SCHOOL OF ECONOMICS AND MANAGEMENT

Master's Programme in Economic Development

# Linking Foreign Aid, Economic Growth and Economic Complexity

By

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**Abstract:** This thesis documents how foreign aid is associated with economic growth and brings a novel perspective by examining how the association depends on economic complexity. By linking the deviations between income and complexity that predict future growth to different relative stocks of knowhow, embodied and codified knowledge between countries, I argue that foreign aid needs to be tailored to variations in contexts of productive knowledge. Foreign aid is studied at the bilateral, modality and sectoral levels through multiple linear regression analysis, using a sample of 27 Sub-Saharan African countries between 2002-2021. The main findings are 1) that the negative association of aid for knowhow, through education, is mitigated in countries where knowhow is scarce and 2) that the positive association of aid for embodied and codified knowledge, through energy, is amplified in countries where such knowledge is scarce. In this way, adding another dimension to which aid needs to be tailored to be effective.

***Keywords***: *Economic Complexity, Foreign Aid, Economic Growth, Productive Knowledge, Aid Effectiveness, Bilateral, Technical Cooperation, Education, Energy, Knowhow*

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# 1 Introduction

How foreign aid affects economic growth may be one of the most contested topics in the development literature. At the pinnacle of the "great aid debate" (Gulrajani, 2011, p. 199), optimists argued for increased foreign aid supply (e.g. Sachs et al., 2004; Burnside & Dollar, 2000; Boone, 1996; Arndt et al., 2015) while pessimists held that the supply does not meet the demand and have generally failed to foster economic growth (e.g. Easterly et al., 2004; Easterly, 2007; Doucouliagos & Paldam, 2009; Hansen & Tarp, 2000; Moyo, 2009, pp. 144-145). In reality, picking sides is complicated. Types of foreign are highly heterogenous and their impact depends on the extent that it is tailored to the context of the recipient in different ways (Qian, 2014; Ramalingam, 2013, pp.360-363; Banerjee & Duflo, 2011, pp. 267-273; Bourguignon & Sundberg, 2007).

Previous studies have examined how the association between foreign aid and economic growth depends on, for example, the policy environment (Burnside & Dollar, 2000; Tang & Bundhoo, 2017), corruption (Svensson, 2000; Moyo, 2009, pp. 49-57) and human capital (Fashina et al., 2018; Nwani, 2021). This thesis brings a novel perspective by documenting how the association depends on countries' levels of economic complexity relative to income, and how this interacts with different types of aid. In this way, elucidating potential heterogeneities between aid types and adding a new dimension of context dependency to which aid may need to be tailored to. At the same time, by focusing on the interaction between aid types and countries' levels of economic complexity relative to income, the study contributes to a scarce literature on how foreign aid is associated with economic complexity (Kamguia et al., 2022; Arpaci-Ayhan, 2022; Gnangnon, 2021, 2024).

Linking aid, growth and complexity is important for two main reasons. First, it can potentially assist in improving aid effectiveness by adding a novel perspective to how donors may need to tailor foreign aid to the recipient context. Second, it is widely recognized that the extent that economic growth is associated with poverty reduction depends on its level of inclusion (e.g. Saad-Filho, 2010; Ngepah, 2017). Hartmann et al. (2017) shows that economies

that grow by becoming more complex tend to have a greater level of inclusion, compared to economies that grow through simpler products, e.g. natural resources. Studying how foreign aid is associated with economic growth from the lens of economic complexity, and depending on their level of economic complexity relative to income, is therefore an important enquiry both for aid effectiveness and potential poverty reduction.

To link aid, growth and complexity, the thesis primarily draws on theory of economic complexity, which suggests that countries grow by producing increasingly sophisticated and diverse products (Hidalgo et al., 2007; Hausmann et al., 2014, p.27). However, the relationship between growth and complexity is imperfect, where deviations have been shown to predict future economic growth (Hidalgo & Hausmann, 2009). Underpinning economic complexity are the three types of productive knowledge, knowhow, embodied and codified, which are complementary in production (Balland et al., 2022). The thesis argues that the deviations can be linked with different relative stocks of these three types of knowledge between countries. This argument draws on the nature of the types of knowledge, where accumulating knowhow is difficult and takes a long time, whereas embodied and codified knowledge can be purchased and easily be transferred (Balland et al., 2022). In two countries with the same productive knowledge, the one with the higher income can therefore be expected to have a greater proportion of embodied and codified knowledge compared to the other. This will be developed further in the literature review and theoretical framework. Following the nature of the types of productive knowledge, aid is thus separated into playing two different roles: increase knowhow or increase embodied and codified knowledge.

To understand how the association between foreign aid and growth varies between types of aid, the thesis investigated foreign aid at three levels. Further, since studies of how aid affects growth have been criticized for poor measurement (Qian, 2014), this disaggregation also helps elucidate potential measurement problems, both in the present study and previous literature. The first level is bilateral aid, encompassing any foreign aid flowing from one country to another. The second is the modality of aid, following Arpaci-Ayhan (2022) who divides bilateral aid into technical cooperation (TC) and non-technical coopertation (non-TC). The third level is the sectoral destination of aid, where the study focuses on education and energy in line with Kamguia et al. (2022). Considering TC and education as links to knowhow, and non-TC and energy as links to embodied and codified knowledge, the thesis aims to elucidate the association between aid and growth depending on both aid type and countries productive

knowledge relative to income (PKI). The research questions that the thesis aims to answer are therefore as follows:

***RQ1:*** *How is foreign aid associated with economic growth?*
***RQ2****: How does the association between foreign aid and economic growth depend on the context of productive knowledge relative to income?*

To answer the research questions, the thesis employs a multiple linear regression analysis using a sample of 27 countries in Sub-Saharan Africa (see Appendix A) between 2002-2021. Which countries in Sub-Saharan Africa that are included is decided by the available data. By using econometrics with a large sample size, the thesis follows the previous aid-complexity literature, whose samples covers multiple regions, ranging from 78 to 126 countries over 15 to 27 years (Kamguia et al., 2022; Arpaci-Ayhan, 2022; Gnangnon, 2021, 2024). Further, a large sample covering countries with both high and low productive knowledge relative to income is elemental to study how the association of foreign aid depends on the context of PKI, and hence answer RQ2. As will be shown in the chapter on data, this is the case for the 27 countries, where approximately a third have a low PKI and two thirds have a high PKI. Furthermore, in contrast to the previous literature, this study chooses to focus on a single region because knowledge tends to diffuse regionally, where increased complexity of neighboring countries tends to have a considerable influence on complexity in the home country (Bahar et al., 2014). What is more, focusing on Sub-Saharan Africa is also especially relevant for real-world reasons. The region receives the world's most bilateral aid by almost a two-fold margin compared to other regions (OECD, 2023). At the same time, a majority of the world's poorest countries are located in the region, in terms of GDP per capita (World Bank, 2024).

## 1.1 Outline of the Thesis

The thesis is divided into seven chapters. The following chapter reviews the literature that is relevant to the nexus of foreign aid, economic growth and economic complexity. Drawing on the literature review and research gap identified, the third chapter develops a theoretical framework. This chapter explicates the theoretical links between aid, growth and complexity, formulates the hypotheses and motivates the control variables.

The fourth chapter describes the data that is used in the empirical analysis. The chapter starts by outlining the source material that is used, describes the data in quantitative terms and discusses its quality with a focus on the context of productive knowledge relative to income and the foreign aid variables. The fifth chapter, method, motivates the use of multiple linear regression analysis, describes how the data is used by outlining the procedures of the empirical analysis and discusses the limitations of the chosen method.

The sixth chapter is the empirical analysis, which begins by testing the robustness of the baseline models. The models were then altered to mitigate the weaknesses that were found, and employed in multiple linear regression analysis. The results section was divided into three subsections, one for each level of foreign aid, with respective regressions. The results were then discussed and related to the literature. Lastly, the thesis concludes by answering the research questions, implications for aid effectiveness and possible areas for future research.

# 2 Literature Review

This chapter will review the literature relevant to the nexus of foreign aid, economic growth and economic complexity. The chapter is divided into two sections. The first section discusses the theoretical underpinnings of economic complexity and the implications of the types of productive knowledge. The second section links aid, growth and complexity, starting by focusing on aid types and then connecting it with the role of context.

## 2.1 Growth and Complexity

### 2.1.1 Theoretical Foundations

Hausmann et al. (2014) situates economic complexity within the economic literature: "One way of describing the economic world is to say that the things we make require machines, raw materials and labor. Another way is to emphasize that products are made with knowledge." (p.13). Neoclassical economic growth theories highlight factor endowments, where the availability and combination of land, labour and capital determines economic growth based on relative costs (e.g. Solow, 1957; Arrow et al., 1961). Other theories underscore countries' institutional arrangements as the main explanation for economic growth in the long run (e.g. Acemoglu et al., 2004; North, 1991). Economic complexity supplements these theories by postulating that countries grow by becoming more complex (Hidalgo et al., 2007), which occurs through the accumulation and diffusion of productive knowledge (Hausmann et al., 2014, pp. 27-30). As countries accumulate more productive knowledge, they are able to diffuse it by producing more sophisticated and diverse products, which implies that economic complexity increases (Hidalgo et al., 2007). However, the notion that increased diversification of production is associated with development is not new (see e.g. Kuznets, 1973). The main novelty that economic complexity scholars generally claim is the ability to measure how diverse and sophisticated products that countries are able to produce, which is revealed by the economic complexity index (ECI) (Hidalgo & Hausmann, 2009; Hidalgo et al., 2007).

Underpinning economic complexity theory and its measurement is the principle that the more specialized each individual in a society is, the more diverse and sophisticated products it will be able to produce (Hausmann et al., 2014, p.15, p.20). Since each individual is limited in how much productive knowledge it can possess and employ due to natural constraints such as time and cognition, the interaction of diversely specialized individuals is what makes a society economically complex (Hausmann et al., 2014, pp. 17-18; Balland et al., 2022). This has famously been explained with analogies to the games of Lego (Hidalgo & Hausmann, 2009) and scrabble (Hausmann et al., 2014, p.20). In terms of scrabble, Hausmann et al. (2014, p.20) explains that the more letters (knowledge) a player (economy) possess, the more diverse and sophisticated words (products) it will be able to formulate (produce). Hidalgo & Hausmann (2009) shows that the products that countries export are highly representative of what they produce. In turn, reflecting the productive knowledge that they have (Hidalgo & Hausmann, 2009). Therefore, trade data is used to create the ECI (Hidalgo & Hausmann, 2009). Hausmann et al. (2014) explains that the ECI measures diversity by "the number of products that a country exports" (p.21) and sophistication by "the number of countries that export a product" (p.21).

### 2.1.2 Types of Productive Knowledge

For a country to move from low to high economic complexity, the type of productive knowledge that it accumulates and diffuses is central. Balland et al. (2022) explains that there are three types of productive knowledge. First, embodied knowledge denotes the material embodiment of knowledge in the form of tools, such as a machine or infrastructure, which can easily be transferred between countries, e.g. by ship or plane (Balland et al., 2022). Formally, embodied knowledge is what the economic complexity index captures through countries' exports (Hidalgo & Hausmann, 2009). Second, codified knowledge can easily be transferred and takes the form of e.g. blueprints or manuals of e.g. technologies (Hausmann et al. 2014, p.16; Balland et al., 2022). Third, knowhow exclusively resides in brains and denotes the knowledge about how to productively use embodied and codified knowledge (Balland et al., 2022). For example, a firm can import a machine with a manual, but to productively use the machine it needs workers that have knowhow of how to productively operate the machine and follow the manual (Balland et al., 2022; Hausmann et al., 2014, p.17). Knowhow, embodied and codified knowledge thus complement each other (Balland et al. 2022).

The types of knowledge have important economic implications in poorer countries. Gerschenkron (1962) argues that poorer countries have the advantage of being able to adopt lessons and technologies from richer countries, which enables poorer countries to grow faster and converge with richer countries over time. The nature of the types of productive knowledge complements Gerschenkron's (1962) argument. In essence, foreign technologies, again for example a machine or manual, is embodied and codified knowledge and thus requires knowhow to be productively used (Balland et al., 2022; Hausmann et al., 2014, p.17). In this way, the extent that foreign technologies can be diffused, and hence impact economic growth, depends on the knowhow in the importing country (Balland et al., 2022; Hausmann et al., 2014, p.17). This can be resembled with the notion that the degree that technology can be transmitted through FDI depends on the level of human capital in the country receiving the investments (e.g. Borensztein et al., 1998; Li & Liu, 2005).

Furthermore, the types of knowledge are related to the ability of economic complexity to predict economic growth. Hidalgo & Hausmann (2009) shows that economic complexity is significantly correlated with income and that "deviations from this relationship are predicative of future growth" (p. 10570). Countries that have high productive knowledge relative to income (high PKI) are predicted to grow fast, while countries with low productive knowledge relative to income (low PKI) are predicted to grow slowly (Hidalgo & Hausmann, 2009). This can be explained with conventional trade theory. In the Hecksher-Ohlin model, the relative costs of the factors of production between countries determine their comparative advantages (Leamer, 1995). From the view of economic complexity, the factors of production can be replaced with the types of knowledge (Hausmann et al., 2014, pp. 27-30; Balland et al., 2022). For example, if countries A and B are equally complex, but A has a lower income, then A has a comparative advantage against B because the relative cost of the same productive knowledge is cheaper in A (Hausmann et al., 2014, pp. 27-30). Simply put, A is able to produce the same products as B for a lower price (Hausmann et al., 2014, pp. 27-30).

However, the nature of the types of productive knowledge (Balland et al., 2022) arguably implies that the proportions of the stocks of three types will vary between countries depending on their level of income. Considering that embodied and codified knowledge can be purchased and easily transferred (Balland et al., 2022) one would expect these types of knowledge to represent a greater proportion of the total productive knowledge of country B (low PKI). In other words, although A and B have the same total level of productive knowledge, one would

expect the higher income of B to enable it to e.g. import technologies, infrastructure or other embodied and codified knowledge that could complement its knowhow. That is, to a greater extent than country A that is poorer. In turn, this implies that knowhow can be expected to represent a greater proportion of the total productive knowledge of country A, since it is less able to purchase codified and embodied knowledge than B.

Furthermore, the notion of relative stocks of the types of productive knowledge between countries depending on their income level follows the nature of how knowhow accumulates in a country. Again, whereas embodied and codified knowledge easily can be transferred, the process of accumulating knowhow is highly path dependent, implying that the knowhow that a country has had in the past affects how knowhow can be accumulated in the present (Hausmann et al., 2014, p.8; Balland et al., 2022). The reason for this is found in the product space, where countries tend to gradually and slowly move towards products that require similar knowhow as they already have (Hausmann et al., 2014, p.8, Hidalgo et al., 2009). In essence, this is because advancing towards products requiring similar knowhow is more feasible than products requiring markedly more diverse and sophisticated knowhow (Hidalgo, 2023). Underlying this slow process is the nature of knowhow itself, which exclusively exists in brains and "moves with enormous difficulty from brain to brain because it is unconscious and does not involve understanding" (Balland et al., 2022, p. 2). This implies that although country B can purchase more embodied and codified knowledge as a result of its relative wealth compared to A, it cannot simply purchase knowhow. Instead, knowhow tends to accumulate between countries through the movement of the people who carries the knowhow (Balland et al., 2022), which is why the diffusion of knowhow tends to be highly regionally concentrated (Bahar et al., 2014). In fact, the knowhow of a country's neighbours tends to considerably affect the knowhow in the home country (Bahar et al., 2014).

However, while knowhow itself cannot be purchased as easily as embodied and codified knowledge (Balland et al., 2022), countries can invest in human capital through education. Zhu & Li (2017) links education with economic complexity, arguing that it enables countries to accumulate knowhow more rapidly, since higher human capital is associated with a faster ability to learn. Hausmann et al. (2014, p. 36-38) agrees that education is a precondition for becoming more complex, but that education as a concept and measurement has a weaker link to knowhow than productive knowledge. They explain that the knowledge acquired through education does not necessarily render productive knowhow, particularly diverse and

sophisticated knowhow. Instead, while education provides the fundamentals for individuals to acquire knowhow, it primarily tends to become diverse and sophisticated on the labour market (Hausmann et al., 2014, p.36-38). Thus, while country B, representing a low PKI, can use its relatively high income compared country A, representing a high PKI, to invest in education, it does not translate into higher knowhow by default.

Returning to Gerschenkron's (1962) argument and the ability of economic complexity to predict growth based on countries' productive knowledge relative to income (Hidalgo & Hausmann, 2009), the notion of different relative stocks of the types of knowledge aligns well. Since countries with a low PKI, i.e. country A, is argued to have a higher proportion of knowhow relative to embodied and codified knowledge, this suggests that it can diffuse foreign technology more easily (Balland et al., 2022) and grow faster through the latecomer advantage (Gerschenkron, 1962). In turn, also aligning with the theory of economic complexity, which suggests that countries with a high PKI will grow faster due to its comparative advantage in the cost of its productive knowledge (Hausmann et al., 2014, pp.27-30).

## 2.2 Linking Aid, Growth and Complexity

The notion that countries may have different relative stocks of knowhow, codified and embodied knowledge, depending on their levels of productive knowledge relative to income, may have implications for how foreign aid is associated with economic growth. As countries grow by becoming more complex (Hidalgo et al., 2009), this section will concentrate on the relatively scarce literature of how foreign aid is associated with economic complexity in light of the more abundant aid-growth literature.

### 2.2.1 Types of Aid

Foreign aid has been linked with economic growth in various ways. In the "great aid debate" (Gulrajani, 2011, p. 199), there has been a tendency to view foreign aid in a simplified way, usually in terms of official development assistance (ODA) (Qian, 2014; Bourguignon & Sundberg, 2007). For example, Sachs et al. (2004) examine foreign aid at the level of ODA and argues that aid supply needs to increase to enable poor countries to overcome poverty traps,

which they argue impedes poor countries from saving and making the investment needed to grow. However, the components of overall foreign aid, as measured by ODA, are highly heterogenous and differs considerably in terms of their potential linkages to economic growth (Qian, 2014; Bourguignon & Sundberg, 2007). Conceiving and measuring foreign aid as one homogenous variable can thus be deceptive, since it contains subcategories that vary in terms of their relevance to growth (Qian, 2014).

Generalization of foreign aid as one homogenous variable is also evident in the literature on foreign aid and economic complexity. Kamguia et al. (2022) finds that overall foreign aid has a negative effect, while Arpaci-Ayhan (2022) suggests that it has a positive impact. However, there is a need to understand their results by aid type in order to link aid to different types of productive knowledge. Arpaci-Ayhan (2022) divides foreign aid into technical cooperation (TC) and non-technical cooperation (non-TC), which are two modalities of bilateral foreign aid. In the data that he uses from the OECD (n.d.a), this refers to the activities through which foreign aid is provided, as opposed to its sectoral destination, e.g. to education or energy. Arpaci-Ayhan's (2022) division follows Sawada et al. (2012) who finds that TC positively affects the transfer and diffusion of technology between countries. Arpaci-Ayhan (2022) argues that foreign aid through TC can be linked to the transmission of skills and knowhow, describing it as "activities with the purpose of accumulating knowledge, skills and knowhow through consultancy or technical support" (Arpaci-Ayhan, 2022, p.740). Of the three types of productive knowledge (Balland et al., 2022), this can most clearly be linked to knowhow. Meanwhile, Arpaci-Ayhan (2022) connects non-technical cooperation (Non-TC) with aid to infrastructure and "physical capital stock and the transfer of tangibles" (p.747). Non-TC can thus be linked with embodied and codified knowledge.

Whereas Arpaci-Ayhan (2022) focuses on the modality of foreign aid, Kamguia et al. (2022) concentrate on its sectoral destination, among others sectors, to education, energy and for humanitarian purposes. The two studies thus differ in the level at which foreign aid is examined, while using the same aid data from the OECD (n.d.a). In the OECD (n.d.a) data, it is clear that for example aid to the education sector can take the form of both TC and Non-TC. Kamguia et al. (2022) links aid to education and energy with human capital accumulation and holds that it can serve as foundation for accumulating knowhow. Following economic complexity theory, Kamguia et al.'s (2022) linking of aid to education to accumulation of knowhow is reasonable as it can be regarded as a precondition for knowhow that exist in brains through e.g. increased

literacy or cognitive ability (Hausmann et al., 2014, pp. 36-38; Balland et al., 2022). In terms of energy, Kamguia et al.'s (2022) motivation is that "it promotes improvements in human capital" (p.74), and hence economic complexity. However, it is more reasonable to characterize energy as embodied knowledge. Drawing on Balland et al.'s (2022) three types of knowledge, one can expect energy to complement knowhow. The notion that energy can constrain production is well-documented (e.g. Wrigley, 2013) and it could arguably be transferred, e.g. through solar panels, i.e. foreign technology, or simply natural resources such as oil and gas. These types are evident in the subcategories of the variable, which are outlined in Appendix B. In this way, energy is more clearly linked to embodied and codified knowledge than knowhow, both because it can be transferred and because it better aligns with Balland et al.'s (2022) description of tools enabling knowhow to diffuse.

Drawing on the three types of productive knowledge and the aid-complexity literature, foreign aid that is relevant to increasing economic complexity can be divided into two main categories: aid for knowhow or aid for embodied and codified knowledge. Examples of aid for knowhow are TC (Arpaci-Ayhan, 2022) and education (Kamguia et al., 2022), while aid for embodied and codified knowledge are non-TC (Arpaci-Ayhan, 2022) and energy (Kamguia et al., 2022). From the theoretical lens that countries grow by becoming more complex (Hidalgo et al., 2007), aid that cannot be clearly linked to the three types of productive knowledge are less likely to positively affect economic growth. This aligns with the view that general measures of foreign aid, such as ODA, includes subcategories that vary in terms of their relevance to promoting economic growth (Qian, 2014). Examples of such aid is e.g. aid for humanitarian purposes, which Kamguia et al. (2022) finds to be negatively associated with complexity.

Relating types of aid to types of productive knowledge makes it interesting to review the scholars' findings. In terms of aid for knowhow, Arpaci-Ayhan (2022) finds that TC has a negative association with economic complexity, which he explains is because knowhow tends to accumulate slowly. On the contrary, Kamguia et al. (2022) finds that aid to education has a positive impact. In terms of aid for embodied and codified knowledge, Arpaci-Ayhan (2022) finds that Non-TC has a positive effect, while Kamguia et al. (2022) finds that aid to energy also has a positive impact. However, with regards to all bilateral aid, the findings diverge, where Arpaci-Ayhan (2022) finds that it has a positive impact while Kamguia et al. (2022) finds that it has a negative effect. Arpaci-Ayhan (2022) explains the mixed findings of this research with differences in theoretical frameworks and aid types considered. By studying foreign aid at

multiple levels under one theoretical framework, the present study therefore aims to contribute to this literature. In this way, possibly elucidating the heterogeneity of foreign aid types for economic growth, from the lens of economic complexity.

### 2.2.2 Role of Context

The notion that how foreign aid is associated with economic growth depends on the context and the extent that aid is tailored to it is well established in the aid-growth literature (e.g. Bourguignon & Sundberg, 2007; Tang & Bundhoo, 2017). Contextual factors that have gained particular attention is that institutional quality (e.g. Maruta et al., 2020), lower corruption (e.g. Svensson, 2000) and a more developed policy environment (e.g. Burnside & Dollar, 2000; Tang & Bundhoo, 2017) are positively associated with aid effectiveness. Indeed, this link has been made in the aid-complexity literature as well, where for example Kamguia et al. (2022) argues that aid is more effective the more democratic the recipient. Furthermore, Ogbuabor et al. (2023) studies how international financial inflows, including aid, FDI and remittances, are associated with economic complexity depending on the institutional quality of the recipient. They find that institutional quality amplifies the positive effects of foreign aid, FDI and remittances, on economic complexity. A frequently cited aspect of institutional quality negatively affecting economic growth is corruption, where aid activities fail to reach their targets as donations are lost through corruption (e.g. Svensson, 2000; Moyo, 2009, pp. 49-57). Furthermore, as recipients can become dependent on foreign aid, where corruption is one interwoven aspect, this may distort the incentives to save and invest in order to grow in the long run (e.g. Economides, 2008; Easterly, 2002).

Other studies emphasize that foreign aid becomes more effective when the recipients have the requisite human capital to put the aid to productive use (e.g. Nwani, 2021). Similarly, Kamguia et al. (2022) suggest that foreign aid is more effective in spurring economic complexity in countries that already have high economic complexity, which they explain with a greater ability to productively absorb foreign aid. In contrast, Gnangnon's (2024) study suggests that the impact of Aid-for-Trade is amplified in countries with low economic complexity, from the lens of the quality of aid flows, referring to less volatile and more predictable flows. Aligning with Gnangnon (2024), Gnangnon (2021) argues that Aid-for-Trade, is more effective in countries with low productive capacities, which is a related concept of economic complexity. Furthermore, since economic complexity and income are highly

correlated (Hidalgo & Hausmann, 2009), Arpaci-Ayhan (2022) also contrasts Kamguia et al. (2022) by suggesting that foreign aid is more effective in countries with low income.

Thus, whereas scholars have examined how the association between foreign aid and economic complexity depends on the level of income (Arpaci-Ayhan, 2022), the level of economic complexity (Kamguia et al., 2022; Gnangnon, 2024), and productive capacities (Gnangnon, 2021), the impact of the deviation between income and economic complexity has not been subject to empirical study. That is, to the author's knowledge. As discussed in the previous section, these deviations may have important implications for the relative stocks of the types of productive knowledge that countries possess. In turn, depending on if countries have more knowhow, or embodied and codified knowledge, aid directed to these types of knowledge may have different effects. This illustrates a research gap at the nexus of foreign aid, economic growth and economic complexity, which motivates further investigation.

# 3 Theoretical Framework

Drawing on the literature review and the research gap identified at the nexus of foreign aid, economic growth and economic complexity, this chapter develops and explicates a theoretical framework. The first section focuses on the mechanisms through which the author expects foreign aid to be associated with economic growth. The second section concentrates on how and why the association is expected to depend on the context of productive knowledge. Based on these two sections and the research questions, the third section formulates the hypotheses that the empirical analysis will test. Thereafter, control variables are chosen, following the previous research, and the limitations outlined.

## 3.1 Aid for Different Types of Productive Knowledge

Following the theory that economies grow by becoming more complex (Hidalgo et al., 2007), productive knowledge is the main channel through which the thesis links foreign aid with economic growth. Considering that Arpaci-Ayhan (2022) attributes mixed results in the previous research to differences in theoretical framework, aid types examined and control variables used, there is a need for unification of the previous research. Foreign aid is therefore investigated at three different levels. The first level is bilateral aid, following both Kamguia et al. 2022 & Arpaci-Ayhan (2022), referring to all aid that is donated between one country to another. The second level is technical cooperation (TC) and non-technical cooperation (non-TC), referring to the modality of foreign aid (following Arpaci-Ayhan, 2022). The third level is the sectoral destination, where aid to education and energy are considered (following Kamguia et al., 2022). As for the second and third level, TC and aid to education are linked to aid for knowhow. Meanwhile, Non-TC and aid to energy are connected to aid for embodied and codified knowhow.

Bilateral aid can be hypothesized to be negatively associated with economic growth, which follows the notion that foreign aid needs to be tailored to recipient needs and context in order to be effective (e.g. Qian, 2014; Ramalingam, 2013, pp.360-363; Banerjee & Duflo, 2011, pp. 267-273; Bourguignon & Sundberg, 2007). At the same time, bilateral aid includes subcategories that are difficult to connect to productive knowledge, such as humanitarian aid that have been found to be negatively associated with complexity (Kamguia et al. (2022). From the lens of productive knowledge, aid for knowhow is also likely to be ineffective because knowhow by nature is difficult to accumulate and tends to do so incrementally and slowly (Balland et al., 2022; Hausmann et al., 2014, p.8). Furthermore, the findings in terms of aid for knowhow are mixed, where Arpaci-Ayhan (2022) finds TC to negatively affect complexity while Kamguia et al. (2022) finds that aid for education positively affects it. Regarding aid for embodied and codified knowledge, this is likely to be more effective as Balland et al. (2022) explains that it can more easily be transferred. Moreover, findings are positive, in terms of both Non-TC (Arpaci-Ayhan, 2022) and energy (Kamguia et al., 2022).

## 3.2 Context of Productive Knowledge Relative to Income

The three levels of foreign aid are then related to the context of productive knowledge relative to income (PKI). Here, the deviations between economic complexity and income that predict economic growth (Hidalgo & Hausmann, 2009) are interpreted as having implications for Balland et al's (2022) three types of complementary productive knowledge, following the literature review. Contemplate for example Guinea, which has a high PKI (GIN) and Kuwait (KWT), which has a low PKI, in figure 1 below. They have the same level of productive knowledge, but their levels of income differ. Since embodied and codified productive knowledge easily can be transferred and purchased (Balland et al., 2022), Kuwait can be expected to have more of it by virtue of having a higher purchasing power. Since knowhow cannot simply be purchased and accumulates slowly (Balland et al., 2022), aid directed to increasing Kuwait's relatively small proportion of knowhow can be hypothesized to be effective in this context. Meanwhile, since Guinea has lower income, knowhow can be argued to represent a greater share of its productive knowledge, hence why aid for embodied and codified knowledge could be hypothesized to be more effective in this context. Furthermore, since Guinea arguably has a higher proportion of knowhow, general bilateral aid can be hypothesized to be more effective in Guinea. This follows the notion that the diffusion of

technology is primarily limited by knowhow as the other types easily can be transferred (Balland et al., 2022). This also aligns with the literature suggesting that the degree that technology can be transmitted through FDI depends on the level of human capital in the country receiving the investments (e.g. Borensztein et al., 1998; Li & Liu, 2005).

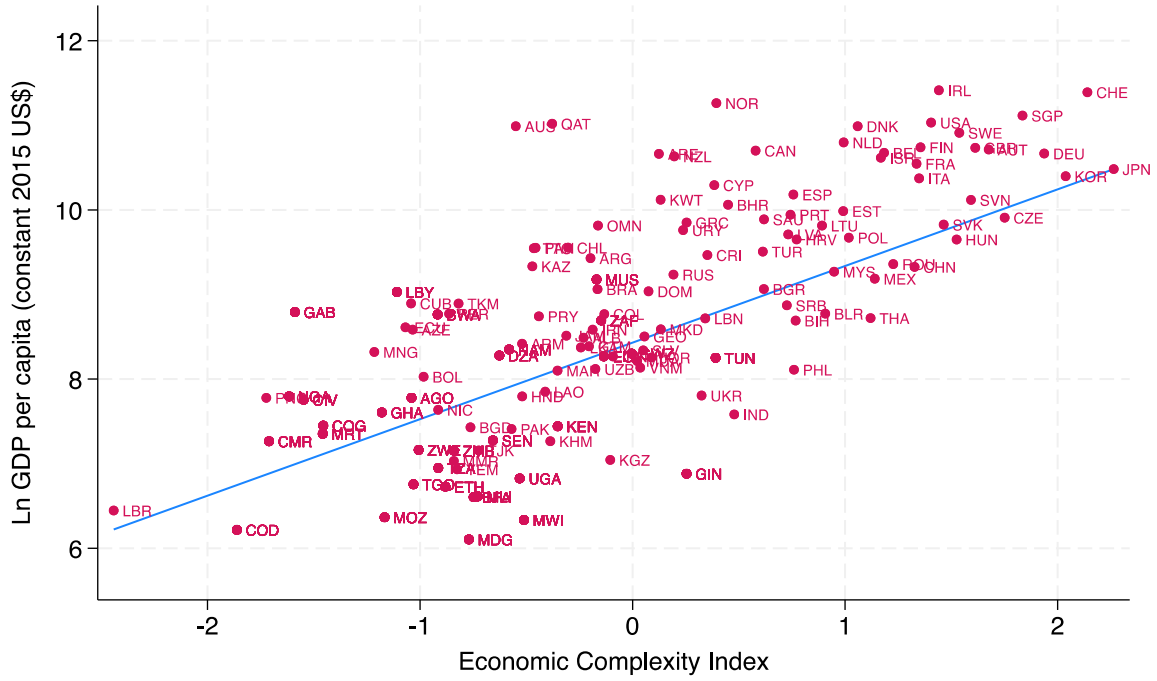


***Figure 1**: Relationship between economic growth and economic complexity in year 2021 (author's construction drawing on Hausmann et al. (2014, p.28)). All countries (N = 132), for which data on GDP per capita (World Bank, 2024) and ECI (The Growth Lab at Harvard University, 2019) are available, was used.*

## 3.3 Hypotheses

Based on the discussion concerning aid types and contexts of productive knowledge relative to income, the thesis can formulate the hypotheses that the empirical analysis aims to test. These are shown in table 1 below.

***Table 1**: Hypotheses*

| |
|---|
| **RQ1: How is foreign aid associated with economic growth?** |
| **H1:** Bilateral foreign aid is negatively associated with economic growth |
| **H2:** Aid for knowhow is negatively associated with economic growth |
| **H3**: Aid for embodied and codified knowledge is positively associated with economic growth |
| |
| **RQ2: How does the association between foreign aid and economic growth depend on the context of productive knowledge relative to income?** |
| **H4:** The negative effect of bilateral aid is mitigated in countries with high productive knowledge relative to income |
| **H5:** The negative effect of aid for knowhow is mitigated in countries with low productive knowledge relative to income |
| **H6**: The positive effect of aid for embodied and codified knowledge is amplified in countries with high knowhow relative to income |

## 3.4 Control Variables

The previous research suggests that there are a number of factors other than context of productive knowledge and foreign aid that determines economic growth, which will need to be controlled for. The first channel follows the literature arguing that general institutional quality is associated with aid effectiveness and economic growth (e.g. Burnside & Dollar, 2000; Tang & Bundhoo, 2017; Maruta et al., 2020). This is especially important as Ogbuabor et al. (2023) shows that how international financial inflows, including aid, FDI and remittances, are associated with economic complexity depends on the institutional quality of the recipient. To control for this, the thesis follows Kim (2019) who studies how Aid-for-Trade affects export diversification and controls for the institutional channel using the World Bank's (2024) estimate of government effectiveness. This variable, and the other control variables are defined in Appendix C. Furthermore, the thesis controls for natural resources dependence, measured as rents as share of GDP, following Arpaci-Ayhan (2022) and Luu Hai (2021). High natural resource rents are associated with a low PKI (Hausmann et al., 2014, pp. 27-30) and this in turn

is associated with slow growth (Hidalgo & Hausmann, 2009). Furthermore, Tabash et al. (2022) finds that it is negatively associated with growth, and therefore the expected association.

In addition to these controls, the study includes a number of controls to test the robustness of the models in the empirical analysis. Following Kamguia et al. (2022), the study controls for financial development, which they proxy with domestic credit to the private sector as a share of GDP. Chu (2020) shows that financial development is positively associated with economic complexity and links it to capital provision, which can positively affect innovation and hence complexity. Following a number of studies (Arpaci-Ayhan, 2022; Kamguia et al., 2022; Kim, 2019), FDI will also be controlled for. Here, the variable FDI as a share of GDP is used, drawing on Arpaci-Ayhan (2022). In line with Ogbuabor's (2023) positive evidence of FDI and remittances on economic complexity, both factors are expected to positively affect growth. The thesis therefore also follows Kamguia et al. (2022) in controlling for remittances, while using the same variable of personal remittances received as a share of GDP. Lastly, the study aligns with Kamguia et al. (2022) in controlling for individuals using the internet as a share of the population, where the expected relationship follows Lapatinas (2019) who finds that it positively affects economic complexity.

# 4 Data

This chapter is divided into two sections. The first section presents and justifies the source material that is used, divided into foreign aid, economic complexity, and economic growth and the control variables. The second section describes the data and the samples,

## 4.1 Source material

### 4.1.1 Foreign Aid

The variable of interest, i.e. predictor, is foreign aid. Following the previous aid-complexity literature (Kamguia et al., 2022; Arpaci-Ayhan, 2022; Gnangnon, 2021; Gnangnon, 2024), the study chose to use the free, readily available and highly comprehensive dataset on foreign aid from the OECD (n.d.a). The data is longitudinal and extends between 2002-2022, albeit the author chose to only include data from 2002-2021 to match the data on economic complexity from The Growth Lab at Harvard University (2019), which only extends until 2021. This data is useful for answering the research questions for several reasons. First, it contains data on most countries in the world. This enables a large sample size, which was a prerequisite for answering the research questions with the chosen method. Large sample sizes are also customary in the literature (Kamguia et al., 2022; Arpaci-Ayhan, 2022; Gnangnon, 2024, 2021). Second, the dataset contains detailed information on the types of foreign aid that flows from donors to recipients at the country-level. This allows the author to capture not only all bilateral foreign aid from official donors, but also disaggregate it by the aid modalities of technical cooperation and non-technical cooperation (following Arpaci-Ayhan, 2022) and the sector destinations of education and energy (following Kamguia et al., 2022). In turn, the relatively detailed nature of the dataset allows the study to link aid types to types of productive knowledge, and thus answer the research questions.

While Kamguia et al. (2022) uses aid commitments, the thesis follows Arpaci-Ayhan (2022) and uses aid disbursements. Commitments reflect “a firm obligation, expressed in writing and

backed by the necessary funds, undertaken by an official donor to provide specified assistance to a recipient country or a multilateral organization" (OECD, n.d.b). As the thesis does not use time lags in the regression models, using disbursements mitigates the issue to some extent since they represent "the release of funds to or the purchase of goods or services for a recipient; by extension, the amount thus spent" (OECD, n.d.b). In contrast, commitments "are recorded in the full amount of expected transfer, irrespective of the time required for the completion of disbursements" (OECD, n.d.b). It can thus be expected that it takes a shorter time until disbursements can be observed to affect economic growth compared to commitments.

The data itself derives from the Creditor Reporting System (CRS) database, which covers around 90% of all Official Development Assistance (ODA), based on reported aid activities from members, both countries and multilateral organizations, of the Development Assistance Committee (DAC) (OECD, n.d.a, b). To extract as much foreign aid data as possible, the data is for all official donors.

### 4.1.2 Economic Complexity

To understand how the association between foreign aid and economic growth depends on the context of productive knowledge relative to income, data on the economic complexity index from The Growth Lab at Harvard University (2019) are used. The data is longitudinal, covering the years 1995-2021 on country-level, albeit it is delimited to 2002-2021 to match the OECD (n.d.a) dataset). The data is also free and readily available. The data is based on trade data from United Nations Statistical Division, International Monetary Fund and the World Bank. This is because exports have been shown to be representative of the products that countries produce, and hence the productive knowledge that they possess (Hidalgo & Hausmann, 2009). The index is constructed following economic complexity theory. Hausmann et al. (2014) explains that the ECI measures diversity by "the number of products that a country exports" (p.21) and sophistication by "the number of countries that export a product" (p.21).

### 4.1.3 Economic Growth and Control Variables

Data for the dependent variable, GDP per capita (2015 constant US$), as well as the control variables, is downloaded from the World Bank (2024). Thus, the thesis follows the previous

research, which either exclusively (Arpaci-Ayhan, 2022) or partly (Kamguia et al., 2022; Gnangnon, 2021, 2024) uses data from the World Bank (2024) for their control variables.

## 4.2 Samples and Variables

The foreign aid variables of interest that are used are and their concrete definitions, including their subcategories, are outlined in Appendix B. Furthermore, all other variables, with descriptions and respective sources are shown in Appendix C. The use of these variables and data can be divided into two samples, where the first sought to establish contexts of productive knowledge relative to income, and will be referred to as "PKI-sample". The second sample to connect the contexts with foreign aid for 27 Sub-Saharan African countries, and will be referred to as "aid-sample".

### 4.2.1 Context of Productive Knowledge Relative to Income

The PKI-sample was used to calculate the relationship between income and economic complexity in order to predict the residuals that capture contexts of productive knowledge relative to income (PKI). This sample was decided by the available data on GDP per capita (World Bank, 2024) and ECI (The Growth Lab at Harvard University, 2019) for the years 2002-2021. To accurately predict the relationship and obtain the residuals, the largest possible sample size based on the two datasets was used. This resulted in 132 countries with 20 annual observations each. The variables of this sample are described in table 2.

***Table 2:*** *Descriptive statistics, PKI-sample*

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| GDPpc | 2637 | 13506.02 | 17478.24 | 255.1003 | 90589.2 |
| ECI | 2637 | .0328256 | .9827075 | -2.778437 | 2.774758 |

Note: 3 years missing from Serbia 2002-2004 in the ECI-data.

Using the PKI-sample, the residuals ($\varepsilon_t$) were obtained from a simple regression using the following equation:

$$[1]\ Ln\_GDPpc_t = \beta_0 + \beta_1 ECI_t + \varepsilon_t$$

To use the residuals in a multiple regression analysis and allow for straightforward interpretation through interactions with the different types of aid, the residuals were transformed into a categorical dummy variable. The variable PKI_cat was thus generated. The value 0 of PKI_cat represents observations that have a high PKI, i.e. higher productive knowledge than their income would suggest. In other words, a high PKI implies that $\varepsilon_t$ is negative (lower than 0). Meanwhile, the value 1 denotes a low PKI, i.e. $\varepsilon_t$ is positive (higher than or equal to 0). A country can thus move between the two categories from year to year.

A limitation of the binary nature of PKI_cat is that nuances within the deviations are not captured. This is a limitation as the theory suggests that the further below (above) the fitted line a country is located in a scatterplot, the faster (slower) the country will grow (Balland et al., 2022; Hidalgo & Hausmann, 2009; Hausmann et al., 2014, pp. 27-30). While this limitation could be overcome by interacting the variables of interests directly with the residuals, $\varepsilon_t$, the interpretation of such a continuous by continuous interaction was seen as more complicated by the author. To accommodate the scope of the paper, the interaction was therefore kept as categorical by continuous. However, whereas the binarization of PKI is a simplification, it arguably does not meaningfully lower the contribution of the empirical analysis when considering similar simplifications in the previous research. For example, Kamguia et al. (2022) considers how the association between aid and complexity depends on if a country has a low or high level of complexity, i.e. binarily. Meanwhile, Arpaci-Ayhan (2022) divides countries into low-income, lower-middle-income and upper-middle-income countries.

Furthermore, while the residuals directly measure countries' productive knowledge relative to income, it is a proxy for their relative stocks of the three types of productive knowledge. However, the proxy is arguably strongly theoretically founded both in the literature review and theoretical framework. The validity of the proxy can also be supported empirically, to some extent, by visualizing the differences in embodied knowledge between the two categories. Since codified knowledge also can be transferred easily or purchased (Balland et al., 2022), one would expect the same mechanisms and differences for this knowledge type. Gross capital formation, which measures purchases of fixed assets, including for example machinery and infrastructure (World Bank, 2024), is arguably a relevant indicator of embodied knowledge. Further, that capital formation complements production is well-founded in the literature (e.g. Solow, 1962), which is also the role of embodied knowledge in production (Balland et al., 2022). Appendix D shows that countries with a low PKI has a higher gross capital formation as a share of GDP,

and that countries with a low PKI have a considerably higher GDP than those with a high PKI. If two countries have the same productive knowledge, this implies that the one with a higher income (low PKI) is more likely to have a greater proportion of embodied and codified knowledge.

### 4.2.2 Linking with Foreign Aid

The second sample was used to link GDP per capita and ECI with foreign aid. This sample was delimited to the focus on Sub-Saharan Africa. The countries that are used was decided by the availability of the data on GDP per capita, ECI and foreign aid. 27 countries for the period 2002-2021 could be matched, a complete list of which is available in Appendix A. How these 27 Sub-Saharan African countries relate to the 132 countries in the PKI-sample is shown in the figure 2 below. The 27 countries are highlighted in red and by country code and the other are represented by the green dots. A key aspect is that the aid-sample contains observations both below and above the fitted blue line, i.e. have different contexts of productive knowledge relative to income.

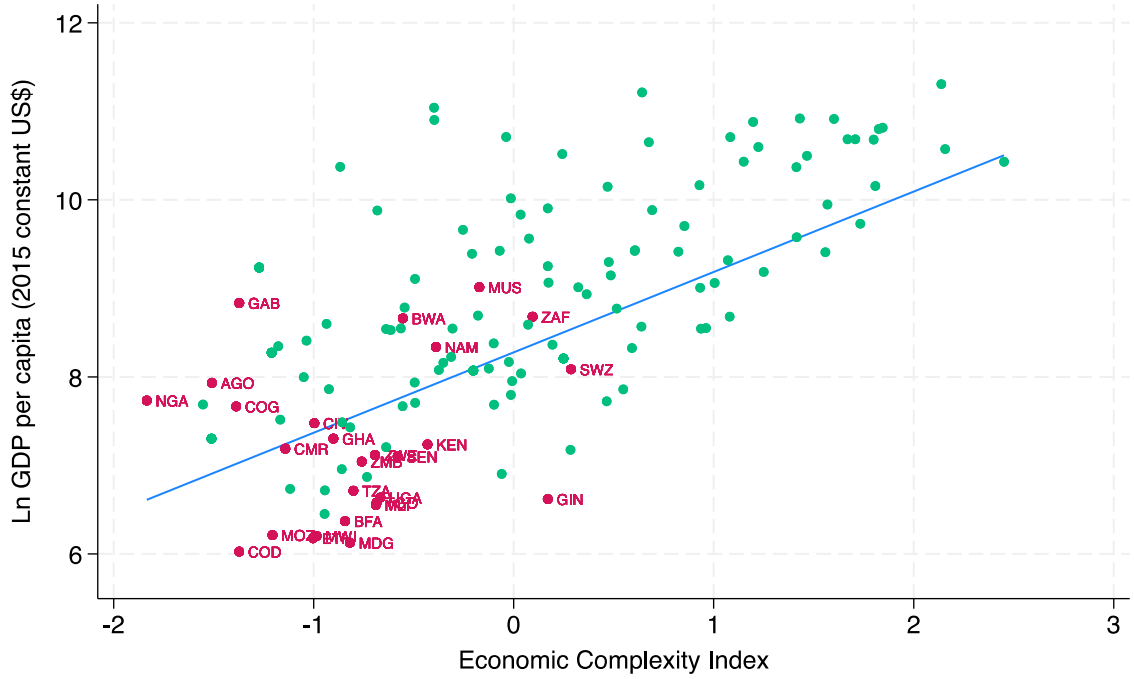


***Figure 2:*** *Relationship between mean GDP per capita and mean ECI between 2002-2021, aid-sample (author's construction)*

Furthermore, table 3 below shows the frequency of the number of years that the 27 countries of the aid-sample spent in the two categories between 2002-2021. Further, in Appendix E, it can be seen that only Côte d'Ivoire (CIV), Cameroon (CMR) and Ghana (GHA) move between the two categories, out of the 27 countries. This is as expected, as these three countries are the closest to the fitted blue line in figure 2 above.

***Table 3:*** *Categories of contexts of productive knowledge relative to income*

| **Context** | **PKI_cat** | **Freq.** | **Percent** |
|---|---|---|---|
| High PKI (below) | 0 | 366 | 67.78 |
| Low PKI (above) | 1 | 174 | 32.22 |
| | Total | 540 | 100.00 |

Note: aid-sample

Moreover, the variables that are used in the aid-sample are quantitatively described in the table 4 below.

***Table 4****: Descriptive statistics, aid-sample*

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| GDPpc | 540 | 2153.356 | 2184.864 | 255.1003 | 10956.95 |
| Bilateral | 540 | 1319.599 | 1363.43 | 25.27665 | 12755.95 |
| PKI_cat | 540 | .3222222 | .4677609 | 0 | 1 |
| Bilateral*PKI_cat | 540 | 250.9441 | 846.9719 | 0 | 12755.95 |
| TC | 540 | 709.0567 | 824.8815 | 0 | 4304.591 |
| TC*PKI_cat | 540 | 146.784 | 466.8065 | 0 | 3425.106 |
| NonTC | 540 | 534.1398 | 1036.779 | .008063 | 12099.92 |
| NonTC*PKI_cat | 540 | 95.2742 | 631.7679 | 0 | 12099.92 |
| Aid_Edu | 540 | 83.51094 | 73.95543 | 1.066805 | 706.7308 |
| Aid_Edu*PKI_cat | 540 | 16.19266 | 38.17066 | 0 | 367.1575 |
| Aid_Energy | 508 | 52.45421 | 75.0574 | .003888 | 471.9911 |
| Aid_Energy*PKI_cat | 508 | 10.01665 | 40.65697 | 0 | 471.9911 |
| Gov_effect | 540 | -.6561521 | .5735179 | -1.841436 | 1.150494 |
| Res_rents | 540 | 11.05334 | 10.4312 | .0023598 | 53.31476 |
| Fin_dev | 475 | 23.65153 | 26.75271 | .4913875 | 142.422 |
| FDI | 539 | 3.566981 | 5.336861 | -17.29224 | 38.94287 |
| Remitt | 530 | 2.209553 | 2.71149 | 0 | 13.61145 |
| Internet | 536 | 13.83201 | 16.76962 | .0724023 | 73.5 |

From this sample, the foreign aid variables of interests will be described more closely. In addition to the definitions of the aid variables in Appendix B, there is a need to expand on how these variables relate to each other. Bilateral aid is the total of all bilateral aid, including such that is disbursed *through* TC and non-TC and *to* the sector destinations of education and energy. This is clear in the OECD (n.d.a) dataset. Following Arpaci-Ayhan's (2022) division, TC and

non-TC captures how bilateral aid is disbursed, e.g. through experts and other technical assistance, and can be in any sector. In the descriptive statistics in table 4, the different means suggest that bilateral aid accounts for most foreign aid, whereas TC and non-TC represents less, and aid to education and aid to energy represents the least. How the variables relate to each other can be further described graphically. Figure 3 below shows the development of TC and non-TC over time, where TC is representing an increasingly large share of bilateral aid compared to non-TC over time. Since non-TC covers all other aid than TC, including humanitarian and emergency aid, this likely explains why these flows are more volatile since such aid may be higher in specific years, e.g. as a response to a humanitarian emergency.

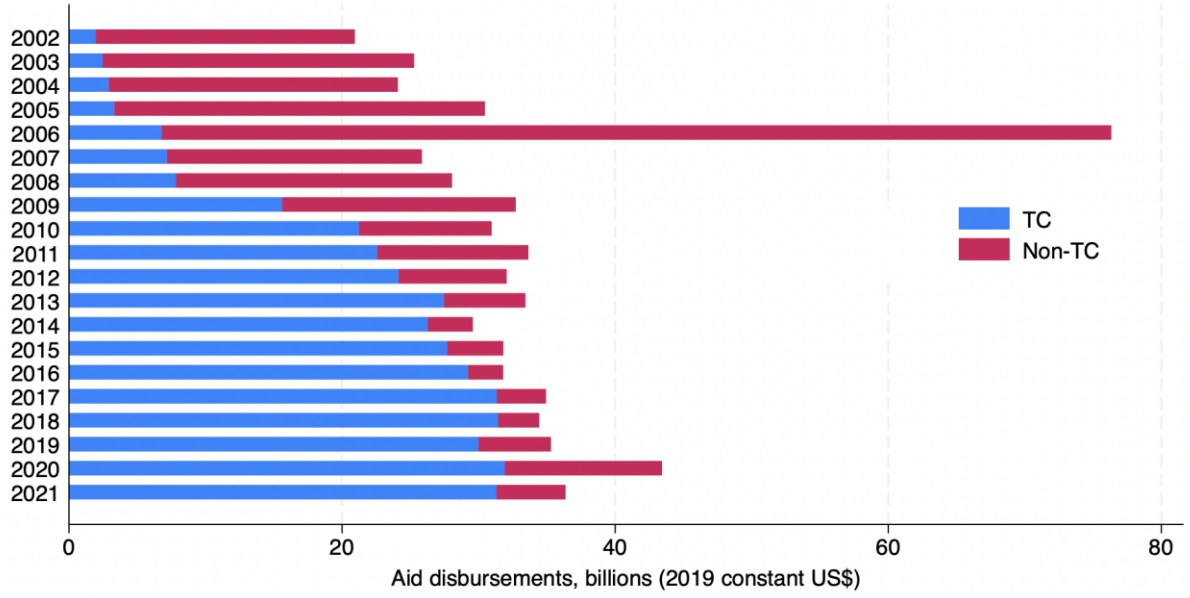


***Figure 3:*** *Aid disbursements by modality (author's construction, drawing on Arpaci-Ayhan (2022, p.741)), aid-sample*

Furthermore, education and energy are the actual sector destinations, irrespective of whether it is disbursed through TC or non-TC. Figure 4 below shows bilateral aid to education and energy, compared to bilateral aid. It can be observed that the sectoral destinations represent a considerably smaller share of aid compared to bilateral aid.

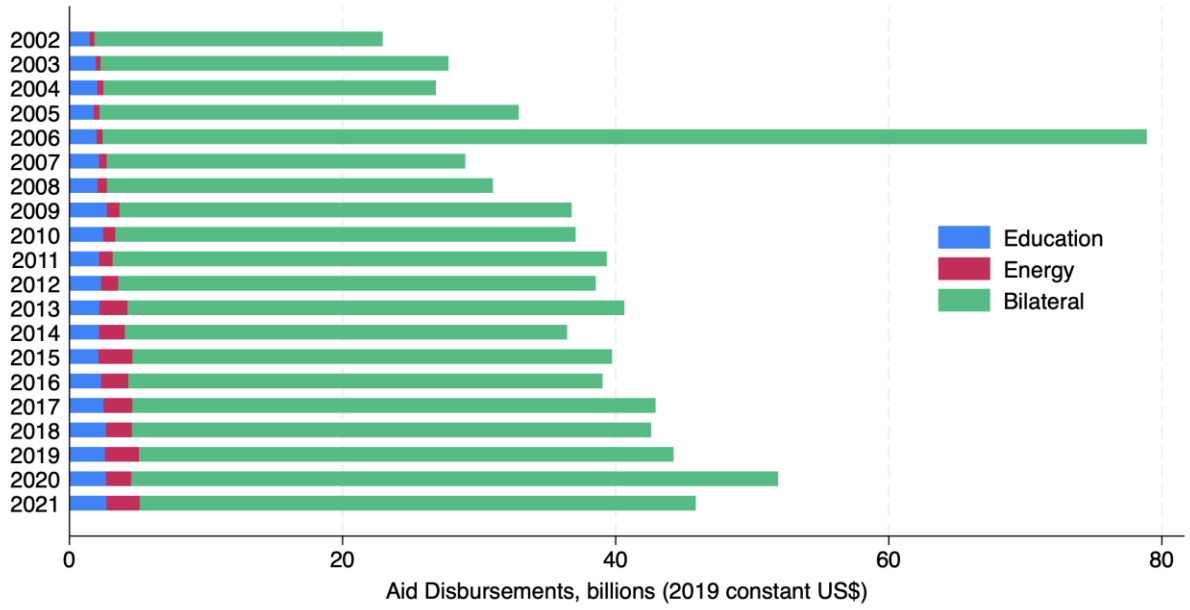


***Figure 4**: Aid disbursements by sectoral destination (author's construction), aid-sample*

Analyzing foreign aid in this way, from bilateral to modality to sector assists in comprehensively understanding how it is associated with growth depending on type and context. However, the validity of the variables can be questioned, in particular for bilateral aid, TC and non-TC. For example, Arpaci-Ayhan (2022) explains his finding that non-TC has a positive effect on economic complexity with the variable captures infrastructure and "physical capital stock and the transfer of tangibles" (p.747). However, the variable also contains multiple other categories that have weak links to such embodied and codified knowledge, which can be seen in Appendix B. Such categories are debt relief, administrative costs not included elsewhere, other in-donor expenses and the not applicable category. Not to mention, the disbursements can have any sectoral destination, similarly to TC and bilateral aid. This echoes the notion that scholars examining foreign aid tend to view it at high levels of abstraction with little regard for what the variables represent (Qian, 2014). While this lowers the validity of the bilateral, TC and non-TC variables, it also adds another dimension by enabling the study to elucidate a common measurement problem in aid research.

Furthermore, moving too close to the sectoral destinations brings issues with data availability to the surface, which can also lower the validity. This can be seen in table 3 for aid to energy, where 32 observations are missing, while the other aid variables to do not have any missing observations at 540 observations.

# 5 Method

The first section of this chapter motivates the choice of multiple linear regression analysis as the method of the thesis. The second section describes and motivates the procedures that were used in the empirical analysis. The first subsection formulates the baseline regression models and the second subsection the tests that were carried out to assess the robustness of the models. Based on the robustness tests, the third subsection describes how and why the baseline models were altered to increase robustness, and reformulates the altered models. The third section discusses the limitations of the chosen method and altered models for the empirical analysis.

## 5.1 Choice of Method

Since the main novelty of the thesis is the linking of how the association between foreign aid and economic growth depends on the context of productive knowledge relative to income, a quantitative research design was chosen to be able to capture the deviations that characterize different contexts. While previous studies focusing on foreign aid and economic complexity have applied different Method of Moment techniques (e.g. Arpaci-Ayhan, 2022; Kamguia et al., 2022; Gnangnon, 2024), the thesis opted to use a multiple linear regression analysis to accommodate the scope of the thesis. The limitations of using this method will be discussed in the end of the chapter.

## 5.2 Procedure

### 5.2.1 Formulating Regression Models

Having constructed the variable denoting context of productive knowledge relative to income, as outlined in section 4.2.1 in the data chapter, the thesis proceeded by formulating the baseline regression models. The first model aimed to test hypothesis one by analyzing the association between all bilateral foreign aid (Bilateral) and how it depends on the context of productive

knowledge relative to income (Bilateral*PKI_cat). The baseline model was as follows, where $X_t$ is a vector of control variables:

$$[2]\ GDPpc_t = \beta_0 + \beta_1 Bilateral + \beta_3 PKI\_cat_t + \beta_2 Bilateral*PKI\_cat_t + X_t + \varepsilon_t$$

The second baseline regression model divided all bilateral foreign aid into the categories of technical cooperation (TC) and non-technical cooperation (NonTC), where the former can be linked to knowhow and the latter to embodied and codified knowledge. The baseline model was as follows:

$$[3]\ GDPpc_t = \beta_0 + \beta_1 TC_t + \beta_2 TC*PKI\_cat_t + \beta_3 NonTC_t + \beta_4 NonTC*PKI\_cat_t + \beta_5 PKI\_cat_t + X_t + \varepsilon_t$$

The third and final regression model replaced technical cooperation as a link to knowhow with aid to education (Aid_Edu). Non-technical cooperation as a link to embodied and codified knowledge was replaced with aid to energy (Aid_Energy). The baseline model was as follows:

$$[4]\ GDPpc_t = \beta_0 + \beta_1 Aid\_Edu_t + \beta_2 Aid\_Edu*PKI\_cat_t + \beta_3 Aid\_Energy_t + \beta_4 Aid\_Energy*PKI\_cat_t + \beta_5 PKI\_cat_t + X_t + \varepsilon_t$$

### 5.2.2 Robustness Tests

Using the regression models formulated above, the empirical analysis proceeded to test their robustness across three dimensions: linearity, imperfect multicollinearity and behavior of the residuals. First, the relationship between GDPpc and the independent variables was tested across different models to see which one best fitted the data. Second, since the study is primarily interested in the estimates of the coefficients, as opposed to only the overall model, imperfect multicollinearity needed to be examined (Stock & Watson, 2021, pp.230-231). This is because high correlation between independent variables in a multiple linear regression lowers the accuracy of the estimated beta coefficients (Stock & Watson, 2021, pp. 230-231). Third, to further understand potential weaknesses of the models and alteration that needed to be made, the thesis proceeded by testing if the residuals were normally distributed and homoscedastic (Stock & Watson, 2021, pp. 195-197). To test these three dimensions, the thesis proceeded by carrying out the tests outlined in table 5 below:

***Table 5**: Robustness tests*

| Dimension | Statistical tests |
|---|---|
| Linearity | Scatterplots of relationship between dependent and independent variables |
| Imperfect multicollinearity | Correlation Matrix and Variance Inflationary Factor |
| Behaviour of residuals | Histogram of the normal distribution the of residuals, Breusch-Pagan test and Shapiro-Wilk test |

### 5.2.3 Altering the regression models

When testing the robustness, it was found that the linearity between the dependent and independent variables is strongest when transforming the variables of interest into natural logarithms. Second, multicollinearity was detected when including the base effect variable for context of productive knowledge (PKI_cat), motiviating the exclusion of the variable. This exclusion does not considerably affect the contribution of the empirical analysis, however. This is because the aim is to understand how the association between foreign aid and economic growth depends on PKI_cat, not how PKI_cat independently affects economic growth. The fact that the deviations independently predict economic growth have also already been well-established in the previous research (e.g. Hidalgo & Hausmann, 2009; Hausmann et al., 2014, pp. 27-30). Third, while the residuals of the overall model, after excluding PKI_cat and logging the variables of interest, did have a reasonably normal distribution, the residuals of the individual variables were not found to be normally distributed. Fourth, it is found that the model suffers from heteroskedasticity, which motivates the use of heteroskedasticity-robust standard errors to mitigate the issue.

Due to these four reasons, the regression models were altered. The “Ln”-part of the following variable names imply that they are expressed in natural logarithms, otherwise the same variable names as in the original regression models apply. In addition, the base effect of the context of productive knowledge (PKI_cat) is excluded. Equation number 5 is the model focusing on bilateral aid, equation 6 concentrates on technical and non-technical cooperation while equation 7 denotes aid to education and energy.

$$[5]\ Ln\_GDPpc_t = \beta_0 + \beta_1 Ln\_Bilateral_t + \beta_2 Ln\_Bilateral*PKI\_cat_t + X_t + \varepsilon_t$$

$$[6]\ Ln\_GDPpc_t = \beta_0 + \beta_1 TC_t + \beta_2 Ln\_TC*PKI\_cat_t + \beta_3 Ln\_NonTC_t + \beta_4 Ln\_NonTC*PKI\_cat_t + X_t + \varepsilon_t$$

$$[7]\ Ln\_GDPpc_t = \beta_0 + \beta_1 Ln\_Aid\_Edu_t + \beta_2 Ln\_Aid\_Edu*PKI\_cat_t + \beta_3 Ln\_Aid\_Energy_t + \beta_4 Ln\_Aid\_Energy*PKI\_cat_t + X_t + \varepsilon_t$$

Each baseline model was then tested against six different specifications, that is, with different combinations of control variables. This was done to analyze how the coefficients and significance of the variables changed depending on the model. In this way, elucidating the consistency and robustness with which the variables predict economic growth.

## 5.3 Limitations

The method and regression models come with several limitations that restricts the reliability of the empirical analysis. A first limitation is that the residuals are not normally distributed and are heteroskedastic, which lowers the reliability of the estimates that will be provided. A second limitation is that the models assume a year to year relationship between foreign aid and economic growth, i.e. that foreign aid in year t has an impact on growth in year t. In the previous research on aid and complexity, for example Kamguia et al. (2022) employs both five-year and ten-year lags for testing the robustness of his models, arguing that the influence of aid may not materialize immediately. With similar reasoning, Arpaci-Ayhan (2022) also lags foreign aid, but only by one year. A related econometric limitation is that the models may suffer from autocorrelation, implying that foreign aid in year t, in this case, may be serially correlated with foreign aid in year t-1 (Stock & Watson, 2021, pp. 558).

A third limitation relates to potential omitted variable bias caused by unobserved differences between the 27 countries included in the data, both in terms of uniqueness between countries as well as changes over time. Econometrically, this limitation can be mitigated by altering the specifications to account for fixed effects (Stock & Watson, 2020, pp. 267-374). Indeed, it appears to be customary to include fixed effects in the literature (e.g. Kamguia et al., 2022; Arpaci-Ayhan, 2022; Gnangnon, 2021, 2024). In practice, the limitations imply that the

empirical analysis will be a descriptive account of the correlation between aid and growth, as opposed to a causal account of the relationship.

# 6 Empirical Analysis

This chapter is divided into three sections. The first section examines the strength of the models by assessing linearity, multicollinearity and the behaviour of the residuals. Based on the weaknesses found in the first section, the second section proceeds by presenting the results of the regression output of the altered models, divided into subsections by the level of foreign aid type. The first subsection focuses on bilateral aid, the second on technical and non-technical cooperation and the third on aid to education and energy. The fourth subsection then examines the control variables. The third and last section discusses and explains the findings and relates them to the literature.

## 6.1 Robustness tests

### 6.1.1 Linearity

The first OLS assumption that will be tested is the linearity in coefficients between the dependent variable, GDP per capita, and the independent foreign aid variables of interest. The main testing will be carried out using bilateral aid, which contains both the modality and sector destination levels. Nothing that the previous research primarily expresses their models in natural logarithms (e.g. Kamguia et al., 2022; Arpaci-Ayhan, 2022), it is plausible that this will improve the fit of the thesis' models as well. I therefore start by expressing both variables in natural logarithms, creating a log-log model, which can be seen in figure 5 below. Compared to the linear-linear, log-linear and linear-log relationships, which can be seen in Appendix F, the linearity is strongest using the log-log model. Furthermore, to ensure that the fit for TC, non-TC, aid to education also are reasonably linear, the relationships in natural logarithms are also in appendices G and H. Therefore, both GDP per capita and all aid variables will be expressed in their natural logarithms moving forward to ensure best possible linear fit.

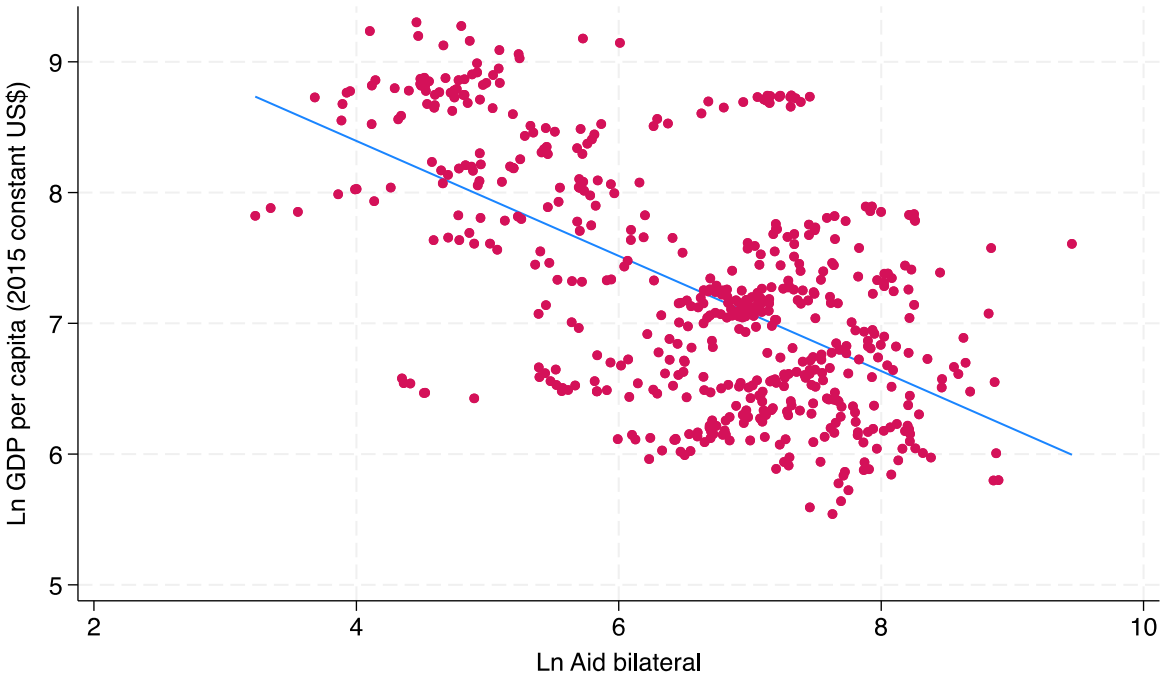


***Figure 5:*** *Natural logarithms of GDP per capita and bilateral aid (author's construction).*

In addition, the degree of linearity between the natural logarithm of GDP per capita and the control variables need to be examined. These variables are already normalized, where Res_rents, Fin_dev, FDI and Remitt are expressed as share of GDP, Internet as share of population and Gov_effect as an estimate between -2.5 to 2.5. It is therefore unreasonable to express these in terms of natural logarithms. The linear fit of these control variables is strong together with the natural logarithm of GDP per capita, which is visualized in Appendix I.

### 6.1.2 Multicollinearity

Since the aim is to understand how the association between foreign aid and economic growth depends on the context of productive knowledge, the values of the individual variables, as opposed to only the overarching model, are the main interest. To ensure that there is no multicollinearity between the independent variables, which could bias the beta coefficients (Stock & Watson, 2021, pp.230-231), this section will investigate the correlations. Table 6 shows the correlation matrix for bilateral aid, the independent variables of interest and control variables. Consistent with the theory that the deviations of economic complexity and income predict economic growth (Hidalgo & Hausmann, 2009), the binary variable capturing these deviations (PKI_cat) is strongly correlated with economic growth (Ln_GDPpc) at 0.7954.

However, PKI_cat is also strongly and almost perfectly correlated with the interaction of bilateral aid and context of productive knowledge (Ln_Aid*PKI_cat) at 0.9688. It is therefore likely that PKI_cat, which captures the base effect of PKI in a regression model, can cause multicollinearity if it is included. This provides a valid reason for continuing to examine potential multicollinearities.

***Table 6:*** *Correlation matrix*

| **Variable** | Ln_GDPpc | Ln_Aid | Ln_Aid*PKI_cat | PKI_cat | Gov_effect | Res_rents | Fin_dev | FDI | Remitt | Internet |
|---|---|---|---|---|---|---|---|---|---|---|
| Ln_GDPpc | 1.000 | | | | | | | | | |
| Ln_Aid | -0.5892 | 1.000 | | | | | | | | |
| Ln_Aid*PKI_cat | 0.7285 | -0.2871 | 1.0000 | | | | | | | |
| PKI_cat | 0.7954 | -0.4438 | 0.9688 | 1.0000 | | | | | | |
| Gov_effect | 0.5723 | -0.2530 | 0.3108 | 0.3819 | 1.000 | | | | | |
| Res_rents | -0.0667 | -0.0394 | 0.1915 | 0.2116 | -0.4978 | 1.0000 | | | | |
| Fin_dev | 0.5767 | -0.1581 | 0.4590 | 0.4580 | 0.6776 | -0.3329 | 1.0000 | | | |
| FDI | -0.1004 | 0.0449 | -0.0376 | -0.0157 | -0.0522 | 0.1895 | -0.0801 | 1.0000 | | |
| Remitt | -0.2225 | 0.1657 | -0.2689 | -0.3304 | -0.2162 | -0.1913 | -0.1308 | -0.0675 | 1.0000 | |
| Internet | 0.5615 | -0.1708 | 0.4186 | 0.4194 | 0.3492 | -0.2458 | 0.4735 | -0.0994 | 0.0422 | 1.0000 |

*Note: Ln_Aid here refers to Ln_Bilateral.*

To further understand potential multicollinearity, the variance inflationary factors will be examined. As expected based on the correlation matrix, (PKI_cat) causes considerable issues with multicollinearity, which is shown in the table 7 below. In the model including PKI_cat, the mean VIF reaches 10.48, which can be regarded as an unacceptable level. When excluding PKI_cat, the mean VIF decreases to 1.72, implying that the variables does not inflate the variance to a meaningful extent. Since the aim of the study is to understand how the association of foreign aid and economic growth depends on PKI_cat, and not how PKI_cat independently affects economic growth, this is a valid reason for excluding PKI_cat from the regression models henceforth.

***Table 7**: Variance inflationary factor, incl. and excl. context of productive knowledge*

| | Including PKI_cat | | Excluding PKI_cat | |
|---|---|---|---|---|
| **Variable** | VIF | 1/VIF | VIF | 1/VIF |
| Ln_Bilateral | 2.31 | 0.433426 | 1.14 | 0.874391 |
| Ln_Bilateral*PKI_cat | 35.43 | 0.028224 | 1.84 | 0.543745 |
| PKI_cat | 44.59 | 0.022426 | | |
| Gov_effect | 3.43 | 0.291284 | 2.64 | 0.379279 |
| Res_rents | 2.25 | 0.443722 | 1.90 | 0.525349 |
| Fin_dev | 2.37 | 0.422795 | 2.30 | 0.434811 |
| FDI | 1.11 | 0.899559 | 1.11 | 0.904225 |
| Remitt | 1.29 | 0.776521 | 1.25 | 0.801243 |
| Internet | 1.57 | 0.634952 | 1.55 | 0.645837 |
| Mean VIF | 10.48 | | 1.72 | |

After analysing potential multicollinearity for bilateral aid, two tests for inflated variance are conducted for the other aid types. For both models, the variance inflation is higher than for bilateral aid, but are overall at acceptable levels. For the model focusing on technical and non-technical cooperation the mean VIF is 2.33 while it for the model concentrating on aid to education and energy is 2.62, which are acceptable levels. These tables are shown in Appendix J.

### 6.1.3 Behaviour of residuals

Having determined how to express the variables to ensure the best possible linear fit and excluded the base effect variable for the context of productive knowledge relative to income to avoid issues with multicollinearity, this section starts by analysing if the residuals are normally distributed. When employing all variables shown in table 7 (excluding PKI_cat) to predict GDP per capita (Ln_GDPpc), the residuals appear to be reasonably normally distributed. This is visualized in a histogram in Appendix K.

Additionally, to understand how the residuals of each variable are distributed, a Shapiro-Wilk test will be conducted. The null hypothesis states that the residuals are normally distributed and hypothesis one states that the residuals are not. The output of the Shapiro-Wilk test is shown in Appendix J. With a p-value $< .01$ for all of the variables, the null hypothesis can be rejected, suggesting that the residuals of the individual variables are not normally distributed.

Furthermore, to ensure that the variance of the residuals is constant and to attempt to justify the assumption of homoskedasticity (Stock & Watson, 2021, p.195), a Breush-Pagan test is conducted based on the residuals already obtained. The null hypothesis is that the residuals are homoscedastic and hypothesis one is that the residuals are heteroskedastic. The squared residuals then replace Ln_GDPpc as the dependent variable in the following model:

$$[8]\ \varepsilon^2_t = \beta_0 + \beta_1 Ln\_Bilateral_t + \beta_2 Ln\_Bilateral*PKI\_cat_t + \beta_3 Gov\_effect_t + \beta_4 Res\_rents_t + \beta_5 Fin\_dev_t + \beta_6 FDI_t + \beta_7 Remitt_t + \beta_8 FDI_t + \beta_9 Internet_t + \varepsilon_t$$

With a p-value < .01, the null hypothesis can be rejected with confidence, which indicates that the model for bilateral aid suffers from heteroskedasticity. Through the same procedure, Breusch-Pagan tests were conducted for the model focusing on TC and non-TC and the model concentrating on aid to education and energy. With p-values < .01 for both tests, the null hypotheses can be rejected with confidence, suggesting that these models also suffer from heteroskedasticity. This motivates the use of heteroskedasticity robust standard errors to mitigate the issue of heteroskedasticity (Stock & Watson, 2021, p. 197).

## 6.2 Results

This section will present the results of the multiple linear regression analysis and is divided into four subsections, where the first three section examines aid at a more specific level and the fourth the control variables. The first section is bilateral aid (following Kamguia et al., 2022; Arpaci-Ayhan, 2022), which is the broadest aid type. The second is TC and non-TC, denoting the modality of bilateral aid (following Arpaci-Ayhan, 2022). The third is education and energy, referring to its sectoral destination (following Kamguia et al., 2022). At all three levels, how the types of aid depend on PKI_cat is tested. Furthermore, following the theoretical framework, TC and aid to education are linked to knowhow, while non-TC and energy are connected with embodied and codified knowledge.

To test the robustness of the regression output depending on the control variables, six models are tested for each of the three types of foreign aid. Furthermore, when interpreting the results, it is important to remember that countries with a high PKI, i.e. high productive knowledge relative to income, represents the reference category of the binary PKI_cat.

### 6.2.1 Bilateral Aid

The first level is bilateral aid. The regressions that are presented here thus aim to test **H1** that bilateral aid is negatively associated with economic growth, and **H4** that the negative effect of bilateral aid is mitigated in countries with a high PKI.

The regression results are presented in table 8. The six regression models are significant ($p < 0.01$) explaining increasing shares of the variance in GDP per capita as control variables are added, with $R^2$ ranging from 0.6881 to 0.8122. Bilateral aid was found to be consistently and significantly ($p < 0.01$) negatively associatied with GDP per capita across model specifications. In model 1 without any controls, every 1% increase in bilateral aid is associated with a 0.3094% decrease in GDP per capita. However, when controlling for government effectiveness and including further controls in models 2 to 6, the negative association is balanced to range between 0.2605% to 0.2697%. Therefore, **H1** that bilateral aid is negatively associated with economic growth can be confirmed.

Furthermore, it was found that the impact of bilateral aid consistently and significantly ($p < 0.01$) depends on the context of PKI across model specifications. In particular, it was found that the negative impact of bilateral aid is mitigated in countries that have a high PKI. For every 1% increase in bilateral aid, the negative impact is mitigated by 0.1383% for these countries. Thus, while bilateral aid is associated with a 0.2605% decrease in GDP per capita for countries with high PKI, the negative association is 0.1222% in countries with low PKI. **H4** that the negative effect of bilateral aid is mitigated by having a high productive knowledge relative to income can thus be rejected.

***Table 8**: Regression output, bilateral aid*

| | Dependent variable: natural logarithm of GDP per capita (2015, constant US$) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Ln_Bilateral | -.3093544*** | -.2669503*** | -.2696926*** | -.2697084*** | -.2693971*** | -.2605443*** |
| | (.01933) | (.0165733) | (.0168226) | (.0182789) | (.0191788) | (.0171389) |
| Ln_Bilateral*PKI_cat | .1956583*** | .1691565*** | .1735757*** | .1670873*** | .16551*** | .1383387*** |
| | (.0080294) | (.0060061) | (.0066717) | (.0069412) | (.0071397) | (.0070255) |
| Gov_effect | | .5014591*** | .463321*** | .3974886*** | .436587*** | .4212998*** |
| | | (.0270803) | (.0420861) | (.0516393) | (.0541142) | (.0513648) |
| Res_rents | | | -.0033055 | -.0036399 | -.0004383 | .0041251 |
| | | | (.0023956) | (.0027605) | (.0030446) | (.0030397) |
| Fin_dev | | | | .0035213*** | .0034889*** | .0018104** |
| | | | | (.000728) | (.0007452) | (.0008443) |
| FDI | | | | | -.0072541*** | -.0083072*** |
| | | | | | (.0024004) | (.0022839) |
| Remitt | | | | | .0175102** | .0061303 |
| | | | | | (.0072121) | (.0070272) |
| Internet | | | | | | .0119064*** |
| | | | | | | (.0012404) |
| Constant | 8.923539*** | 9.022029*** | 9.043366*** | 8.938134*** | 8.918738*** | 8.750991*** |
| | (.1375179) | (.1090005) | (.110978) | (.1175027) | (.1210419) | (.1101031) |
| Observations | 540 | 540 | 540 | 475 | 468 | 464 |
| $R^2$ | 0.6881 | 0.7766 | 0.7775 | 0.7778 | 0.7793 | 0.8122 |
| F Statistic | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |

*Notes: Robust standard errors in parentheses.* **p<0.1; **p<0.05;***p<0.01*

### 6.2.2 Technical and Non-Technical Cooperation

The second level of foreign aid is TC and non-TC, where the former is linked to knowhow and the latter to embodied and codified knowledge. The aim of this section is to test **H2** that aid for knowhow is negatively associated with economic growth and **H5** that the negative association of aid for knowhow is mitigated in countries with low productive knowledge relative to income. Furthermore, the section aims to test **H3** that aid for embodied and codified knowledge is positively associated with economic growth and **H6** that the positive effect of aid for embodied and codified knowledge is amplified in countries with high knowhow relative to income.

The regression results are presented in table 9 . The six regression models are significant ($p < 0.01$) explaining increasing shares of the variance in GDP per capita as control variables are added, with $R^2$ ranging from 0.7009 to 0.8300. Starting with TC, it was found to be consistently and significantly ($p < 0.01$) negatively associated with GDP per capita across model specifications. Specifically, every 1% increase in TC is associated with a 0.0933% to 0.1268% decrease in GDP per capita, depending on the model specification. Thus, albeit a large

improvement from bilateral aid, which is associated with a 0.2605% decrease, the relationship remains negative for TC. **H2** can therefore be confirmed.

Furthermore, it was found that the impact of TC consistently and significantly ($p < 0.01$) depends on the context of productive knowledge relative to income across specifications. Similarly to bilateral aid, it was found that the negative impact of TC is mitigated in countries that have a low PKI. In fact, in models 1 to 5 the influence of having a low PKI considerably mitigates the negative effect. In models 2, 3 and 4, the interaction effect erases the negative base effect of TC, where every 1% increase in TC in countries with a low PKI is associated with a 0.0110% (model 2), 0.0110% (model 3) and 0.0027% (model 4) increase in GDP per capita. While model 1, 5 and 6 also indicates a considerable mitigation of the negative impact of TC through the interactions, the sum remains negative. Nevertheless, it can be concluded that the negative impact of TC is consistently mitigated in countries with a low PKI. **H5** can thus be confirmed.

What is more, similarly to bilateral aid and TC, non-TC was found to be significantly ($p < 0.01$) and consistently negatively associated with economic growth across model specifications. Every 1% increase in non-TC is associated with a 0.1533% to 0.1132% decrease in GDP per capita, depending on the specification. This can be compared with the 0.0933% to 0.1268% decrease in the case of technical cooperation. TC and non-TC thus have relatively similar negative impacts on economic growth. **H3** that aid for embodied and codified knowledge has a positive association with growth can therefore be rejected.

Further, aligning with both TC and bilateral aid, it was found that the impact of non-technical cooperation consistently and significantly ($p < 0.01$) depends on the context of productive knowledge. Further, similar to both bilateral aid and TC, the negative association between non-technical cooperation and GDP per capita is mitigated in countries with a low PKI. Specifically, the interaction effect varies from 0.0959% to 0.1281% between specifications. While this considerably reduces the negative base effects of non-TC, it is not large enough to make the interaction and base effect positive for countries with high income relative to knowhow. **H6** stating that the impact of aid for embodied and codified knowledge is amplified in countries with high PKI can thus be rejected.

***Table 9**: Regression output, technical and non-technical cooperation*

| | Dependent variable: natural logarithm of GDP per capita (2015, constant US$) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Ln_TC | -.1267787*** | -.1025256*** | -.1010564*** | -.0932822*** | -.1005753*** | -.1219941*** |
| | (.0137168) | (.0109197) | (.0110101) | (.0117134) | (.0135807) | (.0131936) |
| Ln_TC*PKI_cat | .1205472*** | .1135486*** | .1120212*** | .0959496*** | .0993302*** | .0648095*** |
| | (.0148512) | (.0104809) | (.0104907) | (.0115167) | (.0117389) | (.0115149) |
| Ln_NonTC | -.1532732*** | -.1408859*** | -.1411814*** | -.1416552*** | -.1378477*** | -.1131724*** |
| | (.009215) | (.0083102) | (.0083665) | (.0086894) | (.0087555) | (.0085296) |
| Ln_NonTC*PKI_cat | .1281716*** | .0973346*** | .0957547*** | .1094567*** | .1022006*** | .1104635*** |
| | (.0190624) | (.0132385) | (.0132189) | (.0149267) | (.0155019) | (.014275) |
| Gov_effect | | .5418413*** | .5632458*** | .5171662*** | .5322432*** | .46497*** |
| | | (.0244653) | (.0384918) | (.0465799) | (.0548878) | (.0526493) |
| Res_rents | | | .0018959 | .0015458 | .0037912 | .006424** |
| | | | (.0023394) | (.002728) | (.003105) | (.0031462) |
| Fin_dev | | | | .0026646*** | .0028395*** | .0018204*** |
| | | | | (.0006774) | (.0007185) | (.0007989) |
| FDI | | | | | -.0059765** | -.0063234*** |
| | | | | | (.0024369) | (.0023198) |
| Remitt | | | | | .0113847* | .0028339 |
| | | | | | (.0067297) | (.0064509) |
| Internet | | | | | | .0116015*** |
| | | | | | | (.0014152) |
| Constant | 8.3508*** | 8.559485*** | 8.550133*** | 8.431152*** | 8.438684*** | 8.292448*** |
| | (.0870223) | (.0617462) | (.0614421) | (.0690672) | (.0732209) | (.0728884) |
| Observations | 539 | 539 | 539 | 474 | 467 | 463 |
| $R^2$ | 0.7009 | 0.8060 | 0.8063 | 0.8066 | 0.8071 | 0.8300 |
| F Statistic | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |

*Notes: Robust standard errors in parentheses.* **p<0.1; **p<0.05;***p<0.01*

### 6.2.3 Aid to Education and Energy

The third and last level of foreign aid is the sectoral level, where aid to education is linked to knowhow, while aid to energy is linked with embodied and codified knowledge. In the same way as the previous section, this section aims to answer H2 and H5 concerning aid for knowhow, and H3 and H6 about aid for embodied and codified knowledge. Here similarities and differences with the results from the aid modality level of TC and non-TC are of particular interest.

The regression results are presented in table 10 . The six regression models are significant ($p < 0.01$) explaining increasing shares of the variance in GDP per capita as control variables are added, with $R^2$ ranging from 0.6741 to 0.8399. Beginning with aid to education, it was found to be consistently and significantly ($p < 0.01$) negatively associated with GDP per capita across

model specifications. In model 1, every 1% increase in aid to education is associated with 0.4422% decrease in GDP per capita. However, after controlling for government effectiveness and including further controls in models 2 to 6, the negative effect decreases to range between 0.3366% to 0.2635%. This negative effect can be compared to the 0.2605% to 0.2697% associated decrease of bilateral aid including controls, and the 0.0933% to 0.1268% associated decrease of TC across all specifications. This shows that aid to education has a marginally stronger negative effect on GDP per capita than bilateral aid, and approximately a three times stronger negative effect than TC. **H2** can therefore also be confirmed when replacing TC with aid to education as a link to knowhow.

Moreover, in line with bilateral aid, TC and non-TC, the impact of education consistently and significantly ($p < 0.01$) depends on the context of productive knowledge relative to income. Further, also in line with bilateral aid, TC and non-TC, the negative effect is mitigated in countries with a low PKI. Similar to the base effect of aid to education, the interaction coefficient appears somewhat inflated in model 1 at 0.3797%. As for models 2 to 6, the interaction coefficient is balanced between 0.2801% to 0.3382%. In models 2, 3 and 5, the negative effect of aid to education in countries with a low PKI is considerably mitigated to between -0.0019% to 0.0295%. In models 4 and 6, the interaction erases the negative base effect to create a weak positive effect of 0.0041% in the former and 0.0167% in the latter. Thus, **H5** that the negative impact of aid to knowhow is mitigated in countries with a low PKI can also be confirmed when replacing TC with aid to education.

Regarding aid to energy, the results are more complicated. First, in model 1, the coefficient appears highly inflated indicating that every 1% increase in aid to energy is associated with a 0.0764% increase in GDP per capita. This is compared to models 2 to 5 where the coefficients range from 0.0228% to 0.03379%. Meanwhile, the coefficient is considerably more deflated in model 6 at 0.0022%. Further, models 1 to 4 are significant, albeit varying between the 1% to 10% levels, while models 5 to 6 are insignificant. What can be inferred from this is that aid to energy is consistently positively associated with economic growth, compared to non-TC that is negatively associated. Therefore, it confirms **H3** that aid for diffusion of knowhow is positively associated with economic growth, hence contrasting the results for non-TC that shows a negative relationship and thus rejects H3. However, due to the variation in significance levels between model specifications, this contrasting confirmation of H3 is only moderately robust.

What is more, in accordance with bilateral aid, TC, non-TC and aid to education, the impact of aid to energy is consistently and significantly ($p < 0.01$) dependent on the context of productive knowledge relative to income. It was found that the positive association between aid to energy and economic growth is amplified in countries with a high PKI by between 0.1009% and 0.0508%. Thus, confirming **H6**, and contrasting the finding for non-technical cooperation, which rejects H6.

***Table 10:*** *Regression output, aid to education and energy*

| | Dependent variable: natural logarithm of GDP per capita (2015, constant US$) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Ln_Aid_Edu | -.4421626*** | -.3329977*** | -.3366271*** | -.3340731*** | -.3353826*** | -.2634992*** |
| | (.0369571) | (.0273456) | (.0270792) | (.0295812) | (.030727) | (.0298136) |
| Ln_Aid_Edu*PKI_cat | .3797387*** | .3034745*** | .3335894*** | .338167*** | .3335193*** | .2801571*** |
| | (.0196762) | (.0167209) | (.019982) | (.0219111) | (.0228512) | (.0206608) |
| Ln_Aid_Energy | .0764177*** | .0228156*** | .0299213* | .0337958** | .0281028 | .0022883 |
| | (.0200239) | (.0168359) | (.0163775) | (.017003) | (.0188682) | (.0180726) |
| Ln_Aid_Energy*PKI_cat | -.0932018*** | -.0507929*** | -.0788261*** | -.1009384*** | -.0966843*** | -.0779803*** |
| | (.0240082) | (.0194247) | (.0216945) | (.0235673) | (.0250231) | (.0232115) |
| Gov_effect | | .5767162*** | .4843683*** | .3604412*** | .4030748*** | .3914321*** |
| | | (.0257017) | (.0432218) | (.0546652) | (.056545) | (.0547698) |
| Res_rents | | | -.0082973*** | -.0127681*** | -.0090919** | -.0052574 |
| | | | (.002762) | (.0032684) | (.0034932) | (.0034798) |
| Fin_dev | | | | .0040328*** | .0041005*** | .0026077*** |
| | | | | (.000776) | (.0007858) | (.0008207) |
| FDI | | | | | -.0031101 | -.0028742 |
| | | | | | (.0021554) | (.0022848) |
| Remitt | | | | | .0272246*** | .015588** |
| | | | | | (.0065803) | (.0062015) |
| Internet | | | | | | .0112057*** |
| | | | | | | (.0011882) |
| Constant | 8.424*** | 8.55935*** | 8.561801*** | 8.413132*** | 8.375517*** | 8.045103 |
| | (.1280552) | (.0827197) | (.0837107) | (.095401) | (.0940843) | .0921423 |
| Observations | 508 | 508 | 508 | 445 | 438 | 434 |
| $R^2$ | 0.6741 | 0.7975 | 0.8020 | 0.8059 | 0.8121 | 0.8399 |
| F Statistic | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |

*Notes: Robust standard errors in parentheses.* **p<0.1; **p<0.05;***p<0.01*

### 6.2.4 Control Variables

Having examined the results for the variables of interest at three levels, the analysis will now turn to the control variables. Here, the relationship between the controls and GDP per capita at all three levels and models will be considered.

Firstly, government effectiveness, financial development and internet are all consistently and significantly ($p < .01$) positively associated with GDP per capita across all models at the three levels, hence robustly following the expected relationships for the three variables.

Secondly, the association between natural resource rents and GDP per capita is inconsistent, where the direction shifts from negative to positive between the three levels. Furthermore, despite being significant at the 1% level for two specifications and at the 5% level for two specifications, it is insignificant for eight specifications. Due to inconsistent change in the coefficients and significance levels, a general relationship cannot be established.

Thirdly, FDI is consistently negatively associated with GDP per capita in all six models at the three levels. At the level of TC and non-TC, the association is also significant at the 5% and 1% levels. At the level of bilateral aid, it is significant at the 1% level. However, it is insignificant at the level of aid to education and energy. FDI thus moderately robustly counters the expectation of a positive relationship.

Fourthly, remittances are consistently positively associated with GDP per capita in all six models at the three levels. The association is significant, albeit with different p-values, in models 5 at the three levels of aid. However, when controlling for internet in models 6 at the three levels, the significance is weakened. At the level of aid to education and energy, the significance is weakened from the 1% to the 5% level, while the coefficients become insignificant at the levels of TC and non-TC and bilateral aid. Nonetheless, remittances moderately robustly follow the expected positive relationship.

## 6.3 Discussion

The findings both contrasts (Arpaci-Ayhan, 2022) and aligns (Kamguia et al., 2022; Gnangnon, 2021) with the aid-complexity literature, suggesting that bilateral aid is negatively associated with economic growth. This finding is consistent across model specifications and a robust confirmation of H1. In this way, supporting the pessimistic line of the aid-growth literature (Easterly et al., 2004; Svensson, 2000; Hansen & Tarp, 2000; Boone, 1996; Doucoliagos & Paldam, 2009) and juxtaposing the optimistic line (Sachs et al. 2004; Arndt et al., 2015). A possible explanation of the negative association is that bilateral aid contains subcategories that are unrelated to economic growth (Qian, 2014), specifically to economic complexity through which countries tend to grow (Hidalgo et al., 2007). Bilateral aid contains subtypes such as humanitarian aid, which have previously been found to have a negative impact on economic complexity (Kamguia et al., 2022).

However, aid for knowhow, which contains aid types that are linked to productive knowledge, is also negatively associated with economic growth. This finding is significant, consistent and robust between specifications for both TC and aid to education. For TC in particular, this aligns with Arpaci-Ayhan (2022), and contrasts Swada et al.'s (2022) finding that the modality positively affects technological diffusion. In terms of education, this contrasts Kamguia et al. (2022), who finds that it has a positive impact. A possible explanation for this finding, which also aligns with H2, is that aid for knowhow is unlikely to be effective because knowhow by nature takes a long time to accumulate and "moves with enormous difficulty from brain to brain because it is unconscious and does not involve understanding" (Balland et al., 2022, p. 2).

A more novel finding and confirmation of H5 is that the negative impact of aid for knowhow is mitigated in countries with low productive knowledge relative to income. Following the theoretical framework, this can possibly be explained with that knowhow is scarcer for countries with a low PKI, compared to countries with the same productive knowledge but a lower income. Therefore, aid for knowhow is arguably better tailored to the knowledge needs of recipients with a low PKI, and therefore comparatively more effective. Although this mitigates the negative effect, it should be highlighted that the total association remains negative

even when accounting for the interaction. In this way, aligning with the pessimistic view of foreign aid in terms of aid for knowhow and even when it is tailored to the context of PKI.

Regarding aid for embodied and codified knowledge, the notion that aid that different aid types of foreign aid differently affects economic growth becomes clear (see e.g. Qian, 2014; Bourguignon & Sundberg, 2007). The association is negative for non-TC, contrasting Arpaci-Ayhan (2022), while it is positive for aid to energy and thus aligns with Kamguia et al. (2022). A possible explanation for the divergence is the level of abstraction at which these variables relate to embodied and codified knowledge. As discussed in section 4.2.2, there is reason to question the validity of TC and non-TC, since parts of the sectoral destinations and modalities that they contain may be irrelevant to the types of productive knowledge. It would be expected that the issue with validity is mitigated the lower the level of abstraction, i.e. closer to the sectoral level, that aid disbursements are measured. Therefore, aid to sectoral destinations, here to education and energy, may be more accurate reflections of the types of productive knowledge and hence the associations with growth.

As a result of the measurement issues, this could explain why H3 and H6 were rejected at the modality level of non-TC, while the hypotheses were confirmed at the sectoral level of aid to energy. H3 states that aid for embodied and codified knowledge is positively associated with growth and H6 that the association is amplified in countries with a high PKI. However, while the confirmation of H3 for aid to energy is consistent across model specifications, it varies in significance levels and is therefore only considered as moderately robust. The confirmation is strong for H6, however. This suggests that foreign aid for embodied and knowledge, specifically to energy, may be constructive in promoting economic growth in countries where this knowledge is likely to be relative scarce, following the theoretical framework.

What is more, the measurement issues could also potentially explain why H4, which states that the negative association of bilateral aid is mitigated in countries with a high PKI, was rejected. If anything, since bilateral aid encompasses both TC and non-TC, the measurement issues are arguably even more pronounced for this variable.

The confirmation of H6 at the level of aid to energy has interesting implications. It supports the notion that capitalizing on Gerschenkron's (1962) latecomer advantage through foreign embodied and codified knowledge, i.e. technology, is contingent on the level of knowhow. This

clearly aligns with the theory of economic complexity suggesting that diffusion of technology is contingent on knowhow, which is a factor that underpins the ability of complexity to predict future growth (Hidalgo & Hausmann, 2009; Balland et al., 2022).

What is more, the confirmations of H5, for both TC and aid to education, and H6 for aid to energy, suggests that the context of productive knowledge relative to income is a factor to consider to more effectively tailor foreign aid to the needs of recipient countries. This adds another dimension to which aid needs to be tailored, contributing to the already long list of factors such as the policy environment (Burnside & Dollar, 2000; Tang & Bundhoo, 2017), institutional quality (Maruta et al., 2020; Ogbuabor et al., 2023), level of corruption (Svensson, 2000) and human capital (Nwani, 2021).

# 7 Conclusions

The aim of this thesis was to document how foreign aid is associated with economic growth, and how the association depends on the context of productive knowledge relative to income. The thesis generally aligns with the pessimistic view of foreign aid (e.g. Easterly et al., 2004; Svensson, 2000; Hansen & Tarp, 2000; Boone, 1996; Doucoliagos & Paldam, 2009). The pessimism is rooted in robust, negative associations of bilateral aid and aid for knowhow, including TC and aid to education, with economic growth. For bilateral aid, the finding both contrasts (Arpaci-Ayhan, 2022) and aligns (Kamguia et al., 2022) with the aid-complexity literature. In terms of aid for knowhow, the finding for TC aligns with Arpaci-Ayhan (2022) and while finding for aid to education contrasts Kamguia et al. (2022).

However, by considering the association across the bilateral, modality and sectoral levels of foreign aid, an important measurement issue in the aid-complexity literature was found and emphasised. This aligns with the previous literature suggesting that conventional aid-growth studies often use highly abstract aid variables, containing subcategories with scarce relevance to growth (Qian, 2014). The measurement issue is especially prevalent for the variables bilateral aid, TC and non-TC, which are considerably broader than the variables of aid to education and aid to energy. This underscores that the well-known measurement issue of the aid-growth literature is contagious in the emerging aid-complexity literature as well (see Arpaci-Ayhan, 2022; Kamguia et al., 2022). The validity of the findings concerning bilateral aid, TC and non-TC, both in previous research and the present study, can therefore be questioned. This suggests that the negative associations found through bilateral, TC and non-TC should not be seen as representative and universal for all foreign aid.

In fact, aid for embodied and codified knowledge measured through aid to energy was found to be positively associated with growth, and this association was found to be amplified in countries where this knowledge is arguably scarce relative to knowhow. Meanwhile, aid for knowhow through aid to education was found to be negatively associated with growth, and this association was found to be mitigated in countries where such knowledge is expected to be relatively scarce. This suggests that the links between aid, growth and complexity are

heterogenous to both aid type and context of productive knowledge relative to income. Thus, confirming the notion that aid needs to be tailored to be effective (Qian, 2014; Ramalingam, 2013, pp. 360-363; Banerjee & Duflo, 2011, pp. 267-273; Bourguignon & Sundberg, 2007) and bringing productive knowledge relative to income as a further dimension that policymakers may need to consider.

## 7.1 Future Research

This thesis was an attempt to link foreign aid, growth and complexity based on the context of productive knowledge relative to income. To accommodate the scope of a master's thesis, both conceptual and empirical sacrifices were made. One main implication is that the findings are correlational and not causal. Since no other studies, to the author's knowledge, have linked foreign aid and economic growth with economic complexity, further efforts are needed to complement and build-upon the present paper. Such studies may, for example, extend the context of productive knowledge relative to income conceptually, particularly with regards to relative stocks of types of knowledge between countries. This may be based on economic complexity or other measures, and employ more comprehensive econometric methods than the one used here, such as a generalized method of moments with fixed effects and lagged variables (in line with Kamguia et al., 2022; Arpaci-Ayhan, 2022; Gnangnon, 2021).

Furthermore, as Bourguignon & Sundberg (2007) argues, research needs to improve on tracing the causal mechanisms between foreign aid and economic growth. This certainly holds for the aid-complexity literature, which to date and including this study, only consists of large-N studies, as far as I am aware. This would force scholars to move beyond the all-encompassing variables such as bilateral aid and technical and non-technical cooperation, which is clearly needed. To trace the mechanisms at the micro-level, studies may for example draw on Hidalgo's (2021) 4W's framework to explore how foreign aid projects relate to the product space. This may be informative to understand if aid is directed to the suitable sectors, at the right time and geographical locations to enable countries to assist countries in becoming more complex. Such studies may present original and worthwhile contributions to both the aid-growth and aid-complexity literature.

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# Appendix A

***Table 11:*** *Sample of 27 countries in Sub-Saharan Africa*

| No. | Country name | ISO-Code |
|---|---|---|
| 1 | Angola | AGO |
| 2 | Burkina Faso | BFA |
| 3 | Botswana | BWA |
| 4 | Cameroon | CMR |
| 5 | D.R. Congo | COD |
| 6 | Rep. of Congo | COG |
| 7 | Côte d'Ivoire | CIV |
| 8 | Ethiopia | ETH |
| 9 | Gabon | GAB |
| 10 | Ghana | GHA |
| 11 | Guinea | GIN |
| 12 | Kenya | KEN |
| 13 | Madagascar | MDG |
| 14 | Mali | MLI |
| 15 | Mozambique | MOZ |
| 16 | Mauritius | MUS |
| 17 | Malawi | MWI |
| 18 | Namibia | NAM |
| 19 | Nigeria | NGA |
| 20 | Senegal | SEN |
| 21 | Swaziland | SWZ |
| 22 | Togo | TGO |
| 23 | Tanzania | TZA |
| 24 | Uganda | UGA |
| 25 | Zambia | ZMB |
| 26 | Zimbabwe | ZWE |
| 27 | South Africa | ZAF |

# Appendix B

***Table 12**: Descriptions of aid variables of interest (from the OECD, n.d.a)*

| Variable | Description | Subcategories |
|---|---|---|
| **Bilateral** | Total bilateral aid disbursements from all official donors (constant 2021 US$, millions). | Any sectoral destination through any modality. |
| **TC** | Total bilateral aid by the aid modality technical cooperation from all official donors (constant 2021 US$, millions), following Arpaci-Ayhan's (2022) division. | Any sectoral destination by the following sub-modalities: Project-type interventions; experts and other technical assistance; scholarships and assistance with student costs. |
| **NonTC** | Total bilateral aid by aid modality non-technical cooperation from all official donors (constant US$, millions), following Arpaci-Ayhan's (2022) division. | Any sectoral destination by the following sub-modalities: Budget support; core contributions and pooled programmes and funds; administrative costs not included elsewhere; other in-donor expenses; not applicable. |
| **Aid_Edu** | Total bilateral aid to the education sector (constant 2021 US$, millions), from all official donors. | Subcategory of the main category social infrastructure and services. The education subcategory includes the following: Education, Level Unspecified, Basic Education, Upper Secondary Education, Post-Secondary Education |
| **Aid_Energy** | Total bilateral aid to the energy sector (constant 2021 US$, millions), from all official donors. | Subcategory of the main category economic infra-structure and services. The energy subcategory includes the following: Energy policy and administrative management; Energy education/ training; Energy research; Energy conservation and demand-side efficiency; Energy generation, renewable sources - multiple technologies; Hydro-electric power plants; Solar energy for centralised grids; Solar energy for isolated grids and standalone systems; Solar energy - thermal applications; Wind energy; Marine energy; Geothermal energy; Biofuel-fired power plants; Energy generation, non-renewable sources, unspecified; Coal-fired electric power plants; Oil-fired electric power plants; Natural gas-fired electric power plants; Fossil fuel electric power plants with carbon capture and storage; (CCS); Non-renewable waste-fired electric power plants; Hybrid energy electric power plants; Nuclear energy electric power plants and nuclear safety; Heat plants; District heating and cooling; Electric power transmission and distribution (centralised grids); Electric power transmission and distribution (isolated mini-grids); Retail gas distribution; Retail distribution of liquid or solid fossil fuels; Electric mobility infrastructures |

Note: the education subcategory contains additional subcategories at a more detailed level.

# Appendix C

***Table 13**: Descriptions and sources ECI, growth and control variables*

| Variable | Description | Source |
|---|---|---|
| **ECI** | Economic Complexity Index computed using Standard international Trade Classification for products (rev. 2) | The Growth Lab at Harvard University (2019) |
| **PKI_cat** | Dummy variable representing the category of productive knowledge relative to income, defined as high or low economic complexity relative to income. | Author's calculation and definition drawing on Hidalgo & Hausmann (2009) and Balland et al. (2022), using data from The Growth Lab at Harvard University (2019) and World Bank (2024) |
| **GDPpc** | GDP per capita (2015 constant US$, thousand) | World Bank (2024) |
| **Gov_effect** | Government Effectiveness: Estimate, which "captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies" (World Bank, 2024). Normalized values ranging from -2.5 to 2.5. | World Bank (2024) |
| **Res_rents** | Total natural resources rents (% of GDP) | World Bank (2024) |
| **Fin_dev** | Proxy for financial development (following Kamguia et al., 2022). Domestic credit to the private sector (% of GDP). | World Bank (2024) |
| **FDI** | Foreign Direct Investment, net inflows (% of GDP) | World Bank (2024) |
| **Remitt** | Personal remittances, received (% of GDP) | World Bank (2024) |
| **Internet** | Individuals using the internet (% of population) | World Bank (2024) |

# Appendix D

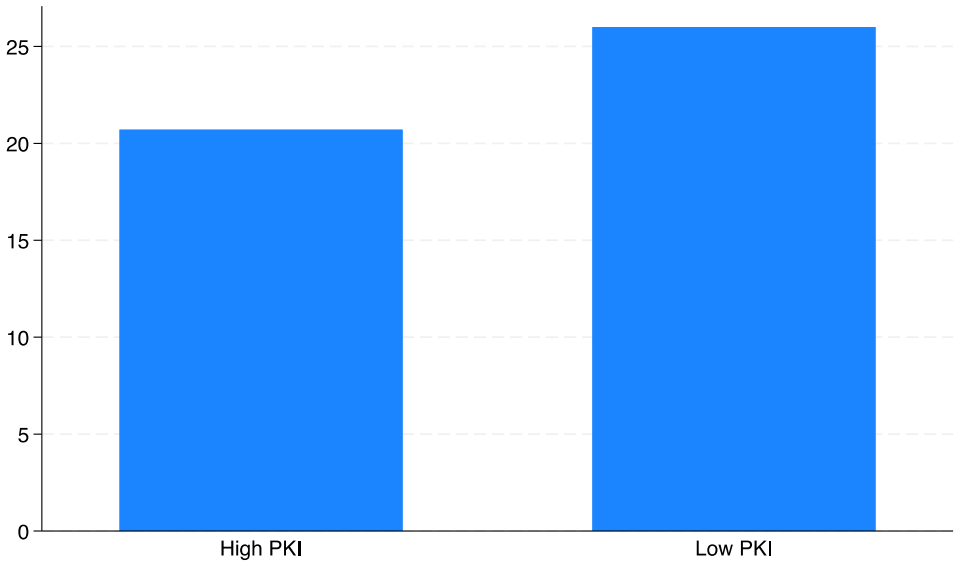


***Figure 6**: Gross capital formation (% of GDP) by context of productive knowledge relative to income, mean from 2002-2021, PKI-sample (author's construction)*

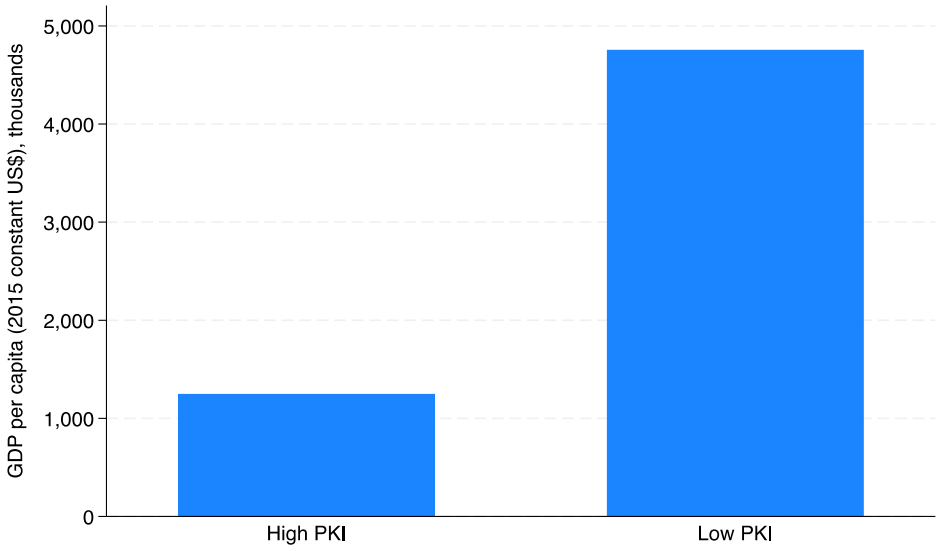


***Figure 7:** GDP per capita by on context of productive knowledge relative to income, mean from 2002-2021 for 132 countries, PKI-sample (author's construction)*

# Appendix E

***Table 14**: Movement between categories of PKI_cat*

| PKI_Cat | Countries consistent within category from 2002-2021 | Countries moving between categories. Number of years spent within category in parenthesis. |
|---|---|---|
| **Observations below (=0)** | BFA; COD; ETH; GIN; KEN; MDG; MLI; MOZ; MWI; SEN; SWZ; TGO; TZA; UGA; ZMB; ZWE | CIV (7);<br>CMR (5);<br>GHA (2) |
| **Observations above (=1)** | AGO; BWA; COG; GAB; MUS; NAM; NGA; ZAF | CIV (13);<br>CMR (15);<br>GHA (18) |

Note: country names corresponding with the ISO-codes are available in appendix A.

# Appendix F

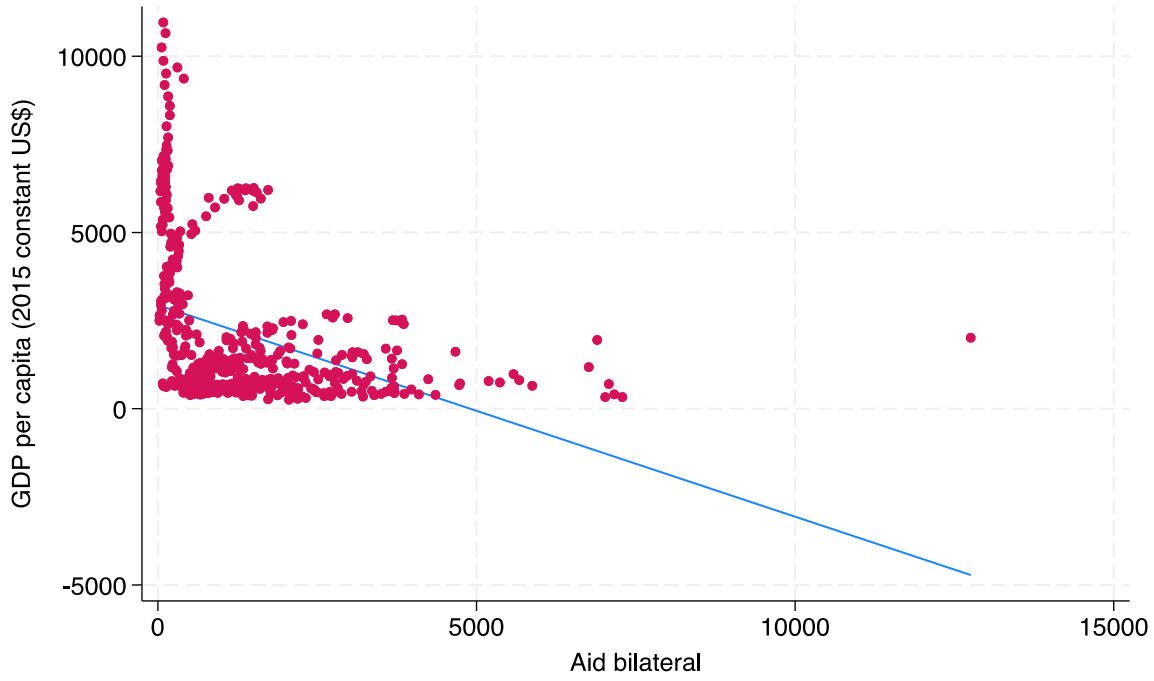


***Figure 8**: Linear-linear fit of GDP per capita and bilateral aid (author's construction)*

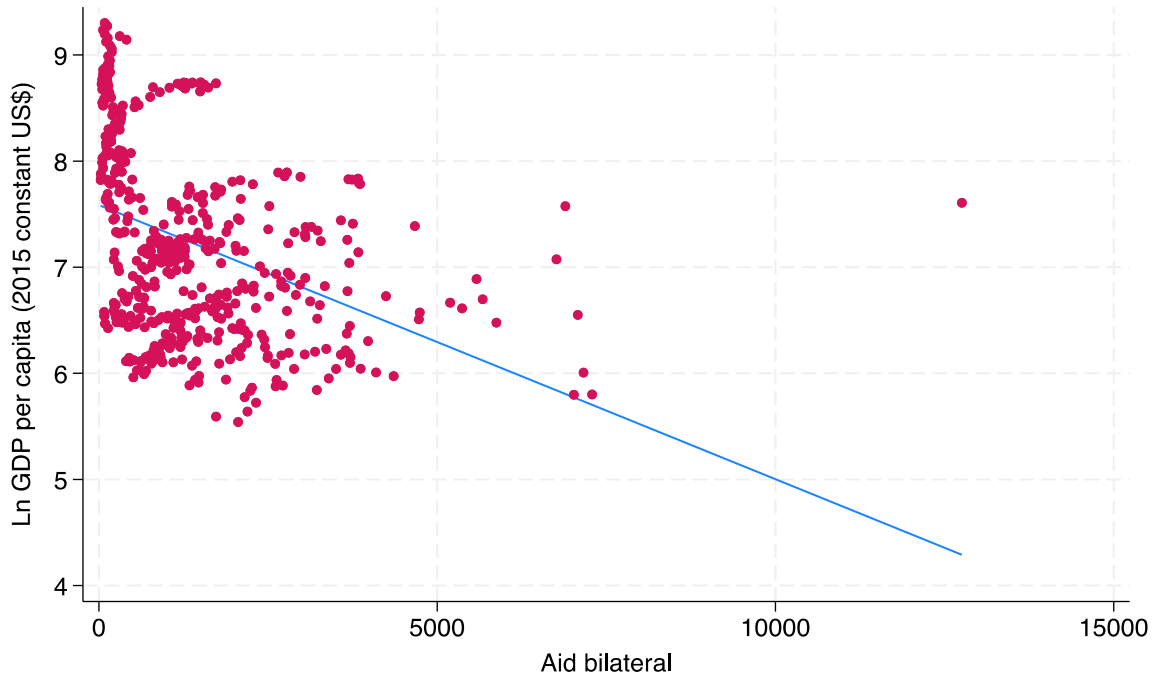


***Figure 9**: Log-linear model of GDP per capita and Bilateral aid (author's construction)*

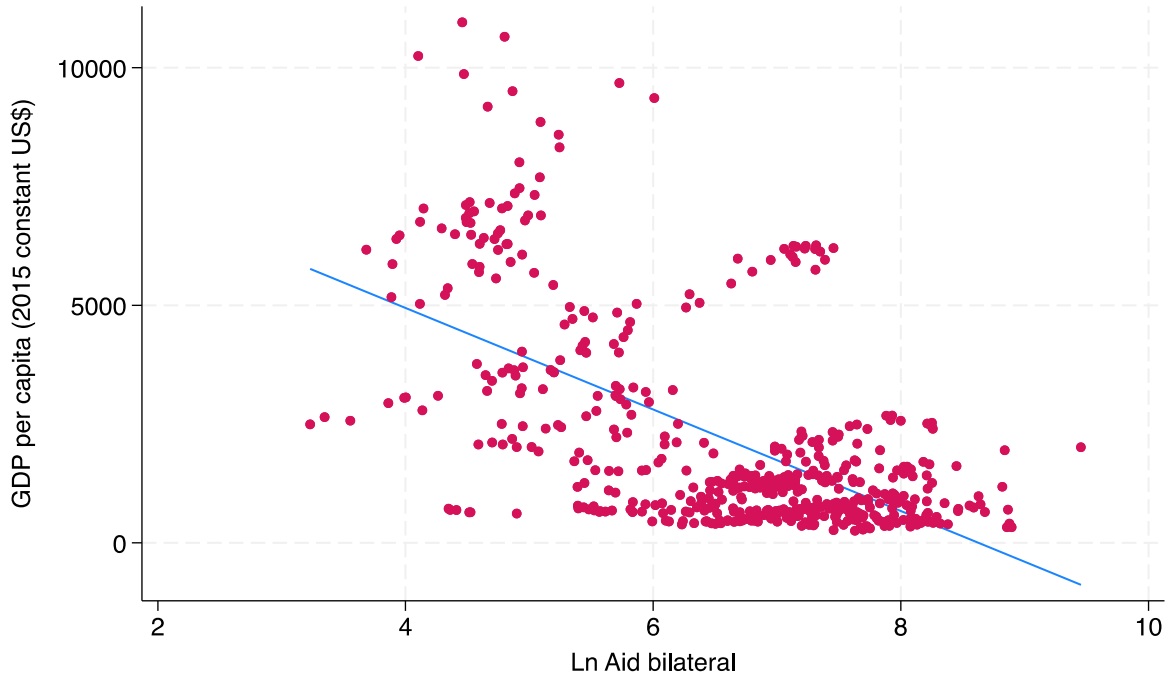


***Figure 10**: Linear-log model of GDP per capita and bilateral aid (author's construction)*

# Appendix G

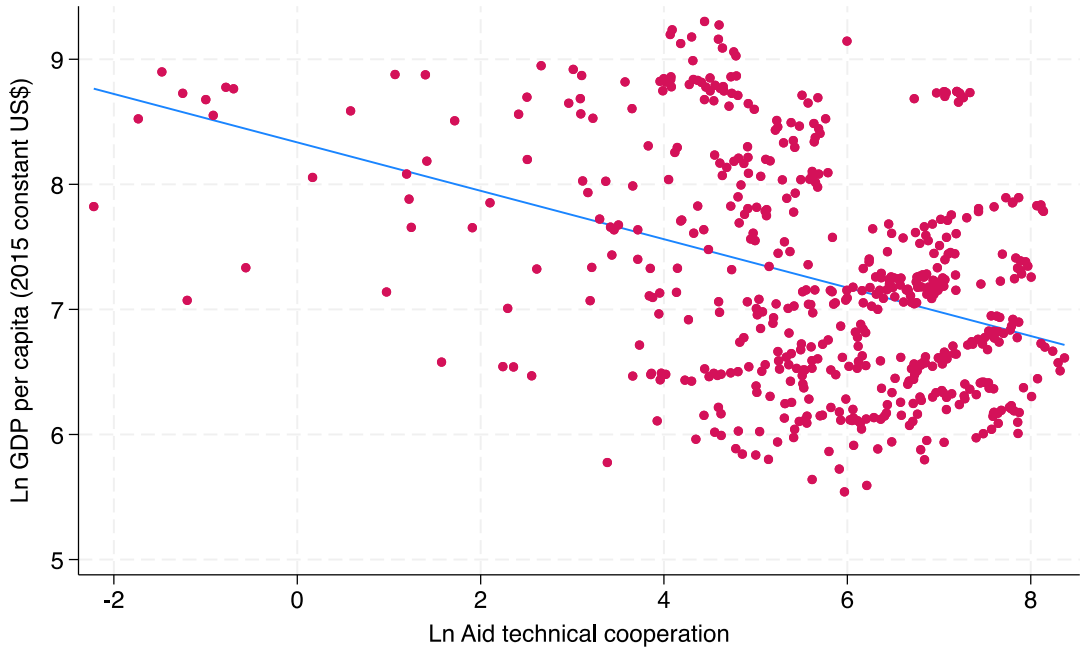


***Figure 11**: Log-log model of GDP per capita and technical cooperation (author's construction)*

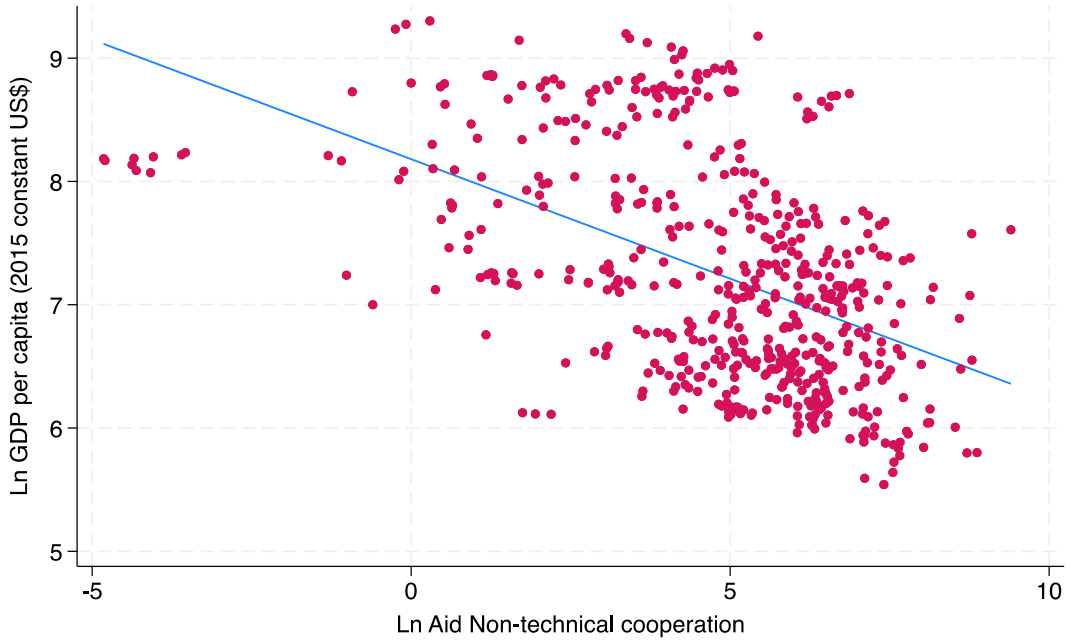


***Figure 12**: Log-log model of GDP per capita and Non-technical cooperation (author's construction)*

# Appendix H

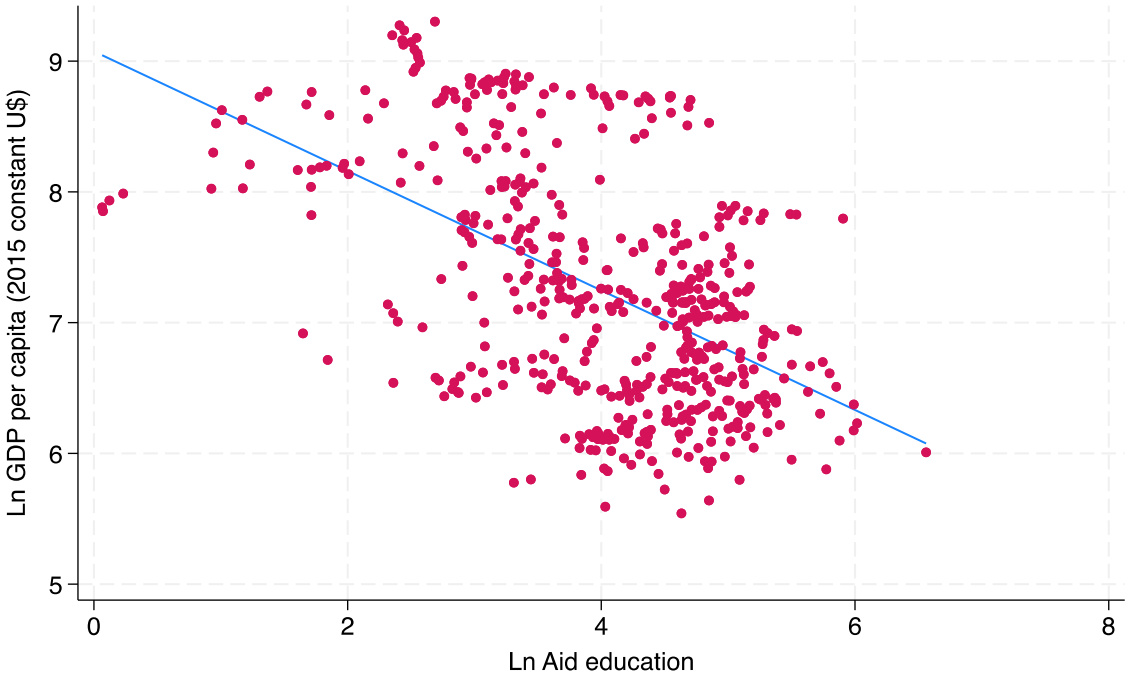


***Figure 13**: Log-log model of GDP per capita and aid to education (author's construction)*

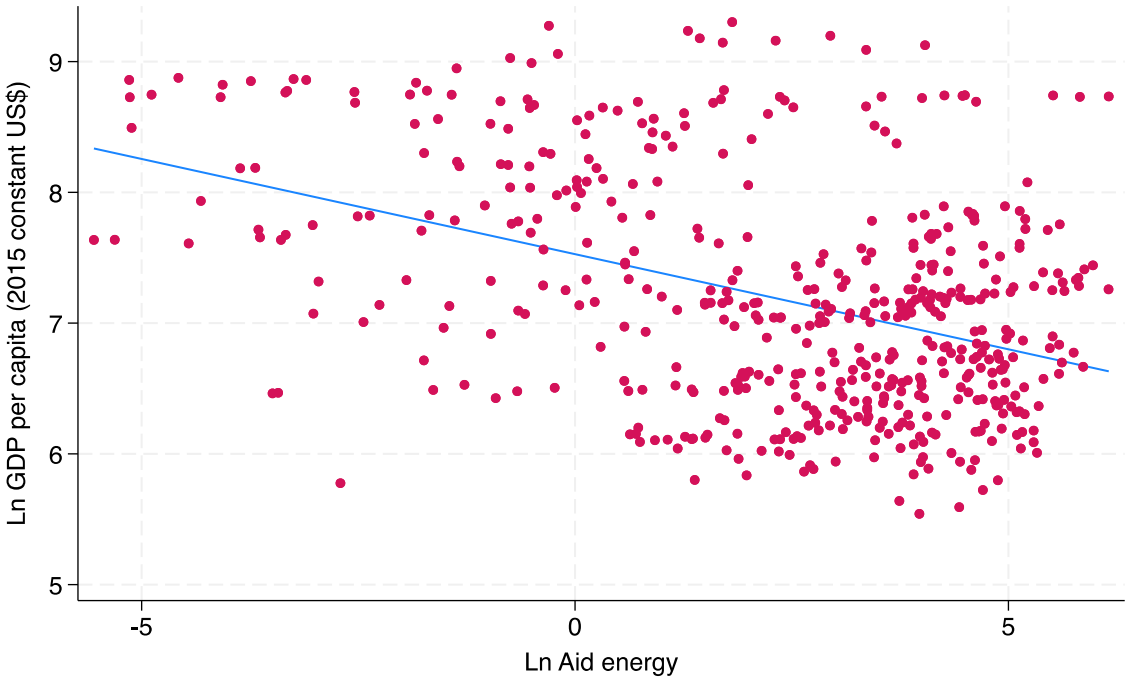


***Figure 14**: Log-log model of GDP per capita and aid to energy (author's construction)*

# Appendix I

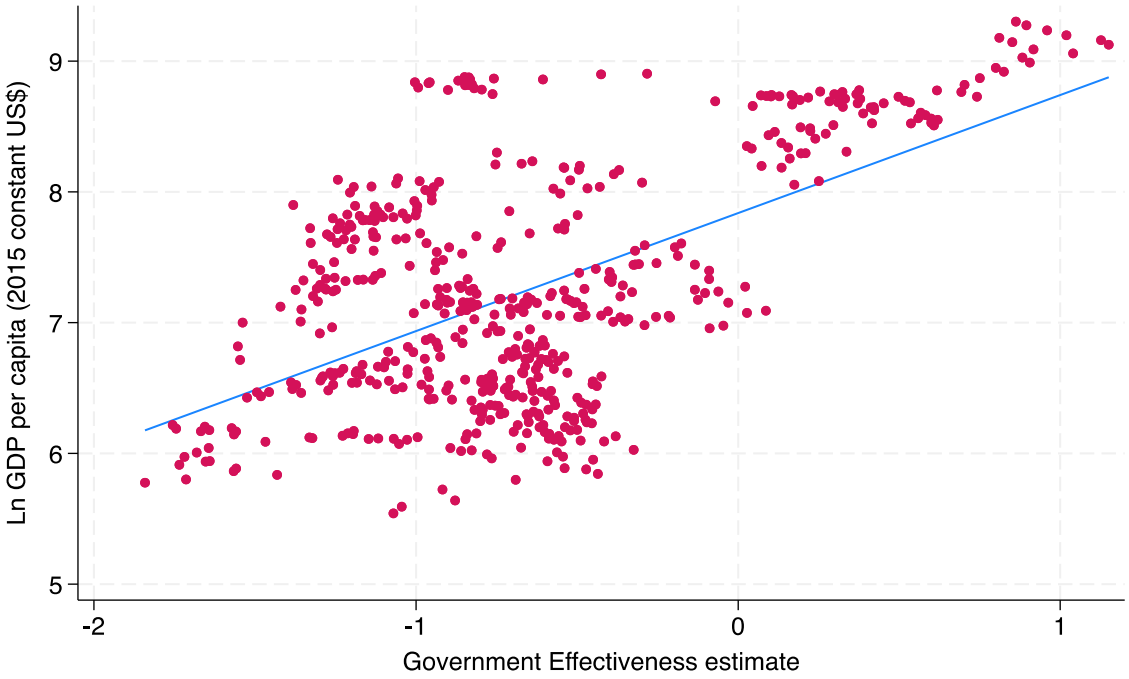


***Figure 15:*** *Natural log of GDP per capita and government effectiveness (author's construction)*

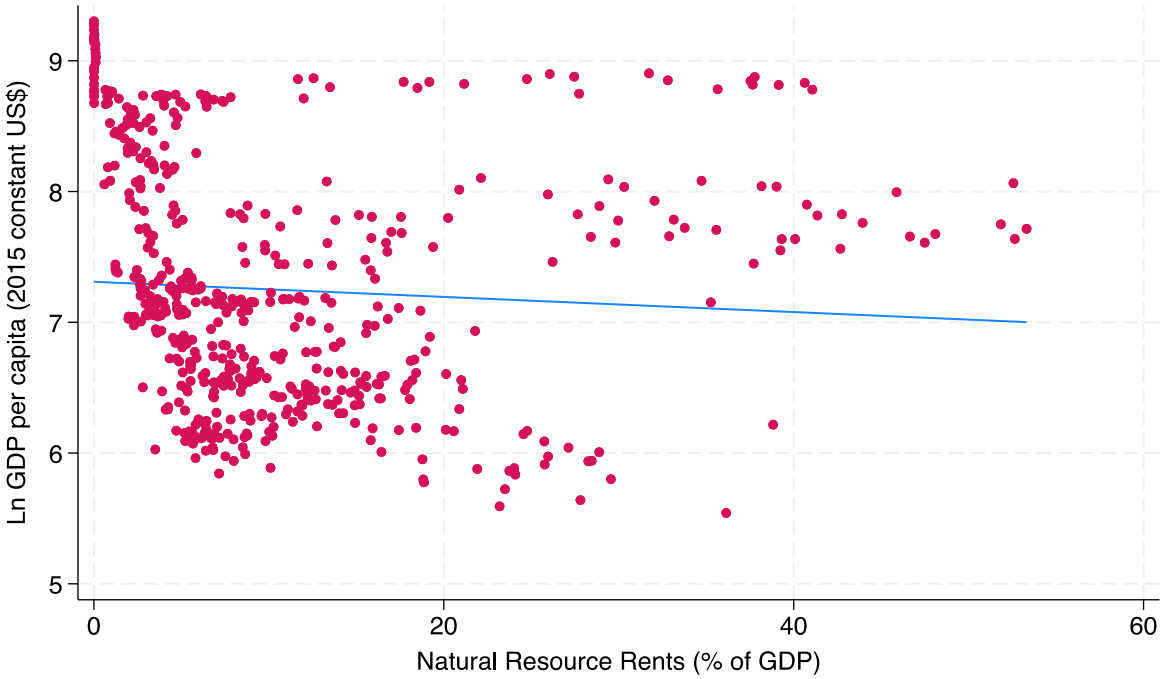


***Figure 16****: Natural log of GDP per capita and Natural Resource Rents (% of GDP) (author's construction)*

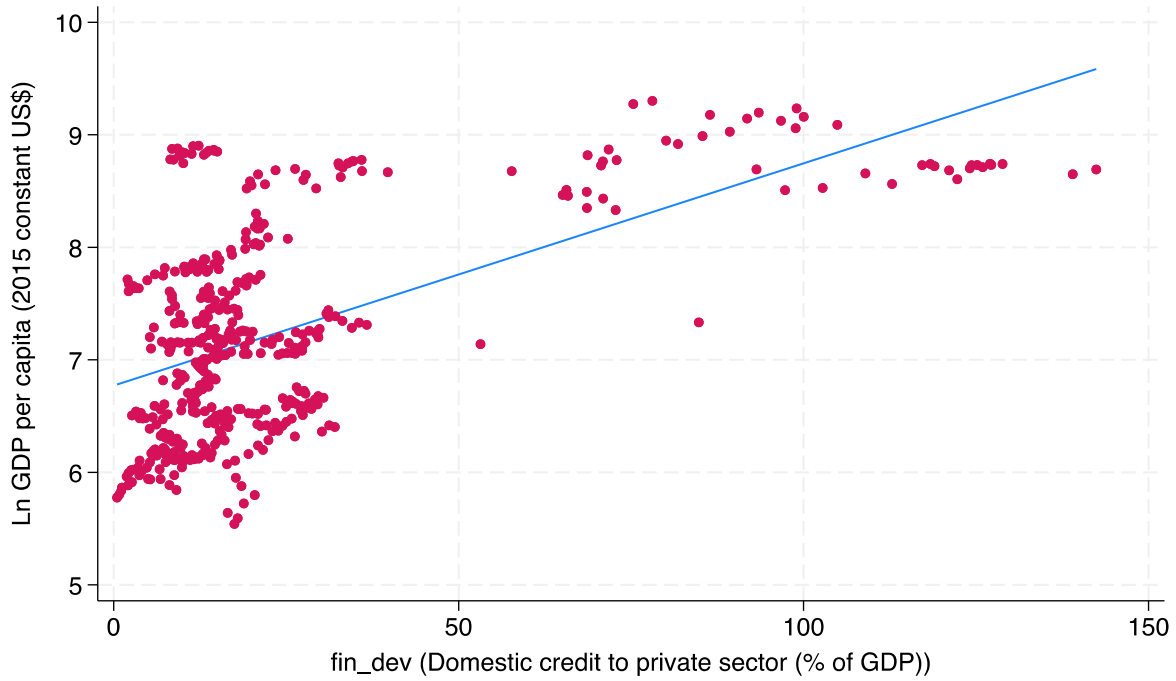


***Figure 17**: Natural log of GDP per capita and financial development (author's construction)*

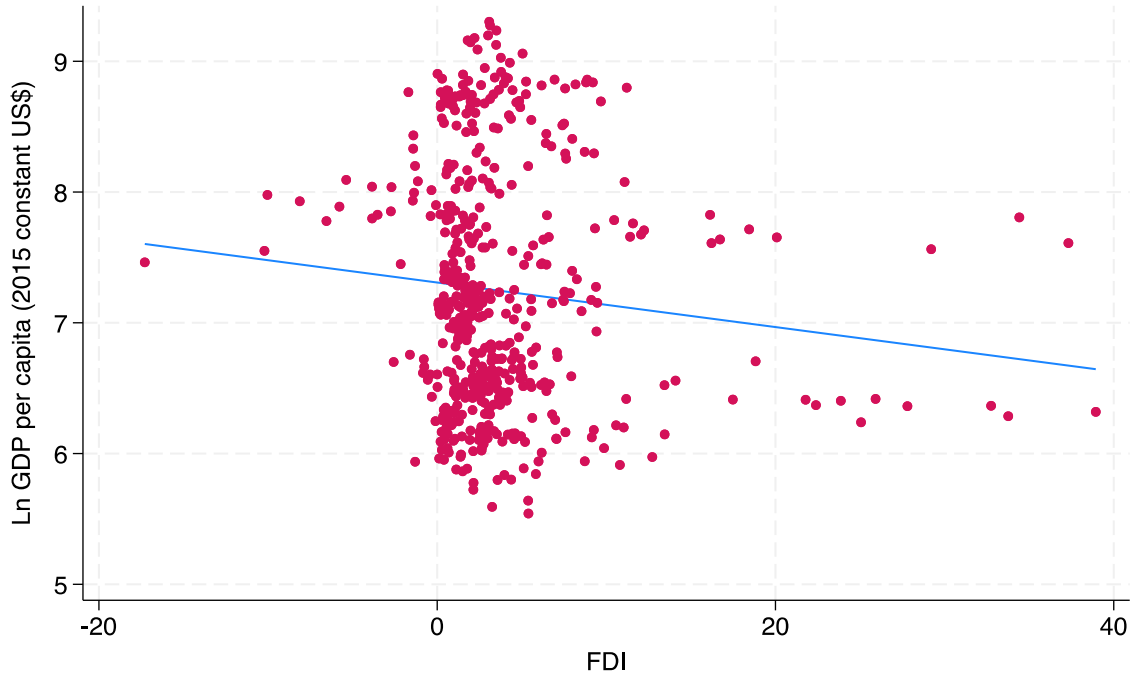


***Figure 18**: Natural log of GDP per capita and FDI inflows (% of GDP) (author's construction)*

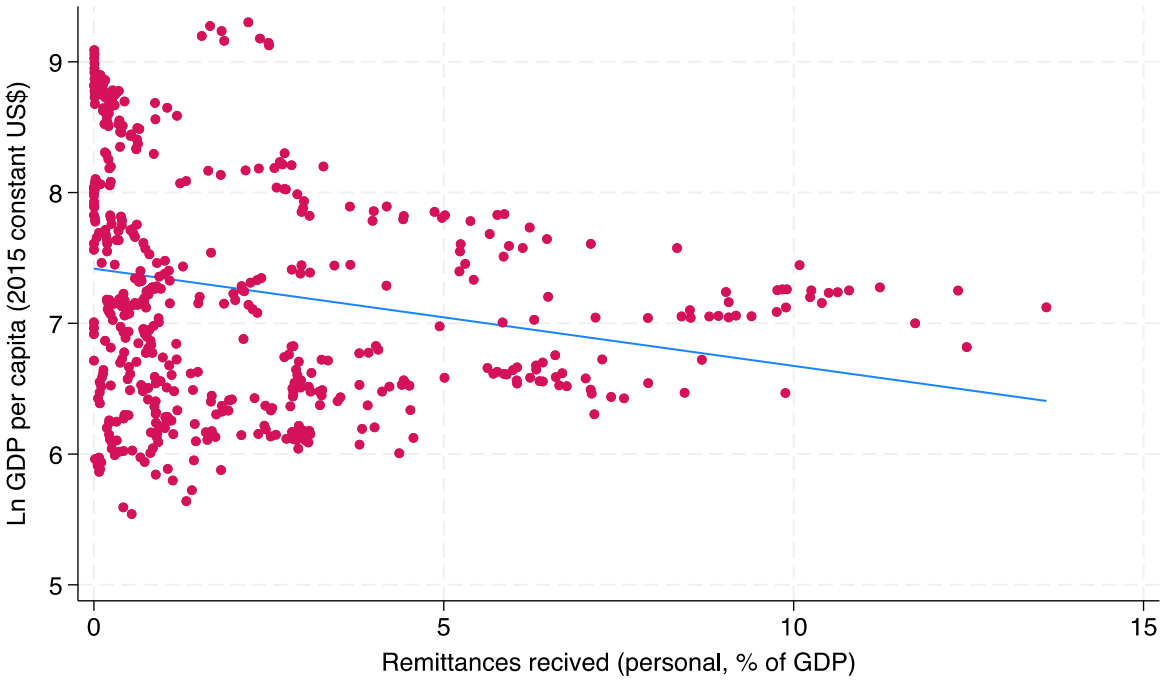


***Figure 19**: Natural log of GDP per capita and remittances (author's construction)*

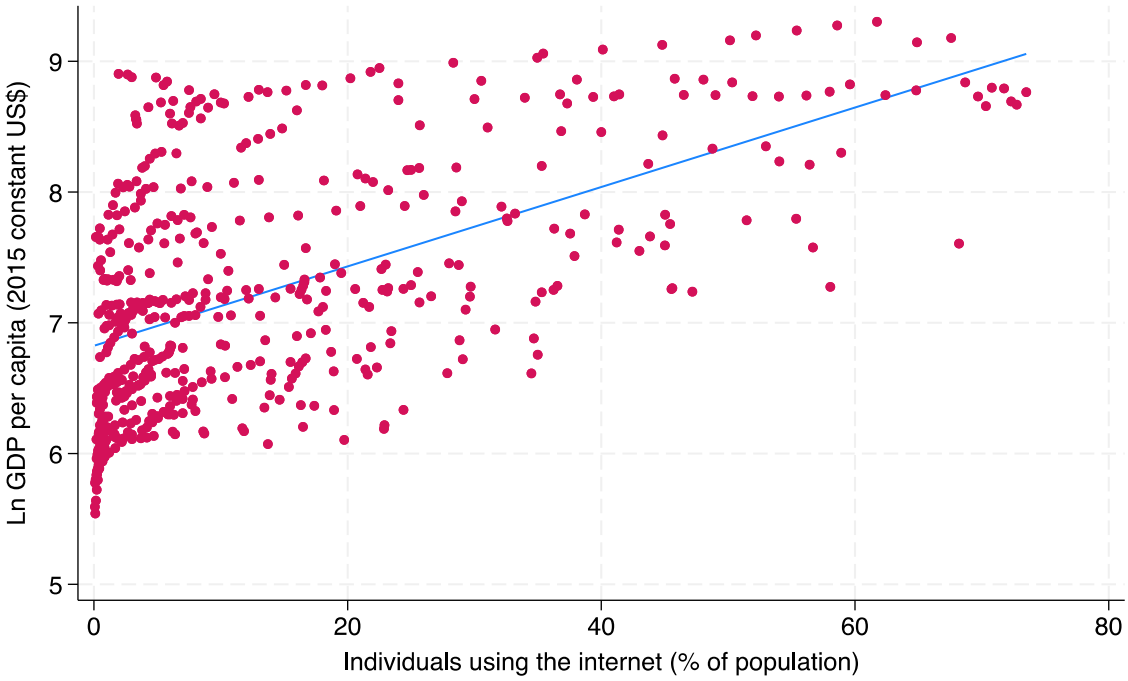


***Figure 20:** Natural log of GDP per capita and internet) (author's construction)*

# Appendix J

***Table 15:*** *Variance inflationary factor, TC and non-TC model*

| Variable | VIF | 1/VIF |
|---|---|---|
| Ln_TC*PKI_cat | 4.45 | 0.224526 |
| Ln_NonTC*PK_cat | 4.07 | 0.245757 |
| Gov_effect | 2.78 | 0.359737 |
| Fin_dev | 2.34 | 0.427384 |
| Internet | 2.20 | 0.453856 |
| Res_rents | 1.87 | 0.534534 |
| Ln_Aid_TC | 1.63 | 0.613836 |
| Ln_Aid_NonTC | 1.53 | 0.653032 |
| Remitt | 1.28 | 0.778811 |
| FDI | 1.12 | 0.891947 |
| Mean VIF | 2.33 | |

***Table 16:*** *Variance inflationary factor, aid to education and energy model*

| Variable | VIF | 1/VIF |
|---|---|---|
| Ln_Aid_Energy | 4.77 | 0.209551 |
| Ln_Aid_Energy*PK_cat | 3.82 | 0.261846 |
| Ln_Aid_Edu*PKI_cat | 3.52 | 0.284339 |
| Gov_effect | 2.83 | 0.353143 |
| Ln_Aid_Edu | 2.55 | 0.391855 |
| Fin_dev | 2.40 | 0.416581 |
| Res_rents | 2.28 | 0.439408 |
| Internet | 1.69 | 0.592371 |
| Remitt | 1.23 | 0.812628 |
| FDI | 1.13 | 0.884630 |
| Mean VIF | 2.62 | |

# Appendix K

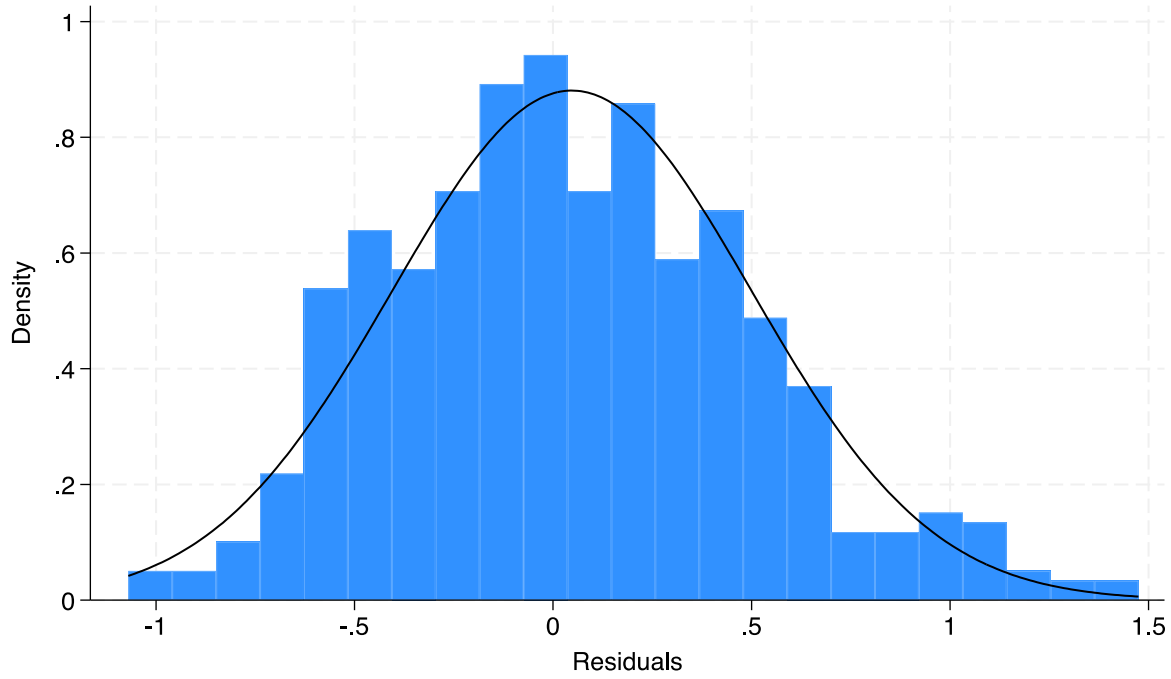


***Figure 21:*** *Distribution of residuals, bilateral aid model with all control variables (author's construction)*

***Table 17****: Shapiro-Wilk test*

| Variable | Obs | W | V | Z | Prob>z |
|---|---|---|---|---|---|
| Ln_GDPpc | 540 | 0.95165 | 17.435 | 6.895 | 0.0000*** |
| Ln_Bilateral | 540 | 0.95916 | 14.726 | 6.488 | 0.0000*** |
| Ln_Bilateral*PKI_cat | 540 | 0.93784 | 22.413 | 7.501 | 0.0000*** |
| Ln_TC | 539 | 0.90436 | 34.427 | 8.536 | 0.0000*** |
| Ln_TC*PKI_cat | 539 | 0.91252 | 31.488 | 8.320 | 0.0000*** |
| Ln_NonTC | 540 | 0.91174 | 31.822 | 8.346 | 0.0000*** |
| Ln_NonTC*PKI_cat | 540 | 0.89323 | 38.498 | 8.806 | 0.0000*** |
| Ln_Aid_Edu | 540 | 0.95460 | 16.371 | 6.743 | 0.0000*** |
| Ln_Aid_Edu*PKI_cat | 540 | 0.94299 | 20.555 | 7.292 | 0.0000*** |
| Ln_Aid_Energy | 540 | 0.91982 | 27.360 | 7.960 | 0.0000*** |
| Ln_Aid_Energy*PKI_cat | 540 | 0.85817 | 48.398 | 9.332 | 0.0000*** |
| Gov_effect | 540 | 0.94621 | 19.394 | 7.152 | 0.0000*** |
| Res_rents | 540 | 0.81281 | 67.493 | 10.160 | 0.0000*** |
| Fin_dev | 475 | 0.62324 | 121.020 | 11.502 | 0.0000*** |
| FDI | 539 | 0.68987 | 111.636 | 11.373 | 0.0000*** |
| Remitt | 530 | 0.77268 | 80.594 | 10.579 | 0.0000*** |
| Internet | 536 | 0.77125 | 81.927 | 10.624 | 0.0000*** |

*Notes:* *$*p<0.1$; **$p<0.05$;***$p<0.01$*