreign aid and economic complexity and to avoid variable omission bias, our baseline analysis controls for a subset of the contemporaneous controls that were found important for economic complexity (Zhu and Fu, 2013; Sweet and Maggio, 2015; Henn et al., 2017; Lectard and Rougier, 2018; Lapatinas, 2019; Saadi, 2020). They comprise: (i) financial development, measured by the domestic credit to private sectors as a percentage of GDP, (ii) Internet, measured by the number of people with access to internet (per 100 people), (iii) remittances measured by the personal remittance inflows as a share of GDP.[8] For Robustness tests, we include five additional controls: Gross fixed capital formation (GFCF), population, inflation, government consumption andforeign direct investment (FDI). In the interactive model, we use polity2 index from the Polity IV project as a measure of democracy.

Table 1 presents the summary statistics of the variables used in the subsequent estimations. It shows that there is a low variation in ECI score among countries, as evidenced by the low standard deviation. Some countries in our sample have not yet succeeded in transforming their economic structure from basic primary commodities to more complex products. A closer look at the data reveals that most of the countries at the lowest end of the economic complexity index are African countries. Table A4 in the appendix presents the correlation matrix between all the variables used in this study. We find that the different measures of foreign aid are negatively related to economic complexity, as measured by the ECI and Economic Fitness indicators.

4.2. Empirical model and estimation strategy

The purpose of this paper is to investigate the effect of foreign aid on economic complexity in developing countries. We hypothesize that foreign aid is negatively associated with economic complexity in developing countries. Therefore, we investigate the following model in Equation (10):

$$Economic\_Complexity = f(Foreign\_Aid,\ X) \tag{10}$$

Where X is the set of control variables presented above.

We estimate relationship described in Equation (10) by performing a dynamic system Generalized Method of Moments (GMM). Based on the review of various strands of (trade) theories, the determinants of developing countries' export complexity can be generally modelled as:

$$ECI_{i,t} = \alpha + \beta_1 ECI_{i,t-1} + \beta_2 Foreign\_Aid_{i,t} + \beta_3 X_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \tag{11}$$

Where $ECI_{i,t}$ is economic complexity index in country i for year t, $ECI_{i,t-1}$ denotes the lagged value of ECI., $ECI_{i,t-1}$ has also been treated with a lag structure by Lectard and Rougier (2018), Saadi (2020). A country's past export sophistication is likely to impact on its current export sophistication. Moreover, as demonstrated by Hausmann et al. (2007), export complexity is a path-dependent process, because

[8] Table A2 provides Variables names and description.

externalities restrict entrepreneurship for new production activities, especially in developing countries. Using lagged dependent variable as regressor renders the model to be a dynamic one and involves some important econometric issues. $Foreign\_Aid_{i,t}$ stands for the net official development assistance received as a percentage of GNI. $X_{i,t}$ is the vector of control variables including per capita GDP, domestic credit, internet and remittances. μ_i is an unobserved country-specific effect and γ_t is time specific effect $\varepsilon_{i,t}$ is the error term.

Introducing lagged economic complexity as explanatory variable invalidates standard static panel regression, due to the "dynamic panel bias" (Nickell, 1981). After eliminating the country-specific fixed effects by first differencing, the first differenced lagged dependent variable is still correlated with the first-differenced idiosyncratic error term because $ECI_{i,t-1}$ is correlated with $\varepsilon_{i,t-1}$. This raises the endogeneity problem, and static estimation will generate biased and inconsistent results. Endogeneity issue may arise from at least three sources: First, reverse causality: foreign aid may be endogenous, and hence there is more likely to have a feedback effect from economic complexity to foreign aid. Second, measurement errors: foreign aid or economic complexity measures are more likely to have measurement errors, particularly in the case of developing countries. Third, variables omission bias: there are important variables (e.g., geographic, cultural or historical factors, etc.) that may be omitted from the regression models but considered as crucial determinant of economic complexity and are correlated with some of the explanatory variables. The common measure in the literature to address such endogeneity issue is to use either instrumental variable approach or a dynamic GMM. In this paper, the system GMM is preferred to that of instrumental variables 2SLS approach.In the literature, the method of instrumental variables using external instruments has been used to effectively solve the problem of reverse causality (Farhadi et al., 2015). However, one limitation of this approach is the difficulty of finding a purely exogenous external instrument that varies from country to country and over time, and therefore this method tends to ignore the endogeneity of other regressors. The GMM has the advantage of dealing with the endogeneity of all the explanatory variables using internal instruments. Moreover, the GMM treats the endogeneity that would come from inverse causality and produces valid instruments.[9]

In order to efficiently estimate the dynamic model formulated above, we use the GMM initially proposed by Arellano and Bond (1991), and further improved by Arellano and Bover (1995), and Blundell and Bond (1998). The GMM technique is declined in two versions: the difference GMM were the lagged levels of the explanatory variables are used as instruments and system GMM were the combination of the regression in differences and the regression in levels are used. However, Bond et al. (2001) have recommended that the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) can dramatically improve efficiency and avoid the weak instruments problem in the first-difference GMM estimator developed by Arellano and Bond (1991). Thus, we employ the Blundell and Bond (1998) system GMM incorporating Windmeijer's (2005) finite-sample correction for standard errors to estimate Equation (12), which produces more efficient estimators. Valid System GMM estimation is established on several conditions. First, in order to obtain consistent estimation on the lagged dependent variable, which is used as regressor, the idiosyncratic error term should have first-order serial correlation but not have second-order serial correlation. That is to say, the Arellano-Bond test for the first-order serial correlation, AR (1), should reject the null hypothesis, while the test for the second order serial correlation, AR (2), should not reject the null. The second condition is the exogeneity and validity of instruments. The Hansen over identification test examines the null hypothesis of the joint validity of instruments, and the Difference-in-Hansen test examines the null hypothesis of the validity of each subset of instruments[10]. To avoid the instrument proliferation problem, we restricted the length of lags as instruments or collapsing the instrument set into a single column for all time points. To what follows, regressions use the "collapsing" method.[11]

For purposes of comparison and, above all, robustness, we also used the IV-2SLS method to analyses the effect of aid on economic complexity (for details, see sub-section 6.2.3).

5. Empirical results

5.1. Baseline results

This subsection presents the baseline results of the effects of foreign aid on economic complexity. The econometric model is estimated using the two-step system GMM and the results are summarized in Table 2. The regressions satisfy the specification tests (AR (1), AR (2) and Hansen tests). There is no evidence of a second serial correlation, but there is strong evidence of a first serial correlation. Moreover, the regressions pass the Hansen test and confirm the validity of the instruments. Lagged ECI is statistically significant at the 1% level in all specifications, showing the path dependence of developing countries' economic complexity. Neglecting this lagged dependent variable will compound the effect of other variables with the path-dependent effect. This notion is consistent with the findings of Hidalgo and Hausmann (2009) and Lectard and Rougier (2018).

Concerning the estimated coefficients, column (1) in Table 2 presents the bivariate specification between foreign aid and economic complexity, which excludes other control variables. Consistent with Fig. 2, the result shows a negative effect of foreign aid on economic complexity. More specifically, the coefficient on foreign aid is −0.0073 with a magnitude suggesting that a 10-unit increase in foreign aid leads to a decrease in economic complexity of about 0.073 unit. The result is consistent with the literature, showing that dependence

[9] This validity is based on the assumption that the current-period shocks in the error term may not linked to the past values of the regressors and the past values of the regressors do not directly affect current value of the dependent variable (Hauk and Wacziarg, 2009).

[10] Hansen test is reported despite it is not robust to the weak instrument problem that is generated by including too many instruments. This problem, coined as "instrument proliferation", leads to false acceptance of the null hypothesis with the unrealistic *p*-value of 1.000 (Roodman, 2009).

[11] This is done via specifying the suffix "collapse" and/or the specific number of lags in the STATA command "xtabond2". All variables in the right-hand side are treated as endogenous regressors, thus need to be instrumented by their lags.

Table 2
Foreign aid and economic complexity (system GMM: 78 countries, 1990–2017).

	Dependent variable: ECI			
	(1)	(2)	(3)	(4)
Lagged ECI	0.9555***	0.8565***	0.7802***	0.7379***
	(0.0350)	(0.0186)	(0.0616)	(0.0676)
Foreign_Aid	−0.0073***	−0.0051***	−0.0098***	−0.0111***
	(0.0019)	(0.0013)	(0.0034)	(0.0036)
Financial development		0.0014***	0.0017*	0.0020**
		(0.0003)	(0.0009)	(0.0009)
Internet			0.0010*	0.0011*
			(0.0005)	(0.0006)
Remittances				0.0108**
				(0.0055)
Constant	0.0049	−0.0993***	−0.1381*	−0.2236**
	(0.0242)	(0.0219)	(0.0708)	(0.0902)
Observations	1922	1826	1470	1403
Number of countries	78	76	76	75
Number of instruments	27	47	48	59
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.504	0.390	0.217	0.143
Hansen OIR	0.377	0.103	0.247	0.259

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

on foreign aid reduces the accumulation of human capital and labor supply (Gong and Zou, 2001); erodes the quality of governance and public sector institutions (Knack 2001; Siba, 2008). This is also in line with the debate from Addison and Tarp (2015) as a result of the recipient's country's mis-management of aid. In column (2), we introduce domestic credit to the private sector as a proxy of financial development. The coefficient associated with foreign aid remains negative and statistically significant. We also find that financial development increases economic complexity. This is consistent with Chu (2020) and Nguyen and Su (2021), and suggests that a well-developed and well-functioning financial market, by reducing financing costs, allocating scarce resources, evaluating innovative projects and managing risks (Hsu et al., 2014) is supposed to favor the development of new and innovative projects, all of which will contribute to economic complexity. Column (3) presents the results with the internet added to the list of control variables. Reassuringly, the estimated negative and significant coefficient on foreign aid remains robust, including the internet. Regarding our control variable, we find the coefficient associated with the internet variable is positive and statistically significant. This reflects the fact that the increase in internet use further accelerates the productive capacity and improves economic complexity (Lapatinas 2019). In column (4) we introduce remittances. Once again, the coefficient associated with official development assistance remains negative and statistically significant, while remittances have a positive effect. The effect of remittances is consistent with findings in Saadi (2020).

As stated by Chauvet et al. (2018), the use of GMM estimators is most of the time required when estimating dynamic models. We provide a test whose aim is to show that the coefficient associated with the lagged dependent variable on the right-hand side reports the appropriate value which should lie between these stemming from OLS and fixed effect estimates. Indeed, OLS estimators lead to upward bias while fixed-effect estimators introduce downward bias (Nickell, 1981). Since GMM estimators help mitigating the bias introduced by the correlation between the lagged dependent variable and the error terms, they should provide coefficients in between those obtained with fixed effects and OLS estimates. As it can be seen in Table A1 of the appendix, the coefficients of the lagged dependent variable are within the appropriate range, confirming the accuracy of our GMM empirical estimates.

5.2. Robustness checks

To test the robustness of our main results, we conduct in this sub section sensitivity analyses along several dimension: using 5-year and 10-year lagged foreign aid, using additional control variables, alternative specification addressing the endogeneity concern of foreign aid, using alternative measures economic complexity. Overall, in all robustness checks, we find results from the specifications equivalent to those in Table 2.

5.2.1. System GMM using 5-year and 10-year lagged foreign aid

Although the results presented in Table 2 provide strong evidence that foreign aid over a year is negatively correlated to economic complexity, it seems more realistic to think that the effect of foreign aid on economic complexity is not immediate. The effect, which necessarily comes through channels such as corruption and human capital, may take some time to be effective. Therefore, to verify this possibility, we re-estimate the effect of foreign aid on economic complexity using 5-year (Columns (1)–(2)) and 10-year (Columns (3)–(4)) lagged foreign aid. The empirical results of this exercise are presented in Table 3, which are qualitatively similar to the baseline system GMM regression results presented in Table 2. One can therefore conclude that the negative effect of foreign aid on economic complexity is robust and significant in developing countries.

Table 3
Foreign aid and economic complexity (System GMM estimates with lagged foreign aid: 78 countries, 1990–2017).

	Dependent variable: ECI			
	(1)	(2)	(3)	(4)
Lagged ECI	0.9141***	0.8631***	0.8989***	0.8417***
	(0.0169)	(0.0268)	(0.0184)	(0.0322)
Foreign_Aid$_{t-5}$	−0.0035***	−0.0039**		
	(0.0010)	(0.0016)		
Foreign_Aid$_{t-10}$			−0.0048***	−0.0052***
			(0.0012)	(0.0017)
Financial development		0.0013***		0.0016***
		(0.0004)		(0.0005)
Internet		0.0003		0.0001
		(0.0003)		(0.0003)
Remittances		−0.0004		−0.0002
		(0.0013)		(0.0015)
Constant	−0.0259*	−0.0883**	−0.0310**	−0.1061***
	(0.0133)	(0.0351)	(0.0144)	(0.0384)
Observations	1665	1415	1618	1,29
Number of countries	78	75	77	73
Number of instruments	27	48	23	48
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.748	0.386	0.821	0.308
Hansen OIR	0.143	0.398	0.0542	0.312

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

Table 4
Foreign aid and economic complexity (System GMM with additional controls: 78 countries, 1990–2017).

	Dependent variable: ECI				
	(1)	(2)	(3)	(4)	(5)
Lagged ECI	0.7530***	0.6996***	0.6981***	0.7349***	0.6455***
	(0.0658)	(0.0716)	(0.0583)	(0.0611)	(0.0699)
Foreign_Aid	−0.0103***	−0.0141***	−0.0138***	−0.0116***	−0.0135***
	(0.0037)	(0.0045)	(0.0042)	(0.0037)	(0.0051)
Financial development	0.0019***	0.0023***	0.0029***	0.0021***	0.0028***
	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0008)
Internet	0.0011**	0.0013*	0.0009	0.0008	0.0013*
	(0.0005)	(0.0007)	(0.0007)	(0.0005)	(0.0008)
Remittances	0.0034*	0.0035	0.0103**	0.0104*	0.0050
	(0.0019)	(0.0025)	(0.0046)	(0.0055)	(0.0073)
GFCF	0.0030				
	(0.0054)				
Population		0.0128			
		(0.0336)			
Inflation			−0.0002		
			(0.0019)		
Government cons.				−0.0005	
				(0.0022)	
FDI					0.0118*
					(0.0070)
Constant	−0.2581*	−0.2385***	−0.2690***	−0.1765	−0.3227***
	(0.1435)	(0.0912)	(0.0642)	(0.2290)	(0.0857)
Observations	1289	1366	1291	1360	1424
Number of countries	71	75	71	72	75
Number of instruments	71	71	70	71	75
AR(1)	0.000	0.000	0.000	0.000	0.000
AR(2)	0.231	0.259	0.311	0.330	0.446
Hansen OIR	0.390	0.470	0.443	0.542	0.351

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

5.2.2. Additional control variables

To check whether the results are robust to controlling for potential omissions, we include additional covariates as shown in Table 4. In particular, the long-term comparative development literature has identified several early development factors which can affect economic performance. Our core results may be biased if we do not properly control for those factors. We therefore include five additional controls: gross fixed capital formation (GFCF); population density, inflation; government consumption, and FDI.

From column (1) to column (5), when we include each additional control variable individually, the coefficient associated with foreign aid remains negative and statistically significant. Thus, our results are robust to the inclusion of additional control variables. Regarding the additional control variables, in column (5) we find that the coefficient associated with FDI are positive and significant. The positive effect of human capital is consistent with the work of Antonietti and Franco (2021) suggesting that accumulating a higher stock of inward FDI per capita Granger-causes a greater economic complexity in a country.

5.2.3. Instrumental-variable approach

We next adopt an instrumental-variable approach to further address the endogeneity issue. To instrument properly for aid, we need a variable that is correlated with aid flows but not with economic complexity, except through included regressors (Baum et al., 2007a, 2007b). Alesina and Dollar (2000) used bilateral trade data to show that the amount of aid is weakly related to the recipient country's economic performance and strongly related to indicators of cultural and historic proximity between the countries. Burnside and Dollar (2000) report that aid is uncorrelated with the recipient country's economic growth thus, on economic complexity. Regarding foreign aid, we rely on an instrumentation procedure based on Tavares (2003). We use the geographic and cultural distance[12] variables and its interaction with the total amounts of aid from the top five donor countries.[13]

The 2SLS regression results are reported in Table 5. The results with respect to the quality of the instruments are satisfactory. With regard to instrument relevance, the Kleibergen-Paap Wald rk F statistic is used to test for weak instruments (Kleibergen and Paap, 2006). The Kleibergen-Paap Wald rk F statistic should be at least 10 for weak identification not to be considered as a problem (Saadi, 2020). The statistic reported in Table 5 are above 10, indicating no problem of weak identification. Moreover, the Kleibergen-Paaprk LM statistic is carried out to test for under-identification. Second, the value of the Sanderson and Windmeijer (2016) F-test for the excluded instrument is biggerthan the rule-of-thumb value of 10 in all cases, which implies that geographic and cultural distance variables are not a weak instrument. Although there may well be reason to suspect non-orthogonality between regressors and errors, the use of IV estimation to address this problem must be balanced against the inevitable loss of efficiency vis-à-vis OLS. It is therefore very useful to have a test of whether or not OLS is inconsistent and IV or GMM is required. Many studies indicate that the aid variable may be endogenous. These studies examine the endogeneity of aid using Durbin-Wu-Hausman (DWH) test (Burnside and Dollar 2000; Dalgaard and Hansen, 2001; Islam, 2005). Following this literature, the DWH test reported in Table 5 does not reject the null hypothesis of exogeneity of foreign aid with respect to economic complexity, IV estimation is not needed, and OLS estimates are unbiased and reliable (Baum et al., 2007a). However, the coefficient associated with foreign aid remains negative and statistically significant, which is consistent with our hypothesis.

5.2.4. Alternative dependent variable

This study has considered ECI from the Observatory of Economic Complexity to investigate the effect of foreign aid on economic complexity (see Table 5). For robustness purpose, we re-estimate our baseline dynamic model using ECI+ and the economic fitness index. The ECI + also measures the diversity and sophistication of a country's export structure, but is adjusted for the difficulty of exporting each product. The fitness index by Tacchella et al. (2012) attempts to capture the complexity of an economy through a similar but slightly different methodology using a nonlinear framework. The result of this exercise is reported in Table 6. Columns (1) and (2) report the results of the effect of foreign aid on economic complexity as measured by ECI+. We find that the coefficients associated with foreign aid are once again negative and statistically significant. Columns (3) and (4) report the results when we use the economic fitness index as the dependent variable. Once again, foreign aid has a negative and statistically significant effect on economic complexity. Therefore, we can conclude that our results remain robust to the use of two alternative dependent variables.

5.3. Heterogeneity of the results

In this subsection, we analyze the intuition of the comparative effects of external aid on economic complexity. In other words, we investigate the relevance of disaggregating the sample in terms of levels of sophistication of the economy and the nature of the aid received.

5.3.1. The level of economic complexity

The effect of external assistance on the level of economic complexity may depend on the existing level of sophistication. Thus, a country already engaged in the sophistication of its economy will be better able to direct external aid to sectors likely to increase its existing level of sophistication, such as qualified human capital, research and development, and innovation (Zhu and Li, 2017; Nguyen et al., 2020) which are all factors that improve economic complexity. To convince ourselves of this empirically, we have divided our sample according to the level of economic complexity (high or low). The results of this exercise are summarized in Table 7. As expected, the effect of external aid varies with the level of economic complexity of the country. In columns (1) and (2) of Table 7, the coefficients associated with the external aid remain negative and statistically significant at the 1% level, suggesting that aid reduces economic complexity in countries with a low level of sophistication. On the other hand, in columns (3) and (4), the coefficients associated with foreign aid become positive and are significant at the 1% level. This result confirms the intuition that countries with a high level of

[12] This is a widely used instrument in the literature see for example Chauvet et al. (2018) and Chauvet and Mesplé-Somps (2007).

[13] The validity of the instruments is tested by a Hansen over-identification test. It cannot reject (at the 10% confidence level) the exogeneity of our instruments.

Table 5
Foreign aid and economic complexity (IV-2SLS:78 countries, 1990–2017).

	Dependent variable: ECI			
	(1)	(2)	(3)	(4)
Foreign_Aid	−0.0316***	−0.0206***	−0.0216***	−0.0257***
	(0.0040)	(0.0036)	(0.0038)	(0.0041)
Financial development		0.0101***	0.0087***	0.0084***
		(0.0005)	(0.0005)	(0.0005)
Internet			0.0046***	0.0044***
			(0.0008)	(0.0009)
Remittances				0.0129***
				(0.0020)
Constant	−0.4177***	−0.7971***	−0.8047***	−0.8363***
	(0.0214)	(0.0324)	(0.0337)	(0.0352)
Observations	1823	1667	1588	1502
R-squared	0.0742	0.2860	0.2986	0.3147
Kleibergen-PaapWald F-stat	309.269	351.213	264.262	355.598
Critical value (10%)	19.93	19.93	19.93	19.93
Critical value (15%)	11.59	11.59	11.59	11.59
Critical value (20%)	8.75	8.75	8.75	8.75
Kleibergen-Paap LM	309.269***	107.565***	144.389****	126.821***
Hansen J statistic	0.820	0.661	0.214	0.273

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

Table 6
Foreign aid and economic complexity (System GMM with ECI+ and Economic Fitness, 78 countries, 1990–2017).

Dependent variables:	ECI +		Economic Fitness	
	(1)	(2)	(3)	(4)
Lagged Dependent variables	0.1588***	0.2863***	0.9699***	0.9049***
	(0.0598)	(0.0763)	(0.0155)	(0.0424)
Foreign_Aid	−0.0326**	−0.0464***	−0.0015***	−0.0035**
	(0.0137)	(0.0172)	(0.0006)	(0.0015)
Financial development		0.0060**		0.0012**
		(0.0025)		(0.0005)
Internet		0.0007		−0.0006
		(0.0018)		(0.0004)
Remittances		−0.0074		−0.0003
		(0.0205)		(0.0008)
Constant	−0.1971**	−0.3425*	0.0216***	0.0304*
	(0.0845)	(0.1829)	(0.0074)	(0.0171)
Observations	1787	1400	1250	1147
Number of countries	78	75	69	66
Number of instruments	23	50	12	51
AR(1)	0.034	0.026	0.000	0.000
AR(2)	0.285	0.302	0.288	0.330
Hansen OIR	0.293	0.118	0.454	0.369

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.
Data on the Economic Fitness Index are available for the period 1995–2015.

sophistication (and therefore necessarily a high level of development) capitalise better on external aid to increase the sophistication of their economy.

5.3.2. Does the type of aid matter?

Previous results have provided strong evidence of a negative and statistically significant relationship between aid received by developing countries and their level of economic complexity. However, can this result be generalized when we considering the type of aid? Indeed, a limitation of the previous results is that aid effectiveness is examined by aggregating different types of foreign aid, such as humanitarian, military, educational, health, agricultural, and other aid, into a single amount. Therefore, it is impossible to draw conclusions about the individual contribution of each specific type of aid to economic complexity. Yet, comparison is important because it allows policymakers and international aid organizations to identify the type of aid that is most effective in boosting economic complexity. Therefore, we follow previous studies (Maruta et al., 2020) and examine the effect of aid from different sectors on economic complexity. We compare the effects of five types of sectoral aid including health, education, agriculture, humanitarian aid and energy aid. These different sectors are of great importance as they are receiving more recent attention from international development agencies, such as the World Bank, in their efforts to promote economic growth and development in poor countries (Maruta et al., 2020). Of the 17 Sustainable Development Goals set by the United Nations in 2015, about 10 of them are related to these sectors. As a result, these sectors

Table 7
Heterogeneity effect according to the level of economic complexity.

	Low level of complexity		High level of complexity	
	System-GMM	IV-2SLS	System-GMM	IV-2SLS
	(1)	(2)	(3)	(4)
Lagged dependent variable	0.0651**		−0.3273***	
	(0.0312)		(0.0705)	
Foreign Aid	−0.0411***	−0.0108***	0.0221***	0.0272***
	(0.0084)	(0.0036)	(0.0030)	(0.0075)
Control variables	Yes	Yes	Yes	Yes
Constant	−0.2496**	−1.0436***	0.3095***	0.1618***
	(0.1027)	(0.0359)	(0.0481)	(0.0411)
Observations	437	1159	128	347
Number of countries	59	59	17	17
Number of instruments	42		17	
AR(1)	0.073		0.084	
AR(2)	0.213		0.121	
Hansen OIR	0.437		0.289	
R-squared		0.2440		0.0752
Kleibergen-PaapWald F-stat		1497.602		463.580
Kleibergen-Paap LM		118.600		13.701
Hansen J statistic		0.330		0.131

Table 8
Foreign aid and economic complexity (System GMM with foreign aid by sectors: 78 countries, 2002–2017).

	Dependent variable: ECI				
	(1)	(1)	(1)	(1)	(1)
Lagged ECI	0.5536***	0.9438***	0.6708***	0.7645***	0.6947***
	(0.0973)	(0.0145)	(0.0736)	(0.0540)	(0.0566)
Aid energy	0.0231*				
	(0.0138)				
Aid education		0.0138**			
		(0.0061)			
Aid health			−0.0183		
			(0.0133)		
Aid agriculture				−0.0495***	
				(0.0177)	
Aid humanitarian					−0.0145*
					(0.0085)
Control variables	Yes	Yes	Yes	Yes	Yes
Constant	−0.5726***	−0.1914***	−0.3215***	−0.1543	−0.2983***
	(0.1796)	(0.0340)	(0.0852)	(0.1327)	(0.0675)
Observations	738	896	885	964	938
Number of countries	75	71	71	71	73
Number of instruments	52	49	62	68	62
AR(1)	0.000	0.000	0.000	0.000	0.000
AR(2)	0.231	0.291	0.346	0.266	0.623
Hansen OIR	0.122	0.134	0.212	0.310	0.165

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.
Data on the different types of aid are available from 2002 in the OECD database.

account for the largest portion of the goals set by the international development communities.

The estimation results are summarized in Table 8. We find that energy and education aid improve economic complexity. These results can be justified because energy aid improves access to electricity, which in turn increases human capital and thus economic complexity. Similarly, aid to education, by directly improving the level of education of the populations of recipient countries, also promotes economic complexity. However, we find that humanitarian aid and agricultural aid reduce economic complexity. We justify these results because, despite their importance for the well-being of the recipient populations, these different types of aid have no real impact on the main factors of economic complexity, such as innovation and human capital.

5.4. Further analysis

5.4.1. Assessing the non linearity

We then try to go further by extending our specification with quadratic aid term to capture a possible nonlinear relationship between aid and economic complexity. The equation tested then takes the following form:

Table 9
Foreign aid and economic complexity (Non linearity with System GMM, IV-2SLS).

	Dependent variable: ECI			
	Two-step system GMM		IV-2SLS	
	(1)	(2)	(3)	(4)
Lagged ECI	0.9659***	0.9354***		
	(0.0391)	(0.0237)		
Foreign_Aid	−0.0192***	−0.0119**	−0.0689***	−0.0554***
	(0.0051)	(0.0054)	(0.0070)	(0.0086)
Foreign_Aid square	0.0005**	0.0003*	0.0013***	0.0015***
	(0.0002)	(0.0002)	(0.0002)	(0.0004)
Control variables	Yes	Yes	Yes	Yes
Constant	0.0346	−0.0620*	−0.3540***	−0.7912***
	(0.0272)	(0.0371)	(0.0230)	(0.0372)
Observations	1922	1399	1773	1514
R-squared			0.1452	0.3416
Number of countries	78	75	78	75
Number of instruments	27	56		
AR(1)	0.000	0.000		
AR(2)	0.507	0.134		
Hansen OIR	0.440	0.160		
Kleibergen-PaapWald F-stat			181.907	105.187
Kleibergen-Paap LM			65.315***	38.416***
Hansen J statistic			0.169	0.416
Thresholds	38.4	39.66	53	36.93

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

$$ECI_{i,t} = \alpha + \beta_1 ECI_{i,t-1} + \beta_2 Foreign\_Aid_{i,t} + \beta_3 Foreign\_Aid^2_{i,t} + \beta_4 X_{i,t} + \mu_i + \gamma_t + v_{i,t} \quad (12)$$

$Foreign\_Aid^2_{i,t}$ is the squared aid; β_3 included to account for the non-linearity of aid – ECI relationship.[14] The other factors remain unchanged.

The results of this exercise are reported In Table 9. The results of the GMM estimates (column (1) and (2)) show that the coefficient associated with aid is negative and statistically significant, confirming our previous results. The coefficient associated with aid squared is positive and highly significant, thus suggesting the non-linearity between foreign aid and economic complexity. The results in columns (3) to (4) show the 2SLS results respectively. These results confirm the U-shape relationship between official development assistance and economic complexity.

The results in Table 9 sufficiently show the existence of a threshold above which the effect of aid on economic complexity becomes positive. For example, in the case of GMMs (column (2)) this threshold is 39.66% of GNI, suggesting that when external aid exceeds this threshold, aid would start to improve economic complexity.[15] However, the question remains as to what factor militates in favor of this inverse effect of aid on complexity. Can a country with poor institutions and permanent political instability like Chad benefit from this positive effect of aid on complexity in this context? In this paper we try to answer this question by appealing to the quality of institutions and particularly the quality of democracy in the following subsection.

5.4.2. Does democracy matter?

The aim of this sub-section is to examine whether aid is effective in increasing economic complexity when the policy environment is better. Indeed, the negative effect of aid on economic complexity, suggested by the previous tables, can be explained by another type of non-linearity in the aid-complexity relationship: those related to the quality of the institutional functioning of recipient countries. Indeed, the distributive impact of foreign aid can be influenced by the capacity of institutions to: (i) ensure or not good public financial management; (ii) make elected officials accountable to the electorate. In this study, we focus on this second effect.

To assess how democracy affects the relationship between foreign aid and economic complexity, we consider the following model specification in Equation (13):

$$ECI_{i,t} = \alpha + \beta_1 ECI_{i,t-1} + \beta_2 Foreign\_Aid_{i,t} + \beta_3 Demo_{i,t} + \beta_4 (Foreign\_Aid_{i,t} \times Demo_{i,t}) + \beta_5 X_{i,t} + \mu_i + \gamma_t + v_{i,t} \quad (13)$$

Where $Demo_{i,t}$ represent democracy in countries i in time t. Following the approach adopted by Chauvet et al. (2018) and Bjornskov (2010), we create a "democracy" dummy variable defined as countries with the Polity IV democracy indicator above the median of our sample (4.8 on a scale of 0–10). We include the interaction term between foreign aid and democracy ($Foreign\_Aid_{i,t} \times Demo_{i,t}$). We are interested in β_3 and β_4, which provide information on the marginal effect of foreign aid on economic complexity acccording to the level of democracy. A positive coefficient on the interaction term would imply that democracy mitigates the negative effect of foreign aid on

[14] According to Islam (2005), nonlinearity can be attributed to inappropriate technology and absorptive capacity constraints.
[15] The attendant computation is in accordance with contemporary literature on quadratic regressions (Asongu and Odhiambo, 2020).

Table 10
Foreign aid, democracy and economic complexity (System GMM: 78 countries, 1990–2017).

	Dependent variable: ECI			
	(1)	(2)	(3)	(4)
Lagged ECI	0.7384***	0.5520***	0.8782***	0.9189***
	(0.0204)	(0.0266)	(0.0100)	(0.0096)
Foreign_Aid	−0.0146***	−0.0090***	−0.0097***	−0.0077***
	(0.0014)	(0.0018)	(0.0009)	(0.0012)
Democracy	0.0020	0.0127	0.0229***	0.0139
	(0.0281)	(0.0321)	(0.0087)	(0.0141)
Foreign_Aid × Democracy	0.0061***	0.0067***	0.0054***	0.0039**
	(0.0018)	(0.0024)	(0.0010)	(0.0018)
Financial development		0.0085***	−0.0001	0.0006***
		(0.0007)	(0.0003)	(0.0001)
Internet			0.0006***	0.0004***
			(0.0001)	(0.0001)
Remittances				0.0020**
				(0.0009)
Constant	−0.0996***	−0.4407***	−0.0584***	−0.0710***
	(0.0231)	(0.0338)	(0.0148)	(0.0154)
Observations	1836	1747	1530	1403
Number of countries	78	76	76	75
Number of instruments	51	51	55	59
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.683	0.540	0.269	0.154
Hansen OIR	0.747	0.303	0.484	0.503

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

economic complexity in developing countries. We expect the interaction between foreign aid and democracy to be positive. The results of this exercise are displayed in Table 10.

Consistent with our expectation, all the coefficients associated with the interaction term in Table 10 are positive and statistically significant at least at the 5% level. This result suggests that democracy mitigates the negative effect of foreign aid on economic complexity. More precisely, this result implies that, compared to democratic countries, non-democratic countries bear a lower level of economic complexity. Our results are in line with Burnside and Dollar (2000) who find that the effectiveness of aid flows in strengthening economic growth in the developing countries to be conditioned on the conduciveness of the policy environment. Collier et al. (2002) also empirically confirmed the effectiveness of aid in a good policy environment.

6. Conclusion

In line with recent studies on economic development, which viewed development and growth as a process of structural transformation of the productive structure, this research focuses on economic complexity. This indicator reflects the availability of productive capabilities that allow a country to produce more sophisticated products; and is seen as a strong predictor of comparative prosperity across countries. As stated by Zhu and Fu (2013), explorations into the determinants of economic sophistication are still insufficient, especially for developing countries, and need to be methodologically improved. Our study contributes to the literature by working to uncover relationship between foreign aid and economic complexity.

We adopt the panel data estimation procedure on a sample of 78 developing countries over the period 1990–2017. Specifically, we apply dynamic panel estimation techniques to investigate the foreign aid-economic complexity relationship. To address endogeneity concerns, we use the geographic and cultural distance variables in interaction with the total amounts of aid from the top five donor countries as instruments. We find that foreign aid affects negatively and significantly the complexity of products exported by the developing countries. We find that the effect of foreign aid on economic complexity is heterogeneous to the level of economic complexity and to the nature of aid received. More specifically, we show that while foreign aid reduces economic complexity in countries with lower economic complexity level, the effect is positive in countries with higher level of economic complexity. Additionally, we show that while foreign aid in energy and education sectors increase economic complexity, the effect is negative for agricultural and humanitarian aid. We also further find a U-shaped relationship between foreign aid and economic complexity. Finally, the empirical results of this paper show that democracy mitigates the negative effect of foreign aid on economic complexity. Our empirical results support Burnside and Dollar's (2000) findings that a good policy environment is important for aid to work effectively.

The empirical findings of this paper offer several implications for future studies. First, future studies examining the link between economic complexity and foreign aid should take into consideration the effect of policy environment. Given that the literature on economic complexity is relatively thin but growing quickly, this paper provides some suggestions about the choice of control variables for subsequent studies. Second, this study establishes a link between foreign aid and economic complexity across countries. However, there are significant variations in official development assistance and economic complexity across regions within a country. Subsequent studies, therefore, may focus on a single country to explore the link between foreign aid and the ECI. Finally, future researches can

further analyze the non-linear relationship between foreign aid and economic complexity using a more appropriate method such as Panel Smooth Transition Regression (PSTR).

Declaration of competing interest

We have no conflicts of interest to declare.

Acknowledgements

The authors would like to thank the two anonymous referees of the journal, Gilles Dufrénot (the associate editor) for their helpful comments and suggestions on the earlier version of this article. However, any remaining errors is solely attributable to the authors.

Appendix

Table A1
Assessing the consistency of SGMM estimators.

	Dependent variable: ECI		
	Fixed effect	GMM	OLS
Lagged ECI	0.7490***	0.9555***	0.9677***
Lagged ECI	0.7495***	0.8565***	0.9555***
Lagged ECI	0.7321***	0.7802***	0.9535***
Lagged ECI	0.7365***	0.7379***	0.9538***

Table A2
Variable's descriptions and data sources

Variables	Descriptions	Sources
ECI	The Economic Complexity Index.	OEC
Economic fitness	Country's diversification and ability to produce complex goods on a globally competitive basis	World Bank Catalog
ECI+	Improved economic complexity index	OEC
Foreign Aid	Net ODA provided, total (% of GNI)	WDI
Aid energy	Indicates the amount of aid capital provided to energy	OECD
Aid education	Indicates the amount of aid capital provided to education	OECD
Aid health	Indicates the amount of aid capital provided to health	OECD
Aid humanitarian	Indicates the amount of aid capital provided in the humanitarian	OECD
Aid agriculture	Indicates the amount of aid capital provided to agriculture	OECD
Financial development	Domestic credit to private sector (% of GDP)	WDI
Internet	Individuals using the Internet (% of population)	WDI
FDI	Foreign direct investment, net inflows (% of GDP)	WDI
Remittances	Personal remittances, received (% of GDP)	WDI
GFCF	Gross fixed capital formation (% of GDP)	WDI
Inflation	Inflation, consumer prices (annual %)	WDI
Population	Annual population growth rate for year t is the exponential rate of growth of midyear population	WDI
Government cons.	General government final consumption expenditure (% of GDP)	WDI
Democracy	The index of political democracy and autocracy	The Polity IV Project

Table A3
List of countries (78)

Afghanistan	Dominican Republic	Madagascar	South Africa
Algeria	Ecuador	Malaysia	Sri Lanka
Angola	Egypt, Arab Rep,	Mauritania	Sudan
Argentina	El Salvador	Mexico	Syrian Arab Republic
Azerbaijan	Ethiopia	Moldova	Tanzania
Bangladesh	Gabon	Mongolia	Thailand
Belarus	Georgia	Morocco	Togo
Belize	Ghana	Mozambique	Trinidad and Tobago
Bolivia	Guatemala	Namibia	Tunisia
Bosnia and Herzegovina	Guinea	Nicaragua	Turkey
Botswana	Haiti	Nigeria	Turkmenistan
Brazil	India	Oman	Uruguay
Cambodia	Indonesia	Pakistan	Uzbekistan
Cameroon	Iran, Islamic Rep,	Panama	Venezuela, RB
Chile	Jamaica	Paraguay	Vietnam
Colombia	Jordan	Peru	Yemen, Rep,
Congo, Dem, Rep,	Kazakhstan	Philippines	Zambia
Congo, Rep,	Kenya	Saudi Arabia	Zimbabwe
Costa Rica	Lao PDR	Senegal	
Cote d'Ivoire	Lebanon	Serbia	

References

Addison, T., Tarp, F., 2015. Aid policy and the macroeconomic management of aid. World Dev. 69, 1–5.
Albeaik, S., Kaltenberg, M., Alsaleh, M., Hidalgo, C.A., 2017a. New Measures of Economic Complexity (Addendum to Improving the Economic Complexity Index) arXiv preprint arXiv:1708.04107.
Albeaik, S., Kaltenberg, M., Alsaleh, M., Hidalgo, C.A., 2017b. Improving the Economic Complexity Index arXiv preprint arXiv:1707.05826.
Alesina, A., Dollar, D., 2000. Who gives foreign aid to whom and why? J. Econ. Growth 5 (1), 33–63.
Alvi, E., Senbeta, A., 2012. Does foreign aid reduce poverty? J. Int. Dev. 24 (8), 955–976.
Antonietti, R., Franco, C., 2021. From FDI to economic complexity: a panel Granger causality analysis. Struct. Change Econ. Dynam. 56, 225–239.
Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev. Econ. Stud. 58 (2), 277–297.
Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error components models. J. Econom. 68 (1), 29–51.
Arndt, C., Jones, S., Tarp, F., 2015. What is the aggregate economic rate of return to foreign aid? World Bank Econ. Rev. 30 (3), 446–474.
Asongu, S., 2012. On the effect of foreign aid on corruption. Econ. Bull. 32 (3), 2174–2180.
Asongu, S.A., Odhiambo, N.M., 2020. Insurance policy thresholds for economic growth in Africa. Eur. J. Dev. Res. 32 (3), 672–689.
Avom, D., Kamguia, B., Njangang, H., 2021a. Understand Growth Episodes in Sub-saharan Africa: Do Exogenous Shocks Matters? The Journal of International Trade & Economic Development, pp. 1–29.
Azam, J.P., Thelen, V., 2008. The roles of foreign aid and education in the war on terror. Publ. Choice 135 (3–4), 375–397.
Azarnert, L.V., 2008. Foreign aid, fertility and human capital accumulation. Economica 75 (300), 766–781.
Avom, D., Kamguia, B., Ngameni, J.P., 2021b. Does volatility hinder economic complexity? Econ. Bull. 41 (3), 1187–1202.
Bahar, D., Rapoport, H., Turati, R., 2020. Birthplace Diversity and Economic Complexity: Cross-Country Evidence. Research Policy, p. 103991.
Banerjee, R., Mishra, V., Maruta, A.A., 2021. Energy poverty, health and education outcomes: evidence from the developing world. Energy Econ. 101, 105447.
Baum, C.F., Schaffer, M.E., Stillman, S., 2007b. ivreg2: Stata Module for Extended Instrumental variables/2SLS, GMM and AC/HAC, LIML and K-Class Regression. http://ideas.repec.org/c/boc/bocode/s425401.html.
Baum, C.F., Schaffer, M.E., Stillman, S., 2007a. Enhanced routines for instrumental variables/generalized method of moment's estimation and testing. State J. 7 (4), 465–506.
Bjornskov, C., 2010. Do elites benefit from democracy and foreign aid in developing countries? J. Dev. Econ. 92, 115–124.
Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. J. Econom. 87 (1), 115–143.
Bond, S., Bowsher, C., Windmeijer, F., 2001. Criterion-based inference for GMM in autoregressive panel data models. Econ. Lett. 73 (3), 379–388.
Boone, P., 1996. Politics and the effectiveness of foreign aid. Eur. Econ. Rev. 40 (2), 289–329.
Brückner, M., 2013. On the simultaneity problem in the aid and growth debate. J. Appl. Econom. 28 (1), 126–150.
Burnside, C., Dollar, D., 2000. Aid, policies, and growth. Am. Econ. Rev. 90 (4), 847–868.
Busse, M., Gröning, S., 2009. Does foreign aid improve governance? Econ. Lett. 104 (2), 76–78.
Camanho, N., Romeu, R., 2011. Did export diversification soften the impact of the global financial crisis? IMF working papers 1–23.
Canh, N.P., Schinckus, C., Thanh, S.D., 2020. The natural resources rents: is economic complexity a solution for resource curse? Resour. Pol. 69, 101800.
Chauvet, L., Mesplé-Somps, S., 2007. Impact des financements internationaux sur les inégalités des pays en développement. Rev. Econ. Paris 58 (3), 735–744.
Chauvet, L., Ferry, M., Guillaumont, P., Jeanneney, S.G., Tapsoba, S.J.A., Wagner, L., 2018. Volatility widens inequality. Could aid and remittances help? Rev. World Econ. 155 (1), 71–104.
Chong, A., Gradstein, M., Calderon, C., 2009. Can foreign aid reduce income inequality and poverty? Publ. Choice 140 (1), 59–84.
Chu, L.K., 2020. The effects of financial development on economic sophistication: evidence from panel data. Appl. Econ. Lett. 27 (15), 1260–1263.
Clemens, M.A., Radelet, S., Bhavnani, R.R., 2012. Counting Chickens when They Hatch: the Short Term Effect of Aid on Growth. Center for Global Development working paper, 44.
Collier, P., Dollar, D., 2002. Aid allocation and poverty reduction. Eur. Econ. Rev. 46 (8), 1475–1500.
Collier, P., Hoeffler, A., Collier, P., 2002. Aid, Policy, and Growth in Post-conflict Societies. The World Bank.
Cuberes, D., Jerzmanowski, M., 2009. Democracy, diversification and growth reversals. Econ. J. 119 (540), 1270–1302.
Dalgaard, C.J., Hansen, H., 2001. On aid, growth and good policies. J. Dev. Stud. 37 (6), 17–41.
Dalgaard, C.J., Hansen, H., Tarp, F., 2004. On the empirics of foreign aid and growth. Econ. J. 114 (496), F191–F216.
Deaton, A., 2013. The Great Escape: Health, Wealth, and the Origins of Inequality. Princeton University Press.
Dieleman, J.L., Graves, C.M., Hanlon, M., 2013. The fungibility of health aid: reconsidering the reconsidered. J. Dev. Stud. 49 (12), 1755–1762.
Djankov, S., Montalvo, J.G., Reynal-Querol, M., 2008. The curse of aid. J. Econ. Growth 13 (3), 169–194.
Dreher, A., Nunnenkamp, P., Thiele, R., 2008. Does US aid buy UN general assembly votes? A disaggregated analysis. Publ. Choice 136 (1), 139–164.

Easterly, W., 2003. Can foreign aid buy growth? J. Econ. Perspect. 17 (3), 23–48.
Farhadi, M., Islam, M.R., Moslehi, S., 2015. Economic freedom and productivity growth in resource-rich economies. World Dev. 72, 109–126.
Gala, P., Camargo, J., Magacho, G., Rocha, I., 2018. Sophisticated jobs matter for economic complexity: an empirical analysis based on input-output matrices and employment data. Struct. Change Econ. Dynam. 45, 1–8.
Galiani, S., Knack, S., Xu, L.C., Zou, B., 2017. The effect of aid on growth: evidence from a quasi-experiment. J. Econ. Growth 22 (1), 1–33.
Gong, L., Zou, H.F., 2001. Foreign aid reduces labor supply and capital accumulation. Rev. Dev. Econ. 5 (1), 105–118.
Hansen, H., Tarp, F., 2000. Aid effectiveness disputed. J. Int. Dev. 12 (3), 375–398.
Harding, T., Javorcik, B.S., 2011. Foreign direct investment and export upgrading. Rev. Econ. Stat. 94 (4), 964–980.
Hartmann, D., Guevara, M.R., Jara-Figueroa, C., Aristarán, M., Hidalgo, C.A., 2017. Linking economic complexity, institutions, and income inequality. World Dev. 93, 75–93.
Hauk, W.R., Wacziarg, R., 2009. A Monte Carlo study of growth regressions. J. Econ. Growth 14 (2), 103–147.
Hausmann, R., Hidalgo, C.A., Bustos, S., Coscia, M., Simoes, A., 2011. The Atlas of Economic Complexity: Mapping Paths to Prosperity. Center for International Development/MIT Media Lab, Cambridge, MA.
Hausmann, R., Hidalgo, C.A., Bustos, S., Coscia, M., Simoes, A., 2014. The Atlas of Economic Complexity: Mapping Paths to Prosperity. Mit Press.
Hausmann, R., Hwang, J., Rodrik, D., 2007. What you export matters. J. Econ. Growth 12 (1), 1–25.
Henn, C., Papageorgiou, C., Romero, J.M., Spatafora, N., 2017. Export Quality in Advanced and Developing Economies: Evidence from a New Data Set. The World Bank.
Hidalgo, C.A., Hausmann, R., 2009. The building blocks of economic complexity. Proc. Natl. Acad. Sci. Unit. States Am. 106 (26), 10570–10575.
Hsu, P.H., Tian, X., Xu, Y., 2014. Financial development and innovation: cross-country evidence. J. Financ. Econ. 112 (1), 116–135.
Islam, M.N., 2005. Regime changes, economic policies and the effect of aid on growth. J. Dev. Stud. 41 (8), 1467–1492.
Kannen, P., 2020. Does foreign direct investment expand the capability set in the host economy? A sectoral analysis. World Econ. 43 (2), 428–457.
Keneck-Massil, J., Nvuh-Njoya, Y., 2021. Did colonisation matter for comparative economic complexity? Econ. Lett. 203, 109851.
Khan, H., Khan, U., Khan, M.A., 2020. Causal nexus between economic complexity and FDI: empirical evidence from time series analysis. Chin. Econ. 53 (5), 374–394.
Kleibergen, F., Paap, R., 2006. Generalized reduced rank tests using the singular value decomposition. J. Econom. 133 (1), 97–126.
Knack, S., 2001. Aid dependence and the quality of governance: cross-country empirical tests. South. Econ. J. 310–329.
Knack, S., 2009. Sovereign rents and quality of tax policy and administration. J. Comp. Econ. 37 (3), 359–371.
Kolstad, I., Wiig, A., 2014. Diversification and democracy. Int. Polit. Sci. Rev. 39 (4), 551–569.
Koren, M., Tenreyro, S., 2007. Volatility and development. Q. J. Econ. 122 (1), 243–287.
Lapatinas, A., 2019. The effect of the Internet on economic sophistication: an empirical analysis. Econ. Lett. 174, 35–38.
Lapatinas, A., Litina, A., 2019. Intelligence and economic sophistication. Empir. Econ. 57 (5), 1731–1750.
Lectard, P., Rougier, E., 2018. Can Developing Countries Gain from Defying Comparative Advantage? Distance to Comparative Advantage, Export Diversification and Sophistication, and the Dynamics of Specialization, vol. 102. World Development, pp. 90–110.
Maggioni, D., Turco, A.L., Gallegati, M., 2016. Does product complexity matter for firms' output volatility? J. Dev. Econ. 121, 94–109.
Maruta, A.A., Banerjee, R., Cavoli, T., 2020. Foreign aid, institutional quality and economic growth: evidence from the developing world. Econ. Modell. 89, 444–463.
Mary, S., Shaw, K., Colen, L., y Paloma, S.G., 2020. Does agricultural aid reduce child stunting? World Dev. 130, 104951.
Morrissey, O., 2015. Aid and Fiscal Behaviour: what Does the Evidence Show?, vol. 69. World Development.
Moss, T.J., Pettersson Gelander, G., Van de Walle, N., 2006. An Aid-Institutions Paradox? A Review Essay on Aid Dependency and State Building in Sub-saharan Africa. Center for Global Development working paper (74), 11-05.
Moyo, D., 2009. Dead Aid: Why Aid Is Not Working and How There Is a Better Way for Africa. Macmillan.
Mukherjee, D., Kizhakethalackal, E.T., 2013. Empirics of health-aid, education and infant mortality: a semiparametric study. Appl. Econ. 45 (22), 3137–3150.
Nguyen, C.P., Su, T.D., 2021. Export Quality Dynamics: Multidimensional Evidence of Financial Development. The World Economy. https://doi.org/10.1111/twec.13103.
Nguyen, C.P., Schinckus, C., Su, T.D., 2020. The drivers of economic complexity: international evidence from financial development and patents. International Economics 164, 140–150.
Nickell, S., 1981. Biases in dynamic models with fixed effects. *Econometrica: Journal of the* Econometric Society 1417–1426.
Njangang, H., Asongu, S., Tadadjeu, S., Nounamo, Y., 2021. Is Financial Development Shaping or Shaking Economic Sophistication in African Countries? European Xtramile Centre of African Studies WP/21/018.
Nunn, N., Qian, N., 2014. US food aid and civil conflict. Am. Econ. Rev. 104 (6), 1630–1666.
Ocampo, J.A., Ros, J. (Eds.), 2011. The Oxford Handbook of Latin American Economics. Oxford University Press.
Ouattara, B., 2006. Foreign aid and government fiscal behaviour in developing countries: panel data evidence. Econ. Modell. 23 (3), 506–514.
Raffer, K., Singer, H.W., 2001. The Economic North-South Divide: Six Decades of Unequal Development. Edward Elgar Publishing.
Rajan, R., Subramanian, A., 2007. Does aid affect governance? Am. Econ. Rev. 97 (2), 322–327.
Riddell, A., Niño-Zarazúa, M., 2016. The effectiveness of foreign aid to education: what can be learned? Int. J. Educ. Dev. 48, 23–36.
Roodman, D., 2009. A note on the theme of too many instruments. Oxf. Bull. Econ. Stat. 71 (1), 135–158.
Saadi, M., 2020. Remittance inflows and export complexity: new evidence from developing and emerging countries. J. Dev. Stud. 56 (12), 2266–2292.
Sanderson, E., Windmeijer, F., 2016. A weak instrument F-test in linear IV models with multiple endogenous variables. J. Econom. 190 (2), 212–221.
Siba, E.G., 2008. Determinants of Institutional Quality in Sub-saharan African Countries. Working Paper in Economics No 310. Gothenburg University, Sweden. https://gupea.ub.gu.se/bitstream/2077/10382/1/gunwpe0310.pdf.
Spatafora, M.N., Anand, R., Mishra, M.S., 2012. *Structural Transformation and the Sophistication of Production* (No. 12-59). International Monetary Fund.
Svensson, J., 1999. Aid, growth and democracy. Econ. Polit. 11 (3), 275–297.
Sweet, C.M., Maggio, D.S.E., 2015. Do stronger intellectual property rights increase innovation? World Dev. 66, 665–677.
Sweet, C., Eterovic, D., 2019. Do Patent Rights Matter? 40 Years of Innovation, Complexity and Productivity, vol. 115. World Development, pp. 78–93.
Tacchella, A., Cristelli, M., Caldarelli, G., Gabrielli, A., Pietronero, L., 2012. A new metrics for countries' fitness and products' complexity. Sci. Rep. 2, 723.
Tacchella, A., Cristelli, M., Caldarelli, G., Gabrielli, A., Pietronero, L., 2013. Economic complexity: conceptual grounding of a new metrics for global competitiveness. J. Econ. Dynam. Control 37 (8), 1683–1691.
Tavares, J., 2003. Does foreign aid corrupt? Econ. Lett. 79 (1), 99–106.
Temple, J., Van de Sijpe, N., 2014. Foreign aid and domestic absorption. J. Int. Econ. 108, 431–443.
United Nations, 2016. The Millennium Development Goals Report 2015. New York, USA. 2015.
Valette, J., 2018. Do migrants transfer productive knowledge back to their origin countries? J. Dev. Stud. 54 (9), 1637–1656.
Van de Sijpe, N., 2013. Is Foreign Aid Fungible? Evidence from the Education and Health Sectors. The World Bank.
Vu, T., 2019. Does Institutional Quality Foster Economic Complexity? https://doi.org/10.2139/ssrn.3509939 Available at SSRN 3509939.
Windmeijer, F., 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. J. Econom. 126 (1), 25–51.
World Bank, 2021. World Development Indicators. Available at. https://databank.worldbank.org/source/world-development-indicators.
Zhu, S., Fu, X., 2013. Drivers of Export Upgrading, vol. 51. World Development, pp. 221–233.
Zhu, S., Li, R., 2017. Economic complexity, human capital and economic growth: empirical research based on cross-country panel data. Appl. Econ. 49 (38), 3815–3828.