Essays on Economic Growth, Poverty, and Child Educational Performance in Africa

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This is to certify that the dissertation prepared by Kahsay Berhane Lemma, entitled: *Essays on economic growth, poverty and child educational performance in Africa* and submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Economics complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

This doctoral dissertation consists of an introduction and three independent single-author papers on economic growth, poverty and child educational performance in Africa. The introduction introduces the rest of the chapters and the motivation for studying these aspects and the contributions that the three papers make to existing literature. The dissertation has three standalone papers which were written so that they would eventually be published as separate articles in academic journals. Previous versions of these papers have been published as chapters in three different books published by Palgrave Macmillan, Routledge and Springer.

The first paper studies the role of financial development and institutional quality in economic growth in an era of globalization based on the dynamic common correlated effect (DCCE) method in 40 African countries over the period 1980-2014. The overall financial development measure is calculated as an average of indices measuring the extensiveness of financial institutions and financial markets. The financial institutions index includes information on banks, insurance companies and pension and mutual funds, while the financial markets index includes information on stock and bond markets. This paper studies financial depth, access and efficiency of both financial institutions and financial markets. Its empirical findings show that overall financial development had a positive and significant effect on long-term economic growth in the entire sample. However, the effects of financial development and its sub-components on economic growth varied across different levels of economic development and across the two dimensions of financial development -- extensiveness of financial institutions and of financial markets.

The second paper analyzes the differentiated relationship between trade liberalization and poverty in 43 African economies over the period 1980-2014. It uses the augmented mean group (AMG) estimator which allows for parameter heterogeneity and cross-sectional dependence in its panel common-factor estimates to avoid biased and inconsistent estimates. Its findings show that generally speaking trade openness had a positive and significant relationship with poverty reduction. However, country-specific empirical results show that the effect of trade openness on poverty varied across countries. This suggests that the effect of trade liberalization on poverty is heterogenous and depends on country-specific trade policy and poverty reduction strategies.

The third paper provides a micro-panel analysis of the impact of child nutrition, health and household wealth on children's educational performance as measured by the Peabody Picture Vocabulary Test (PPVT) score in Ethiopia. The study uses the second and third rounds of longitudinal data from the Young Lives survey in Ethiopia on two cohorts of children. The survey covered 1,792 children aged around 5-years and 444 children aged around 12-years in 2006. The same children were covered in 2009 and are included in my analysis. The results show that the child-nutrition-and-health indicator had a positive and significant effect on child cognitive skills for the younger cohort, while it had an insignificant effect on the older cohort. The study also found that the household wealth index had a positive and significant relationship with children's educational performance for all ages considered in the study. Furthermore, the findings also show that child labor had a negative effect on a child's academic achievements in the older cohort, and this effect was stronger for girls than it was for boys of similar ages.

Keywords: Economic growth, poverty, child educational performance, dynamic heterogeneous, standard panel model, African countries.

Table of Contents

List of Tables

List of figures

Introduction and Summary of the Dissertation

"An integrated, prosperous, and peaceful Africa, driven by its own citizens and representing a dynamic force in the international arena"

The Pan-African Vision supported by the African Union (African Union Commission, 2015)

1. Introduction

In the last three decades, almost all the African countries have witnessed regional and global integration in economic, social and political dimensions. Policymakers in developing countries have often considered globalization in general and trade liberalization in particular as being favorable for economic growth and poverty reduction, not only because of the classical argument of taking advantage of comparative advantage but also because of the idea that globalization provides benefits by enhancing strong competition, by promoting a larger market for firms' products so that they can take advantage of the economies of scale and by inducing transfer of technology and thus increasing efficiency in production (see, for example, Bloom et al., 2016; Dorn et al., 2017; Lang & Tavares, 2018; Samimi & Jenatabadi, 2014).

Many African countries have made multilateral and regional efforts to liberalize trade by reducing both tariff and non-tariff barriers, by providing more uniform levels of protection among the member countries within the same economic bloc and by promoting free flow of foreign direct investments to achieve sustainable and inclusive economic growth on the continent.

The effect of globalization depends on a set of complimentary economic characteristics such as improvements in financial systems and institutional quality that can stimulate efficiency in resource allocation thus boosting economic growth. Therefore, in addition to participating in globalization, African countries have also made significant efforts to expand the depth, efficiency and stability of their financial systems, which have included liberalizing them. Likewise, there have also been substantial improvements in the level of institutional quality in Africa in the past few decades which has helped facilitate skill and technology transfers from developed countries and foreign investors, led to efficient resource allocations and encouraged the accumulation of

savings and human capital, all of which improve total factor productivity and boost economic growth in the countries implementing them.

However, despite African countries' engagement in economic, social and political globalization and the expansion of their financial systems, the continent has not yet achieved the expected outcomes and remains the poorest continent in the world due to numerous longer-term challenges. Some of the many problems that have hampered economic growth and left much of Africa with persistently high levels of poverty are lack of sufficient human and physical capital, lack of well-functioning financial systems, absence of good institutional quality, slow or no structural transformations to move resources from the low-productive agricultural sector to the higher-productive manufacturing-and-service sectors and recurrent exposure to weather-related shocks and natural disasters. Moreover, rapid population growth in Africa has contributed to an increase in the number of poor from 280 million in 1990 to 330 million in 2012 (Beegle et al., 2016). The 2016 edition of the Brooking Institution's annual Foresight Africa projections report also shows that the world's poor will gradually be more concentrated in Africa, keeping the continent at the forefront on the global poverty agenda even in an era of globalization (Sy, 2016).

To tackle the numerous structural challenges, almost all African countries have been implementing the long-term continental development plan Agenda 2063, the global Sustainable Development Goals (SDGs) and short-term national development plans to achieve broad-based and inclusive economic growth that creates employment opportunities for all, especially for women and the youth, and eradicates extreme poverty on the continent in the shortest possible period of time. Both the global and continental development goals are harmonized and integrated with each other and are also further aligned with national development plans to ensure the realization of Africa's vision to become a future growth pole that shares the benefits of sustainable development with all people in an area free from hunger and poverty by 2063.

To achieve the SDGs and Agenda 2063's goals, Africa needs a strong, visionary and determined leadership that reallocates resources to more productive sectors, resulting in sustainable and inclusive economic growth that creates employment opportunities for all, implements policies to eradicate extreme poverty and narrows inequalities in the region. Among other things, a well-functioning financial system and sound institutional quality are crucial for ensuring smooth international financial flows from the developed to the developing economies and for channeling

available financial resources into higher productive investments, resulting in sustained and inclusive economic growth. In the last few decades, financial sector development has been on the agenda of almost all African policymakers who have undertaken significant efforts to expand the depth, efficiency and stability of the financial systems.

Moreover, African policymakers need to strengthen regional and global integration; increase investments in infrastructure such as inter- and intra-continental road and railways and rural and urban electrification; and ensure availability of clean water and sanitation and functional health centers. They also need to promote and enhance the private sector's development that will enable the sharing of the benefits of development with all the people in Africa. Furthermore, plans for meeting both Agenda 2063 goals and the SDGs need investments in the people of Africa including investments in early childhood development, investments that broaden access to education and investments that strengthen skills in science and technology and innovation and research so that the people can drive the continent's development.

Malnutrition has been on the agenda of almost all African countries since it is one of the most serious problems facing these countries. Its importance is reflected in both the SDGs and in short-term national development plans. Notably, malnutrition in a child within the first 1,000 days of his or her life can cause irreversible damage to his/her cognitive development and has negative educational, income and productivity consequences that reach far into adulthood. Although malnutrition in African countries decreased between 2000 and 2015, high levels of malnutrition and growth failures still persist in Ethiopia.

This dissertation is comprised of three standalone papers on different areas of developmental economics in the context of Africa. The purpose of Paper 1 is to examine the role of financial development and institutional quality in economic growth for 40 Africa countries over the period of 1980-2014. Paper 2 investigates the differential effects of trade liberalization on poverty in 43 African countries. Paper 3 sheds light on the impact of nutrition, health and household wealth on a child's educational performance in Ethiopia using panel data from the Young Lives dataset.

The next three sections of this chapter provide a brief statement of the problems and research questions investigated, the objectives of the dissertation and the methodological approaches and

data sources. This chapter also provides a summary of the three papers that follow, including their contributions and policy implications.

2. Statement of the problem and research questions investigated

All African countries have been implementing the global SDGs and the long-term Agenda 2063 plan in Africa to achieve sustainable and inclusive economic growth and to eradicate poverty. To achieve such broad and comprehensive goals in a globalized world, African countries have made substantial progress in the efficient use of financial resources, improved institutional quality, enhanced global and regional economic integration and greater investments in human capital and health.

Furthermore, over the last few decades almost all African countries have been extensively engaged in trade liberalization and have improved their financial development. Even though financial development has improved, it is still segmented, bank-based, government-directed and oligopolistic, facing little competition (Demirgüç-Kunt et al., 2008; Ncube, 2007). Moreover, it is not possible to channel excess savings in developed countries into efficient and profitable investments in developing countries since the banks and capital markets in the latter countries are not fully integrated with the global market. Hence, whether further development in financial markets and/or financial institutions will accelerate economic growth in Africa remains an unresolved empirical question which the first paper investigates.

Since the late 1980s, almost all African countries have increased their dependence on trade and adopted more liberal trade policies under structural adjustment programs (SAPs) designed by the World Bank and The International Monetary Fund (IMF). More recently most of the African countries have engaged in regional economic integration and joined the World Trade Organization (WTO) to increase the free flow of goods and services to drive economic growth and for eradicating poverty on the continent. Trade liberalization affects poverty indirectly through its impact on growth and more directly through its impact on incomes such as wages, through its effect on employment and price levels, and through government revenue loss from low or no tariffs. Moreover, the effect of trade liberalization depends on a number of factors including the range and types of commodities exported, the number of markets they are exported to and the market share these exports have in those markets, and the level of economic development. Hence, it is crucial to examine the country-specific impact of trade liberalization on poverty in Africa.

Reducing malnutrition forms a part of the SDGs and has been on policymakers' agenda in many African countries. Though stunting in sub-Saharan African countries has declined from 49 percent in 1990 to 34 percent in 2016 its prevalence differs across countries with Ethiopia remaining above the average for sub-Saharan African countries. As per the Demographic Health Survey (DHS) approximately 40 percent of the children aged under 5 years in Ethiopia were stunted in 2010, decreasing from 58 percent in 2000 (Headey, 2014). Malnutrition is one of the most serious global and regional challenges that causes irreversible damage to cognitive skills, which reduces a child's educational performance and his or her labor productivity in adulthood. Hence, improving children's nutritional status and households' socioeconomic status has become an important policy priority for the Government of Ethiopia.

This dissertation seeks to fill existing gaps in the literature by answering the following research questions:

- ✓ Does financial development matter for economic growth?
- ✓ Does financial development have a differentiated impact on economic growth as per countries' income levels?
- ✓ Does trade liberalization reduce poverty in African countries, and if so is the effect of trade liberalization on poverty similar across countries?
- ✓ Does malnutrition lead to lower cognitive skills among Ethiopian children?

3. Objectives of the dissertation

The main aim of this dissertation is to throw light on the role that financial development, institutional quality and globalization play in economic growth in Africa; the differentiated effect of trade liberalization on poverty in Africa; and the impact of nutrition, health and household wealth on children's educational performance in the Ethiopia.

Its specific objectives are to:

- ➢ Examine the impact of financial development on economic growth in Africa.
- ➢ Investigate how the effect of financial development on economic growth differs across income categories of those countries.

- Investigate whether the different components of financial development affect economic growth differently in a general sample of African countries and in countries in different income categories of those countries.
- Examine the impact of globalization on economic growth in a sample of African countries and in different income categories of those countries.
- Analyze the effect of institutional quality on economic growth in a sample of African countries and in different income categories of those countries.
- Analyze the differentiated effect of trade liberalization on poverty in Africa.
- Examine the effect of malnutrition and household wealth on educational achievements at different ages in Ethiopia.
- Investigate the effect of early child investments on later child-development outcomes and the initial and contemporaneous impact of household wealth on a child's achievements.
- Explore whether the three indices on which the aggregate wealth index is built have different effects on children's cognitive skills.

4. Methodological approaches and data sources

This section presents the methodological approaches of the three papers and the data that they use.

4.1 Empirical methodologies

This dissertation uses different econometrics methodologies in each paper depending on the subject being studied. The first two papers use cross-country long macro-panels in Africa, while the third paper uses micro-panel data from a single country, Ethiopia.

Paper 1 uses a recent methodology for working with heterogeneous dynamic cross-sectionally dependent panel data to examine the long- and short-run impact of financial development and institutional quality on economic growth. This paper addresses endogeneity among the variables and accounts for cross-sectional dependence that often exists in cross-country investigations (Chudik & Pesaran, 2015; Ordoñez-Callamand, 2017). More specifically, it uses the dynamic common correlated effects (DCCE) estimator proposed by Chudik and Pesaran (2015) which extends Pesaran's (2006) common correlated effects (CCE) estimator by allowing for cross-

sectionally heterogeneous coefficients in the panel ARDL model. This is suitable for assessing both short- and long-run relationships. The DCCE estimator allows for cross-sectional dependence in both static and dynamic specifications of endogenous regressors while having average and country-specific heterogenous coefficients.

To determine the existence of a long-run relationship among two or more non-stationary variables, the paper uses two groups of cointegration tests: the first group consists of tests introduced by Pedroni (1999, 2001, 2004) which solves the problem of small samples and allow for heterogeneity in the intercepts and slopes across the different members of the panel. However, these tests ignore cross-sectional dependence in cross-country panel analysis. The second group consists of the second-generation cointegration tests developed by Westerlund (2007) which are robust to structural breaks and take into account cross-sectional dependence (Westerlund & Edgerton, 2008).

Paper 2 also uses a recently-developed methodology, the augmented mean group (AMG) estimator (Bond & Eberhardt, 2013; Eberhardt & Bond, 2009; Eberhardt & Teal, 2010) that allows us to control for dynamics, bi-directional feedback effects, cross-country heterogeneity and cross-sectional dependence arising from observed and unobserved common factors such as, in the case of this paper, trade and economic integration among African countries, commodity price shocks and the financial crisis of 2007-08. Thus, the first step of the empirical analysis in this paper is to examine the existence of cross-sectional dependence and the degree of integration of the variables using the cross-sectional dependence (CD) statistics given by Pesaran (2004) and the second-generation panel unit-root test statistics developed by Pesaran (2007). The second-generation panel unit-root test is preferred because this test overcomes the problem of cross-sectional dependence which is commonly found when working empirically with panel data. Detailed model descriptions of the DCCE and the AMG estimators are provided in Paper 1 and Paper 2 respectively.

Paper 3 takes advantage of the longitudinal dimension of the data to examine the impact of malnutrition, child health and household wealth on educational achievements. These relationships may not be straightforward as there may be unobserved heterogeneity in parents' decision-making that affects children's health outcomes and educational achievements at the same time. Such potential endogeneity poses a challenge in estimating the impact of malnutrition, child health and household wealth on educational achievements. Longitudinal research has many advantages over

other cross-sectional analysis since it enables us to examine the dynamics of educational performance over time which can help solve the potential problem of endogeneity. This paper uses two types of regressions: cross-sectional regressions on data in a single survey round for each of the two age cohorts and regressions focusing primarily on first-differences (changes) in variables between survey rounds.

4.2 Data sources

The first two papers use long cross-country macro-panel datasets, whereas the last paper uses an extensive longitudinal micro-level dataset from the Young Lives survey in Ethiopia. As the datasets for the first two papers are similar, albeit with some different variables included, they are presented together in the next section.

Data sources for Papers 1 and 2

The dataset used in Papers 1 and 2 is compiled from various sources and is comprised of long time series macro-level data over the period 1980-2014 for 40 African countries (Paper 1) and 43 African countries (Paper 2) respectively. The number of countries included in each paper and the time length were dictated by data availability.

The first paper investigates the role of financial development and institutional quality in economic growth in Africa in a globalized world. This paper uses the logarithm of real GDP per capita in chained PPPs (in million 2011 US$) obtained from the Penn World Table (PWT 9.0) as a dependent variable. Most of the previous studies on financial development use monetary aggregates (such as M2 and M3 as a ratio of GDP), private credit as a ratio of GDP and combinations of these indices and proxies for financial development. In contrast, the first paper uses a broad-based and comprehensive financial development indicator composed of nine different indices that measure the depth, access and efficiency of financial development. These indices come from the International Monetary Fund (IMF) and were constructed by Svirydzenka (2016). The index combines the characteristics on both the development of financial institutions, including banks, insurance companies, mutual funds, pension funds and other types of non-bank financial institutions, and the degree of development of financial markets, including stock and bond markets.

Existing research also uses various measures of institutional quality. Paper 1 uses the average of political rights and civil liberties indices collected from Freedom House. It incorporates three

dimensions of institutional quality in the political rights index—electoral process, political pluralism and participation and the functioning of the government. It uses four dimensions of institutional quality in the civil liberties index—freedom of expression and beliefs, associational and organizational rights, rule of law and personal autonomy and individual rights.

The paper constructs an overall globalization index and its three sub-indices covering economic, social and political dimensions of globalization from 23 indicators using the principal component analysis given by Dreher (2006) and Dreher et al., (2008). The data was collected from KOF website's ETH database (ETH Zurich, 2016).

The second paper investigates how trade liberalization has a differential effect on poverty across African countries. It considers two dependent variables, each being a proxy for poverty, specifically household consumption per capital and infant mortality rate with the latter obtained from the World Bank's (2015) World Development Indicators. Among the independent variables is trade share in GDP (that is, [exports + imports]/GDP), the most commonly used proxy for trade openness collected from the Penn World Table (PWT 9.0). In addition, the analysis also uses the rural–urban inequality (RUI) variable (measured by the ratio of agricultural value added to summation of industrial and service value-added, the growth of real GDP per capita and the growth in the consumer price index, all of which are collected from the World Bank's (2015) World Development Indicators. This paper also uses information on foreign direct investments obtained from the United Nations Conference on Trade and Development (UNCTAD, 2015).

Data sources for Paper 3

Paper 3 examines how malnutrition affects the educational performance of a child at different ages in Ethiopia based on data collected from the Young Lives survey. The Young Lives project is a long-term international research project to investigate the changing nature of child poverty over 15 years in four developing countries (Ethiopia, India, Peru and Vietnam), which is funded by UK Aid of the Department for International Development (DFID) and co-funded by the Netherlands Ministry of Foreign Affairs. The project follows two birth cohorts of children in each country, a younger cohort and an older cohort. So far, the project has collected four rounds of data on these children -- Round 1 in 2002 (aged 1 and 8 years), Round 2 in 2006-07 (aged 5 and 12 years), Round 3 in 2009 (aged 8 and 15 years) and Round 4 in 2013 (aged 12 and 19 years).

The Young Lives dataset for Ethiopia includes information from 20 sentinel sites (12 rural and eight urban) in five major regions (Addis Ababa, Amhara, Oromia, the Southern Nations, Nationalities and Peoples Region (SNNP) and Tigray, accounting for around 90 percent of the total population). The child population was purposively sampled to represent it in a balanced way. Paper 3 uses data from Round 2 (on 5-year-olds and 12-year-olds in 2006-07) and from Round 3 on the same children in 2009 for each cohort.

Paper 3 uses the results of the Peabody Picture Vocabulary Test (PPVT) in both the rounds (Rounds 2 and 3) as a proxy for a child's cognitive skills and it uses the height-for-age z-scores as a proxy for accumulated investments in a child's nutrition and health. The height-for-age z-score is derived from considering the distribution of the international reference population for the same age group (provided by the US National Center for Health Statistics and recommended by the World Health Organization and the US Center for Disease Control and Prevention) and calculating how many standard deviations above or below the median of the reference population a child's height lies. A population-level deficit in height (that is, a child's height is below the median of the reference population) is considered to be reflective of growth impairment caused by the child facing a deficient environment that may include poor diet and inadequate care and attitude to health. Paper 3 also uses an aggregate household wealth index constructed as a weighted average of the three sub-indices provided in the Young Lives survey—an index of households' access to services, an index of housing quality and an index of ownership of various consumer durables.

5. Summary of the papers, including contributions and policy implications

This section discusses the main contributions and policy implications of each paper in the order that they appear in this dissertation. The first paper is on the role of financial development and economic growth in Africa, the second paper is on the effects of trade liberalization on poverty and the third paper is on how child nutrition, health and household wealth affect children's educational performance in Ethiopia.

5.1. Paper 1: The role of financial development and institutional quality in economic growth in Africa in the era of globalization

Paper 1 assesses the role that financial development and institutional quality play in economic growth in Africa in an era of globalization. The paper uses a novel methodology for dynamic panel data estimation, the DCCE estimator, that was recently developed by Chudik and Pesaran (2015)

to account for cross-sectional heterogeneity and cross-sectional dependence arising from observed and unobserved common factors. Some common factors that are relevant for this paper are the recent financial crisis of 2007-08, economic and financial integration among countries and variations in primary commodity prices. Moreover, for a deeper investigation of financial development and to make some comparisons, the analysis using the entire sample of countries was repeated separately for countries in three different income categories as delineated by the World Bank: low-income, lower-middle income and upper-middle income.

An earlier version of this paper was published as Berhane (2018): 'The role of financial development and institutional quality in economic growth in the era of globalization', in Almas Heshmati (ed.), *Determinants of Economic Growth in Africa*, Palgrave Macmillan. That paper was extensively reviewed and improved upon based on the comments and suggestions of my supervisors and an external reviewer.

The empirical analysis in Paper 1 is based on time-series data on selected macroeconomic indicators observed across 40 African countries over the period 1980–2014. It uses heterogeneous panel estimation techniques with cross-sectional dependence. The dependent variable, real per capita GDP in chained PPPs (in 2011 US$), is obtained from the Penn World Table (PWT 9.0) and the independent variables include the real stock of physical capital from PWT 9.0; the financial development index from IMF (constructed by Sahay et al., 2015); the institutional quality index from Freedom House; and the overall globalization index from the ETH database (ETH Zurich, 2016).

In Paper 1, the Pesaran (2004) cross-sectional independence test, the Pesaran (2007) second-generation panel unit root test, the Pedroni (1999, 2001, 2004) residual-based test and the Westerlund (2007) error-correction-based panel cointegration tests are performed before applying the DCCE estimator, which is an extension of the CCE estimator.

To select appropriate tests for panel unit roots and panel cointegration in the empirical analysis it is crucial to first check for the existence of cross-sectional dependence for each variable in the panel. The presence of a high degree of global and regional trade integration, financial integration and overall globalization such as economic, social and political globalization makes a country sensitive to economic shocks in other countries. Hence, it is worthwhile to use the Pesaran (2004)

CD test to test the validity of the assumption of cross-sectional independence which tests whether each cross-sectional unit (country in this case) can be treated as an isolated entity with no impact on other countries. According to the Pesaran CD test statistics, the null hypothesis of cross-sectional independence is rejected at the 1 percent significance level for all series. This implies that there is cross-sectional dependence among the sample of countries in the panel.

Since each of the variables being considered for later regressions faces a cross-sectional dependence problem, the 'CIPS' test suggested by Pesaran (2007), which allows for the presence of cross-sectional dependence was used to determine the degree of integration in the respective variables. Based on the CIPS test, all the presented variables appear non-stationary in levels, except financial development under the specification without trend and the institutional quality indicator from Freedom House. However, the CIPS tests also indicate that all variables are stationary in first-difference under the specifications without trend (constant only) and with trend (constant and trend) at the 1 percent significance level. In other words, the panel unit root test results confirm that no variable is I (2).

Based on the dynamic DCCE estimates the empirical results suggest that in the long run increases in per capita capital stock and in the financial development and the globalization indices have positive and significant effects on per capita output when using the entire sample of countries, whereas improved institutional quality has positive and significant effects on short-run economic growth for the entire sample of countries and for the sub-sample of low-income countries. Furthermore, looking at different income levels, the empirical evidence shows that the impact of financial development on economic growth varies across countries due to the heterogeneous nature of their economic structures, institutional qualities and degree of financial development. Moreover, different components of the financial development indices have various impacts on economic growth across the entire sample and across income groups.

Paper 1 highlights some specific policy implications. First, when studying the effect of aggregate financial development on economic growth it is important to consider this effect across different levels of economic development in countries and the effects of the sub-components of financial development on economic growth. Second, countries should reform and strengthen their financial sectors to accelerate economic growth. A strong financial sector mainly relaxes credit constraints

and enhances economic growth when there is an institutional environment to support it. Third, policymakers need to design and implement active development strategies to benefit from globalization and put in place policies to counteract the negative effects of the immutable forces of globalization on social and political systems.

5.2. Paper 2: The differential impact of trade liberalization on poverty in African countries

The second paper investigates the differentiated effects of trade liberalization on poverty in Africa. Many African countries have been opening their economies in the past three decades mainly because policymakers in developing countries have often believed that trade liberalization enhances sustainable economic growth and helps reduce poverty. Theoretically, trade liberalization provides benefits by enhancing strong competition and promoting a larger market for firms' products so that they can take further advantage of economies of scale. Trade liberalization also induces transfer of technology thereby increasing efficiency in production. Thus, many developing countries have made multilateral and regional efforts to liberalize trade by reducing tariff and non-tariff barriers and by providing more uniform levels of protection among the member countries. African countries have undertaken structural adjustment programs (SAPs) and have engaged in comprehensive trade liberalization through both the World Trade Organization (WTO) and through regional economic integration. However, empirical evidence on trade liberalization's impact on poverty reduction in developing countries remains controversial (Harrison, 2006; Ravallion, 2003). Although African countries' engagement in such economic openness and trade liberalization since the late 1980s has been substantial, the impact of that engagement on poverty has been neither substantial nor evenly effective in poverty reduction across the countries.

The empirical work in this paper is based on a large cross-country dataset covering 43 African countries for the time-period 1980-2014. The study uses the augmented mean group (AMG) estimation technique for panel data models to examine the average effect of trade liberalization on poverty. With this technique, it is possible to produce robust country-specific effects of trade liberalization on poverty on the continent.

An earlier version of this paper was published as Berhane (2017): 'Differential impact of trade liberalization and rural–urban income inequalities on poverty in African countries', in Almas Heshmati (ed.), *Economic Transformation for Poverty Reduction in Africa*: *A multidimensional*

Approach, Routledge, Taylor and Francis Group. That paper was improved based on comments and suggestions from my supervisors and an external reviewer.

Paper 2 studies the differential impact of trade liberalization on per capita household consumption and infant mortality rate (per 1,000 live births). Both the per capital household consumption and infant mortality rate are considered good proxies for poverty in the literature. Studies that have used per capita household consumption as a proxy for poverty include Datt and Ravallion (1992), Odhiambo (2009, 2010), Quartey (2008), Sehrawat and Giri (2016a, 2016b) and Uddin et al., (2014). Studies that have used infant mortality as a proxy for welfare and poverty include Dursun and Ogunleye (2016), Odhiambo (2016) and Polat et al., (2015).

The choice of these variables as proxies for poverty is based on several justifications. First, the concept of poverty in developed and developing countries is fundamentally different. Poverty in developing countries is about individuals attaining their basic needs in the consumption of goods and services while in developed countries it is about relative poverty. Therefore, in developing countries per capita household consumption expenditure, which includes all kinds of expenditure on goods and services, becomes a good proxy for poverty. Likewise, in developing countries where there is lack of sufficient food and health facilities, the infant mortality rate becomes another good proxy for poverty. As several previous studies have pointed out, the infant mortality rate is typically higher for poor households at the bottom of the income distribution and reducing infant mortality has been a global priority in the Millennium Development Goals and has also been incorporated in the Sustainable Development Goals (Chao et al., 2018; Pritchard & Williams, 2011; Ramos et al., 2018; Waldmann, 1992).

Second, both these variables have the key advantage of being available on a yearly basis from 1980 onwards for almost all the countries in Africa which makes them especially useful in this study.

Trade liberalization can affect per capita household consumption and the infant mortality rate through different channels, and the effects of trade liberalization can be different across countries due to their different economic and institutional conditions. Several previous cross-country studies were unable to capture such heterogeneity among countries and regions (see, for example, Bardhan, 2007; Nissanke & Thorbecke, 2006; Odhiambo, 2016; Ravallion et al., 2007; Winters et

al., 2004). To explicitly capture the existence of cross-sectional dependency and potential slope heterogeneity, this paper uses a different methodology from the ones used in previous studies, namely the augmented mean group (AMG) estimator which was first developed by Eberhardt and Bond (2009) and later improved by Eberhardt and Teal (2010) and Bond and Eberhardt (2013) and which takes into account the existence of cross-sectional dependency and slope heterogeneity.

The findings of this paper show that, on average, both greater trade openness and greater per capita income growth have positive and significant associations with poverty reduction (more specifically, higher per capita consumption and lower infant mortality), while greater rural-urban inequalities are significantly and negatively associated with poverty reduction. However, the country-specific empirical results reveal that the effect of trade openness on poverty varies across countries. This suggests that the effect of trade liberalization on poverty is heterogenous and depends on country-specific characteristics of trade policy and poverty reduction strategies and that the one-policy-fits-all approach is not an effective and efficient strategy in Africa.

5.3. Paper 3: The impact of nutrition, health and household wealth on children's educational performance

The third paper assesses the impacts of (a) child nutrition and health and (b) household wealth on children's educational performance at different ages based on the second and third rounds of the Young Lives survey in Ethiopia on two age cohorts of children. An earlier version of this paper was published as Berhane Lemma (2016): 'The Impact of Child Malnutrition and Health on Cognitive Skills in Ethiopia: Using a Standard Panel Data Analysis', in Almas Heshmati (ed.), *Poverty and well-being in East Africa: A multifaceted Economic Approach*, Springer. That paper was extensively revised and improved upon based on the comments and suggestions of my supervisors and an external reviewer.

Child malnutrition is defined as a child not having enough dietary intake containing the right amount of nutrients to live a physically active life that allows healthy functioning. Malnutrition encompasses both overnutrition and undernutrition, but undernutrition is one of the most serious development challenges in poor countries such as Ethiopia. A child without the right nutrients, health services and care during his or her first 1,000 days of life, from conception till the second birthday, can cause invisible and irreversible damage to the brain and cognitive development and

has direct negative consequences on educational, income and productivity outcomes that reach far into adulthood. The problem is especially critical for undernourished girls because of its consequences not only on women's own health but also on the health of their children. This creates vicious cycle where malnourished girls grow into women who are more likely to face cognitive impairments, short stature, lower resistance to infections, a higher risk of diseases and death and who are more likely to have unhealthy and/or malnourished children, holding back the positive development of future generations.

The relationship between nutrition, health and educational performance of school-age children in developing countries has been of interest to many researchers because of the frequent observation that many children in these countries do not complete primary education and those who do complete it, do not perform as well as children in developed countries. Several studies in developing countries have found that reducing early child malnutrition, as measured by low height-for-age which is an indicator of stunting, has a positive effect on educational achievements (Ampaabeng & Tan, 2013; Duc, 2009; Duc & Behrman, 2017; Glewwe & Miguel, 2007; Haile et al., 2016; Martorell et al., 2010; Sánchez, 2017; Sanchez & Decrcon, 2009; Spears, 2012; Tooley et al., 2016; Woldehanna et al., 2017).

The contributions of this paper are two-fold. First, it examines the effects of earlier and contemporaneous malnutrition on educational achievements at different ages, issues which, to my knowledge, have been neglected in previous studies. Second, since improving households' socioeconomic status to break the cycle of poverty acts as a way of improving child development outcomes and has large benefits due to increased rates of return from later investments, this paper also examines the effect of a household's socioeconomic status on its children's educational performance. The empirical results show that an indicator of child nutrition and health based on the child's height-for-age has a positive and significant effect on the child's cognitive skills for the younger cohort, but it has an insignificant effect on those skills for the older cohort. The paper also finds that improvements in households' socioeconomic status has a positive and significant effect on children's educational performance at all ages considered in the study. Furthermore, the findings also show that child labor has a negative effect on a child's academic achievements for the older cohort and that this effect is stronger for girls than for boys.

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Paper One

The Role of Financial Development and Institutional Quality in Economic Growth in Africa in the Era of Globalization

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Paper One

The Role of Financial Development and Institutional Quality in Economic Growth in Africa in the Era of Globalization

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Abstract

This paper examines the effect of financial development, institutional quality and globalization on economic growth in African countries using the Dynamic Common Correlated Effects (DCCE) estimator for 40 African countries classified as low, lower-middle and upper-middle income countries over the period 1980-2014. Its empirical findings show that increases in per capita stock, financial development and globalization had significant and positive effects on long-run economic growth, whereas improved institutional quality had a positive and significant effect on the short run economic growth for the entire sample of countries and for a subsample of low-income countries. Furthermore, looking at different income levels, the empirical evidence shows that financial development's impact on economic growth varies across countries due to the heterogeneous nature of their economic structures, institutional quality and financial development. Moreover, different components of the financial development indices had varying impacts on economic growth across the complete sample and across income groups. This highlights the importance of studying the relationship between aggregate financial development and its sub-components and economic growth across different levels of economic development. The analysis also confirms that financial development enhances economic growth under sound institutional quality.

Keywords: Financial development, globalization, institutional quality, economic growth, dynamic common correlated effects

The Role of Financial Development and Institutional Quality in Economic Growth in Africa in the Era of Globalization

1. Introduction

Every country in Africa strives to achieve a higher level of economic growth and eradicate poverty. However, many African countries lack sufficient human and physical capital, a well-functioning financial system and sound institutional quality, which hamper economic growth and poverty reduction on the continent. Many macroeconomic factors contribute to a country's economic growth; they have received much attention in various literatures, such as those dealing with natural resource endowments, financial development, institutional quality, macroeconomic stability, and globalization, including economic, social and political globalization.

Since the 1980s and 1990s, African countries have been more integrated with the world economy and have undertaken significant efforts to expand the depth, efficiency and stability of their financial systems. Such expansion facilitates technological transfers, induces efficient resource allocations and encourages savings and human capital accumulation, all of which improve total factor productivity and economic growth. However, these efforts have typically not brought expected economic growth and macroeconomic stability due to several significant structural challenges, particularly lack of quality institutions, good governance and financial constraints. Hence, governments in Africa as also international organizations have emphasized the building of efficient institutions and the development of financial sectors as priorities in their agendas to have African countries benefit from globalization and achieve sustainable economic growth.

Theoretical and empirical evidence on how financial development and globalization affect economic growth has been mixed and controversial. Several empirical studies in macroeconomics have used cross-sectional and panel data analyses to investigate the impact of financial development on economic growth (see, for example, Beck et al., 2000; Cojocaru et al., 2016; Hassan et al., 2011; Khan & Senhadji, 2003; King & Levine, 1993; Law & Singh, 2014; Levine et al., 2000; Levine & Zervos, 1998; Lu et al., 2017; Menyah et al., 2014; Samargandi et al., 2015; Valickova et al., 2015; Zhang et al., 2012). Other studies have analyzed the relationship between financial development and economic growth using time-series analyses (Christopoulos & Tsionas, 2004; Demetriades & Hussein, 1996; Luintel et al., 2008; Odedokun, 1996). Their results vary

across countries and studies depending on the sample of countries used, the indicators used for measuring financial development and the econometric approaches employed for the analyses.

In addition to financial development, the literature discusses institutional quality and globalization, particularly economic globalization, as characteristics that can boost economic growth. Economic globalization is comprised of two major components – greater economic flows between countries (for example, trade, foreign direct investment, portfolio investment, and income payments to foreign nationals) and reduced restrictions on those flows (reductions in, for example, hidden import barriers, mean tariff rate taxes on international trade and capital restrictions). Grossman and Helpman (2015) reviewed theoretical arguments of how globalization enhances economic growth through capital accumulation, foreign direct investment, technological spillovers, knowledge diffusion and integration with the world market. There is empirical evidence based on different econometric methodologies that globalization has had significant and positive effects on economic growth in developing countries (Meraj, 2013; Morita et al., 2015; Ray, 2012; Umaru et al., 2013). However, recent studies suggest that not all globalization has a positive and linear effect on economic growth (Kilic, 2015; Ying et al., 2014; Zahonogo, 2017).

Furthermore, several empirical studies in the growth literature have also investigated the role of institutional quality in economic growth using individual country time-series data and using cross-sectional country data (Acemoglu & Johnson, 2005; Acemoglu & Robinson, 2013; Bozoki & Richter, 2016; Krasniqi & Desai, 2016; Rodríguez-Pose, 2013; Sarmidi et al., 2014). Interestingly, institutional quality has also been shown to affect the channel through which financial development and globalization influence economic growth (Aderlini et al., 2013; Chang et al., 2009; Hartmann et al., 2017; Mullings, 2017).

Since financial development and globalization indicators are complex and multidimensional in nature, studies in this area necessitate great care in analyzing for their impact on economic growth. Moreover, previous research on economic growth in Africa has generally ignored the potential connections between financial development, globalization and institutional quality. To the extent that these connections have been researched, the empirical evidence is mixed and inconclusive. Therefore, the objective of the current study is to examine the effects of financial development, institutional quality and globalization on economic growth in a group of 40 African countries over

the period 1980-2014 in three income-based sub-groups: low-income, lower-middle income and upper-middle income countries following the World Bank's classification (2016) based on per capita income.[1] According to this classification, the 40 countries were categorized as: 19 low-income, 14 lower-middle income and seven upper-middle income countries for the year 2015. Between years, countries may shift upward or downward between income categories since the thresholds used in this classification are updated annually based on the exchange rate and adjusted for inflation rate or due to trends in economic growth in countries. However, in developing countries in general and in African countries in particular, the countries can cross the threshold, but they are not too far away from their initial position. Hence, such movements are not expected to affect the analysis.

This paper contributes to filling the following research gaps. First, to overcome the shortcomings of single indicators as proxies for financial development, it uses a new broad-based financial development indicator, composed of nine different indices that measure the depth, access and efficiency of financial development. These indices were constructed by the International Monetary Fund (IMF) and each captures characteristics of both financial institutions—including banks, insurance companies, mutual funds, pension funds and other types of non-bank financial institutions—and financial markets, including stock and bond markets (Svirydzenka, 2016).

The paper also uses comprehensive measures of globalization and institutional quality indicators as additional regressors. The KOF index of globalization, originally developed by Dreher (2006) and further updated by Dreher et al. (2008), includes characteristics of economic globalization, social globalization and political globalization is employed as proxy for globalization. To measure institutional quality, the paper uses the average of the Political Rights and Civil Liberties indices from Freedom House. Jones and Tarp (2016) and Wako (2018) have pointed out that these indices include factors like institutional inputs (for example, democracy, rule of law and property rights) and institutional outputs (for example, corruption, policymaking, accountability, transparency and bureaucratic quality). As compared to the World Bank's Worldwide Governance Indicators

[1] Low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,025 or less in 2015; lower middle-income economies are those with a GNI per capita between $1,026 and $4,035; and upper middle-income economies are those with a GNI per capita between $4,036 and $12,475.

(WGIs), these institutional quality indices data are based on a wider range of indicators to reflect the overall institutional quality of the country and cover a longer time dimension.

Second, this paper uses recent methodological developments in panel time series heterogeneous dynamic cross-sectional dependent panel data methods. More specifically, it uses the Dynamic Common Correlated Effects (DCCE) estimator proposed by Chudik and Pesaran (2015), which is an extension of the Common Correlated Effects (CCE) estimator to allow for cross-sectional dependence, static and dynamic specifications of endogenous regressors and fixed and country-specific coefficients.

Third, as compared to previous studies, the dataset for this paper covers a longer time span (1980 - 2014) for a large number of African countries. Finally, the analysis complements its main findings for the entire sample of 40 African countries by considering analogous estimates for three income-level sub-groups -- low, lower-middle and upper-middle income countries. To the best of the author's knowledge, this is the first study to assess how growth is affected by financial development, institutional quality and globalization using the DCCE estimator for a non-stationary dynamic panel allowing for parameter heterogeneity and correcting for cross-sectional dependence. The focus of the paper is not only on financial development's impact on growth but also on whether the sub-components of financial development (that is, financial institutions and financial markets) affect economic growth differently for the entire sample of countries and at different income levels.

The rest of the paper is organized as follows. Section 2 provides a brief review of theoretical and empirical literature related to the study, while Section 3 outlines the data used, the definitions of the variables and the model specification and methodology. Section 4 discusses the empirical results and Section 5 gives the conclusion and policy recommendations based on what the results imply.

2. Literature Review

In this section, the theoretical and empirical literatures on financial development, institutional quality, and economic growth in the recent globalized world will be reviewed.

2.1. Theoretical Literature Review

Over the past four decades, endogenous growth models have generally been the theoretical basis for studies on the nexus between financial development and economic growth. Theoretically, the channels through which financial development affects saving and investment decisions and hence affects economic growth have been discussed extensively in the literature. The nexus between financial development and economic growth is characterized by both optimistic and skeptical approaches.

According to the optimistic approach, efficient financial systems help countries acquire and process information on firms, managers and economic conditions, thereby leading to more efficient resource allocations and the enhancement of total factor productivity that can stimulate economic growth (Boyd & Prescott, 1986; Greenwood & Jovanovic, 1990). Second, under better financial systems, shareholders and creditors monitor firms more effectively and enhance corporate governance which makes savers more willing to finance production and innovations in profitable investments which in turn boosts productivity, capital accumulation and economic growth (Bencivenga et al., 1995; Harrison et al., 1999; Stiglitz & Weiss, 1983; Sussman, 1993). Third, a well-developed financial system mobilizes savings and facilitates efficient allocation of resources (Greenwood et al., 2013; King & Levine, 1993). Fourth, financial arrangements play a pivotal role in reducing agency transaction and information costs, thereby enhancing innovation activities and growth (Aghion et al., 2005). Finally, sound financial systems can also contribute to high-return investments through risk-sharing investments in human capital and research development that accelerate economic growth (Aghion et al., 2009; Bencivenga & Smith, 1991; De Gregorio, 1996; Devereux & Smith, 1994; Galor & Zeira, 1993; Greenwood & Jovanovic, 1990; Obstfeld, 1994; Saint-Paul, 1992).

According to the skeptical approach, high systemic risks[2] can lead to increased economic growth and financial volatility with potential negative impacts on economic growth in the short to long term. Financial sectors may take on neglected risky loans, insure risky assets and may be affected by external shocks due to asymmetric information, all of which increases banking instability and

[2]Higher systemic risks imply more frequent and/or more severe crises which in turn negatively affect economic growth rates in the short and medium term.

can generate systemic financial crises (see, for example, Allen & Carletti, 2006; Gai et al., 2008; Gennaioli et al., 2012) and misallocation of natural resources and labor into the fast-growing financial sector when ideally those inputs should be used in other sectors. The financial sector attracts more skilled workers while the other real sectors are left behind due to the absence of sufficient human resources, which can have negative repercussions for growth (Bolton et al., 2016; Philippon, 2010; Santomero & Seater, 2000).

Moreover, deviations from the unique optimal size of the financial sector create inefficiencies leading to high costs for the economy (Santomero & Seater, 2000), sub-optimal low savings, growth due to financial deregulation (Jappelli & Pagano, 1994) and informational overshooting that expands the economy to a new capacity due to financial liberalization which is unknown till it is reached (Zeira, 1999). These are some of the main factors that lead financial development to higher systemic risks and then lower economic growth. Therefore, theoretically it is not clear whether financial sector development contributes to economic growth or not particularly in developing countries like those in Africa.

Theoretically, there are many channels through which financial development, institutional quality, globalization and financial-institutional interactions can affect economic growth and the level of technology and efficiency. A higher degree of financial development and institutional quality can encourage accumulation of physical capital, human capital, FDI inflows and transfer of technological knowledge thus promoting economic growth. Globalization also contributes to economic growth by inducing more efficient allocation of internal and external resources and by helping shift technological advancements from developed countries to developing economies with the less-developed countries exploiting developed countries' innovations through learning-by-doing effects. On other hand, Stiglitz (2004) indicates that globalization ('when not well managed') does not spur economic growth due to globalization, for example, adversely affecting job creation, widening income inequalities and inducing risks. Governments in developing countries might lose control over their monetary policies in the course of globalization. Therefore, how globalization affects economic growth remains an empirical question.

2.2. Empirical Literature

Building on theoretical evidence, there is extensive empirical literature on the role that financial development plays in developing countries' economic growth. As in theoretical studies the evidence in the empirical literature shows mixed and inconclusive results and differs among countries as per their characteristics of financial development, institutional quality, globalization, the development stage of the country and country-specific macroeconomic factors.

Most research in the finance-and-growth literature has found a positive relationship between financial development and economic growth (Adu et al., 2013; Akinlo & Egbetunde, 2010; Christopoulos & Tssionas, 2004; Goldsmith, 1969; Hassan et al., 2011; Kargbo & Adamu, 2009; King & Levine, 1993; Levine et al., 2000; Levine & Zervos, 1996; Luintel et al., 2008; Odedokun, 1996; Rafindadi & Ozturk, 2016; Shahbaz & Rahman, 2012; Zhang et al., 2012).

However, notwithstanding the early empirical evidence, some studies have found a negative relationship between financial development and economic growth (Friedman & Schwartz, 2008; Kaminsky & Reinhart, 1999; Loayza & Ranciere, 2006; Lucas, 1988; Rousseau & Wachtel, 2011). Kaminsky and Reinhart (1999) suggest a possible negative channel of the effect of financial development on economic growth through the triggering of financial instability. Loayza and Ranciere (2006) found evidence of the co-existence of a positive relationship between financial intermediation and output in the long run and a negative short-run relationship due to financial instability.

Other related studies have shown that the positive effect of financial deepening weakens over time regardless of the country's level of development (Beck et al., 2014; Rousseau & Wachtel, 2011). Levine et al. (2000) suggest that a larger financial sector increases growth and reduces volatility over the long run while enhancing growth at the cost of higher volatility over short-term horizons.

Furthermore, recent studies document the existence of a certain threshold of financial development beyond which additional deepening generates decreasing returns to economic growth and stability. Using a sample of 87 developed and developing countries, Law and Singh (2014) provide a threshold analysis of the finance-growth link. Their findings reveal that finance is beneficial for growth up to a certain level but further development of finance beyond this threshold tends to affect growth adversely. Similarly, Arcand et al. (2015); Cecchetti and Kharroubi (2012); Deidda

and Fattouh (2002); Huang and Lin (2009); Samargandi et al. (2015); and Shen and Lee (2006) also found that the nexus between financial development and economic growth had an inverted U-shape effect where a higher level of financial development tended to slow down economic growth.

Existing empirical evidence on the relationship between financial development and growth shows dependence on countries' income levels. De Gregorio and Guidotti (1995) and Huang and Lin (2009) found that the positive effect of financial development on economic growth is much more significant in low-income and middle-income countries than in high-income countries. Calderón and Liu (2003) suggest that financial deepening contributes more to growth in developing countries than in industrial ones. A similar result is found by Masten et al., (2008) who analyzed a sample of European countries. They show a strong and positive effect on economic growth only for countries with intermediate levels of development. Seven and Coskun (2016) examined whether financial development reduced income inequalities and poverty in 45 emerging countries for the period 1987–2011. They found that although financial development promoted economic growth this did not necessarily benefit low-income emerging countries.

To show the existence of an optimal level of financial development, Ductor and Grechyna (2015) employed the first-difference generalized method of moments estimator (FD-GMM) in 101 developed and developing countries over the period 1970-2010. They empirically examined the relationship between financial development and real sector output and its effect on economic growth. Their results show that the effect of financial development on economic growth depended on the growth of private credit relative to growth in real output.

Furthermore, financial development also affects growth indirectly through positive spillovers from foreign direct investments (FDI), which stimulate economic growth in a well-functioning financial system. Empirically, Alfaro et al. (2004); Hermes and Lensink (2003); Shahbaz et al. (2013) among many others show that financial development encourages FDI inflows and transfers of technology and managerial skills that have positive spillover effects on economic growth. Using gravity-type models, Donaubauer et al. (2016) show that bilateral FDI increases with better developed financial markets in both the host and source countries, which has positive impacts on economic growth.

Several studies done in recent years show that strong legal and institutional frameworks are critical for creating an environment in which the financial sector facilitates economic growth. Al-Yousif (2002) argues that the relationship between financial development and economic growth cannot be generalized across countries because economic policies are country-specific, and their success depends on the efficiency of the institutions implementing them. Similarly, Demetriades and Law (2006) extended Arestis and Demetriades (1997) and Demetriades and Andrianova's (2004) studies on the role of institutions in the financial-growth nexus. By employing cross-sectional and panel data estimation on a sample of 72 countries for the period 1978-2000 they found that financial development had a greater effect on growth when the banking system was operating within a sound institutional framework.

Using a sample of 85 countries over the period 1980–2008 and employing the threshold estimation technique, Law et al. (2013) found that the impact of finance on growth was positive and significant only after a certain threshold level of institutional development had been attained. Specifically, financial development had an insignificant effect on growth when the institutions quality indicators (that is, institutional quality variables taken from ICRG and WGI) were below the threshold and had a significant and positive effect on institutions above the threshold level. These findings suggest that the financial development-growth nexus is contingent on institutions, where financial development promotes growth after institutions exceed a certain threshold level. Ng et al. (2015) employed threshold estimation techniques on a cross-section of 85 countries during the post-crisis period. They found that the impact of stock market liquidity on growth was positive and significant only in countries where there was a high level of property rights protection but there was mixed evidence when there were low to medium degrees of protection. Moreover, using broader governance indicators as threshold variables and instrumental variables, the threshold regressions confirmed the main finding of identifying a threshold level above which institutional quality can positively shape the stock market's impact on economic growth.

Using both ordinary least squares (OLS) and system generalized methods of moments (SYS-GMM) estimates on 1980-2010 data for 21 sub-Sahara African countries, Effiong (2015) found evidence of threshold effects by introducing a linear interaction term between financial development and institutional quality in growth regressions. In his model, financial development contributed positively to growth but only in good policy environments. Various studies (for

example, Acemoglu, 2006; Acemoglu & Robinson, 2008, 2010; Rodrik & Subramanian, 2003) have provided new impetus to empirical research by showing that institutions affect the economic growth of individual firms and countries.

Le et al. (2016) used a panel dataset of 26 countries over the period 1995-2011 to investigate the impact of institutional quality, trade and financial development on economic growth using the dynamic Generalized Method of Moments (GMM) model. They found that better governance and improved institutional quality impacted financial development in developing economies while economic growth and trade openness were vital determinants of financial depth in developed economies. Therefore, the effect of financial development on economic growth may vary based on the level of the financial indicator itself and on institutional quality, income level and other country-specific conditions.

Furthermore, Ying et al. (2014) showed that economic globalization in the Association of Southeast Asian Nations (ASEAN) countries affected economic growth positively, but social and political globalization affected it negatively. In a similar vein, Kilic (2015) investigated the effect of different components of globalization on economic growth using panel data for 74 countries and provided evidence that economic and political globalizations have a positive impact on economic growth while social globalization has a negative impact on economic growth.

3. Data Description and Methodology

3.1. Data Source and Descriptive Statistics

The dataset used in this paper comprises time series data of selected macroeconomic indicators for 40 African countries (see the list of countries in Table A1 in the Appendix) on an annual frequency over the period 1980-2014. The number of countries included, and the time period of the study were dictated by data availability. All the variables used in the descriptive and econometrics analysis along with their symbols and sources are given in Table 2.1, which is followed by a discussion of the variables.

Table 2.1: Description of symbols, definitions of variables and data source

Variable defined	Data source
Per capita GDP at chained PPPs (in mil. 2011 US$) in log	Penn World Table, version 9.0 (henceforth PWT9.0).
Stock of per capita physical capital (in mil. 2011 US$) in log	PWT 9.0
Financial development index	IMF
Overall globalization index	ETH Zurich 2016
Political rights	Freedom House 2017
Civil liberties	Freedom House 2017

Note: PWT 9.0: Penn World Tables version 9. IMF: International Monetary Fund. *ETH Zurich 2016: The KOF index of globalization available at: http://globalization.kof.ethz.ch/*

Per capita real GDP

The dependent variable is the logarithm of per capita GDP in chained PPPs (in 2011 US$) obtained from the Penn World Table (PWT 9.0).

Stock of per capita real physical capital: The logarithm real stock of physical capital (at constant national prices in mill. 2011 US$) is provided in PWT 9.0. The stock of physical capital includes information on four assets: structures (including residential and non-residential), machinery (including computers, communication equipment and other machinery), transport equipment and other assets (including software, other intellectual property products and cultivated assets). Using this series versus other physical capital stock series previously developed in the literature has several advantages because it is viewed as a direct proxy of contribution of capital accumulation, as well as an indicator of efforts made to develop basic economic infrastructure.

The financial development index: To capture the overall size and depth of financial development most previous empirical studies on financial development have used monetary aggregates (such as M2 and M3 as a ratio of GDP), private credit as a ratio of GDP and to a lesser extent the ratio of stock market capitalization to GDP. However, financial development is multidimensional, including enhancements in financial institutions and financial markets. Therefore, to investigate the finance-growth relationship more accurately this paper uses the financial development index, a new broad-based measure constructed by Sahay et al., (2015) and obtained from the IMF. They constructed this index for 183 countries on annual frequency from 1980-2014 capturing both financial institutions and financial markets. This index is an improvement over the conventional measures of financial development. Conceptually, it incorporates information on a broader range

of financial institutions including banks, insurance companies, pension and mutual funds and financial markets such as the stock and bond markets. This index defines financial development as a combination of depth (size and liquidity of the markets), access (individuals and companies' ability to access financial services) and efficiency (institutions' ability to provide financial services at low costs and with sustainable revenue and level of activity in capital markets) in both financial institutions and financial markets. The financial development index ranges from 0 (lowest level of development) to 1 (highest level of development) as do its sub-indices on financial institutions' development and financial markets' development.

The institutional quality index: This paper measures institutional quality as an average of the Political Rights and Civil Liberties indices provided by Freedom House over the period 1980-2014. The political rights index is constructed from 10 different questions grouped into three sub-categories: three questions each on the electoral process and the functioning of the government and four on political pluralism and participation. The civil liberties index is derived from 15 questions grouped into four sub-categories: four questions each on freedom of expression and beliefs, rule of law and personal autonomy and individual rights, and three questions on associational and organizational rights. Each of these institutional quality measures from Freedom House ranges from 1 (greatest degree of freedom) to 7 (smallest degree of freedom), but for convenience and comparability with other similar studies this paper re-scaled these two indices so that 7 means the best institutional quality and conversely a score of 1 means the lowest level of institutional quality,[3] and the overall institutional quality index is the equally-weighted average of these two indices. One advantage of Freedom House's institutional indices as compared to the World Bank's Worldwide Governance Indicators (WGIs) is that the time dimension of the data is longer and also that they are based on a wider set of indicators.

The globalization index: The overall globalization index (the KOF index of globalization) and its three sub-indices covering the economic, social and political dimensions of globalization are constructed from 23 variables using principal component analysis. The principal component analysis uses all available data on an individual variable and computes the variance of the variables used. The larger the variance of an individual variable, the greater is the weight of the variable. The economic globalization index includes two variable groups: (i) actual flows (trade, foreign

[3] Each re-scaled index is calculated to be 8 minus the average of the original index from Freedom House.

direct investments, portfolio investments and income payments to foreign nationals) and (ii) restrictions (hidden import barriers, mean tariff rate, taxes on international trade and capital account restrictions). The social globalization index includes three variable groups. Firstly, it assesses cross-border personal contacts (telephone traffic, transfers, international tourism, foreign population and international letters). Secondly, it includes information on cross-border information flows (internet users, television and trade in newspapers) and thirdly, the index includes measurements of cultural proximity (number of McDonald's restaurants, number of IKEA stores and trade in books in relation to GDP).

The political globalization index includes four individual variables: number of foreign embassies in a country, memberships in international organizations, the number of participations in the UN Security Council's missions in which the country has been engaged and the number of bilateral and multilateral agreements that the country has concluded since 1945. The KOF index of globalization which was introduced in 2002 (Dreher, 2006) and its construction details can be found in other studies (Dreher et al., 2008) and are available on the KOF website. I accessed the globalization data from the ETH database (ETH Zurich, 2016). The values of the overall globalization index and each of its sub-indices can range from 1 (minimum globalization) to 100 (maximum globalization).

3.2. Theory and model specifications

Both endogenous and exogenous growth theories have been in recent use to investigate the determinants of economic growth across countries. Following Mankiw et al. (1992) and Demetriades and Law (2006), this paper uses a Cobb-Douglas production function augmented with financial development, institutional quality and globalization variables. Based on previous literature and the framework posited by León-Ledesma et al.(2015); Omri et al. (2015); Rahman et al. (2015); and Zerihun (2014), labor-augmenting technology *A* is determined not only by technological improvements but also by financial development, institutional quality and globalization within the augmented Cobb-Douglas production function.

To examine the link between financial development, institutional quality, globalization and growth, I used the production function with constant returns to scale and productivity growth that is purely labor augmenting or 'Harrod-neutral' for each country *i* at time *t* with some modification. This is presented as:

$$Y_{it} = K_{it}^{\alpha}\left(A_{it}L_{it}\right)^{1-\alpha} \tag{1}$$

where Y_{it} is real gross domestic product (GDP) in country i (i=1,2,3, ..., 40) at time t ($t = 1,2,3,...,35$), K_{it} is physical capital stock, L_{it} is the stock of raw labor and A_{it} is a labor-augmenting factor measuring the level of technology and efficiency in country i at time t in an economy. This equation assumes that $0 < \alpha < 1$, implying decreasing returns to all capital.

In existing literature, the elasticities in the production function are typically estimated under the assumption of country homogeneity and cross-sectional independence which are strong assumptions. This paper uses a flexible framework to estimate the elasticities from a panel of countries allowing for slope heterogeneity while taking into account cross-sectional dependence. There are theoretical and empirical reasons to expect that there will be important heterogeneity and cross-sectional dependence across countries.

Hence, under the assumption of slope heterogeneity across countries raw labor and labor-augmenting technology are assumed to evolve exogenously at rate n_i and g_i, and are presented as:

$$L_{it} = L_{i0}e^{n_i t} \tag{2}$$

$$A_{it} = A_{i0}e^{g_i t + \theta_i' D_{it}}e^{\mu_{it}} \tag{3}$$

where n_i is the exogenous labor force growth rate in country *i*, A_{i0} is time-invariant country specific technology and g_i is the exogenous rate of technological progress in country *i*. Moreover, D_{it} is a vector of financial development, institutional quality and globalization indices that can affect the level of technology and its efficiency in country i at time t and θ_i is a vector of coefficients related to these variables. The term μ_{it} represents the error term. The production function in Eqn. (1) can be written in a per-worker form such that:

$$y_{it} = \frac{Y_{it}}{L_{it}} = A_{it}^{1-\alpha}k_{it}^{\alpha} \quad \text{where} \quad k_{it} = \frac{K_{it}}{L_{it}} \tag{4}$$

Taking the log transformation on both sides of Eqn. (4) yields:

$$\ln y_{it} = (1-\alpha)\ln A_{it} + \alpha \ln k_{it} \quad (5)$$

Taking the log of Eqn. (3) and then substituting the result in Eqn. (5) leads to:

$$\ln y_{it} = (1-\alpha)\ln A_{i0} + (1-\alpha)g_i t + (1-\alpha)\theta_i' D_{it} + \alpha_i \ln k_{it} + (1-\alpha)\mu_{it} \quad (6)$$

The vector D_{it} in Eqn. (6) allows for variations across a country which implies that different countries may converge at different steady states based on the steady state levels of their financial development, institutions and globalization.

Augmenting Eqn. (6) with the lagged value of the dependent variable gives a standard dynamic panel model specification as:

$$\ln y_{it} = (1-\alpha)\ln A_{i0} + (1-\alpha)g_i t + \beta_{1i} y_{it-1} + (1-\alpha)\theta_i' D_{it} + \alpha \ln k_{it} + (1-\alpha)\mu_{it} \quad (7)$$

Finally, replacing the expression $(1-\alpha)\ln A_{i0} + (1-\alpha)g_i t$ in Eqn. (7) by the sum of a constant β_0, a time-varying parameter γ_t, and a country-specific parameter η_i, letting $e_{it} \equiv (1-\alpha)\mu_{it}$, and replacing the remaining constant parameters in Eqn. (7) with β terms, we get:

$$\ln y_{it} = \beta_0 + \beta_{1i} \ln y_{it-1} + \beta_{2i} \ln k_{it} + \beta_{3i}' D_{it} + \gamma_t + \eta_i + \varepsilon_{it} \quad (8)$$

where in the empirical application $\ln y_{it}$ and $\ln y_{it-1}$ are the log-transforms of real per capita GDP (PPP chained 2011 US$) and its lagged value respectively, $\ln k_{it}$ represents the log of per capita physical capital stock, D_{it}, consists of indices representing the degree of financial development, institutional quality and globalization. Moreover, γ_t and η_i correspond to the time effect and the unobserved country-specific effect respectively and μ_{it} refers to the regression random error term.

The conventional panel specification assumes that there is slope homogeneity and cross-section independence. In the context of Eqn. (8), this means that all the elasticity and semi-elasticity parameters are equal across countries (β_{1i}, β_{2i} and β_{3i} do not vary by i) and the regression error term should show no systematic patterns of correlation across countries. The slope homogeneity restriction implies that each country with a different level of economic development such as low-income (for example, Ethiopia, Uganda and Tanzania), upper-middle income (Botswana, Namibia

and South Africa) and higher-income (for example, Equatorial Guinea and Seychelles)[4] countries should have the same parameters in a growth regression. However, this is a strong assumption which is likely to be violated in reality. Moreover, due to strong inter-economy relationships, global technological and financial shocks, co-movements of macroeconomic aggregates and worldwide environmental changes, the assumption of cross-sectional independence is unrealistic and the assumption that the covariance of the residual is zero can be easily violated. Westerlund and Edgerton (2008, p. 666) support this point: 'When studying macroeconomic and financial data for example, cross-sectional dependencies are likely to be the rule rather than the exception, because of strong inter-economy linkages.'

3.3. Econometric methodology

The methodology in this paper follows four steps. First, it tests the cross-sectional independence of each variable using the Pesaran (2004) test for N=40 and T=35, where N is the cross-section dimension and T is the time dimension. Second, it investigates the integration levels of the variables using appropriate panel unit root tests. That is, in case the cross-sectional dependence is rejected, the first-generation panel unit root test by Maddala and Wu (1999) is used. Instead, if there is evidence of cross-sectional dependence, the CIPS test suggested by Pesaran (2007), a second-generation panel unit root test that controls for cross-sectional dependence, is used. Third, depending on the integration levels of the variables, slope heterogeneity and cross-sectional dependence, both first- and second-generation panel cointegration tests are used: the Pedroni (1999, 2001, 2004) residual-based test and the Westerlund (2007) error-correction-based test. Finally, given the importance of slope heterogeneity and cross-country dependence in the African context, a recently developed model that allows for slope heterogeneity and cross-sectional dependence is employed.

This empirical strategy differs from micro-panel techniques such as fixed-effects estimations and panel-data GMM designed for panels having large N and small T as introduced by Arellano and Bond (1991) and Blundell and Band (1998), where the latter technique provides consistent and efficient parameter estimates when the independent variables are strictly exogenous, and the error term is cross-sectionally independent. However, it is reasonable to assume that with globalization and its increased economic and financial integration and greater political and cultural inter-

[4] Income categories of African countries based on the World Bank's Development Indicators.

relationships, strong interdependencies have been generated among the panel countries so that cross-country correlations will influence the micro-panel results obtained from GMM in larger time and panel dimensions. Moreover, the role of financial development and globalization in economic growth might be different across countries due to country-specific policies and differences in institutional quality in each country. Thus, it is crucial to consider heterogeneities in countries and cross-sectional dependence in dynamic panel regressions.

Hence, the DCCE estimator developed by Chudik and Pesaran (2015) is an appropriate estimator. This estimator allows for lags in the dependent variable and weakly exogenous regressors and is more robust to parameter heterogeneity and weak cross-section dependence compared to micro-panel estimators. As pointed out by Chudik et al. (2013), conditioning only on country-specific variables does not guarantee independence of cross-sectional errors because there could be omitted common factors, probably associated with the independent variables, which affect the countries. These are the reasons why I use the DCCE estimator as compared to the standard fixed-effects and GMM estimators which are unlikely to satisfy the strong assumptions of slope heterogeneity and cross-sectional dependence in long panel time series data.

3.3.1. Cross-sectional dependency test

In a macroeconomic panel, cross-sectional dependency can be introduced because of a finite number of unobservable and/or observed common factors that affect all countries, albeit to varying degrees (Coakley et al., 2006). Such common factors can be strong factors with more widespread effects like the oil price shocks of the 1970s, the recent financial crisis of 2007-08, economic and financial integration among countries and the continued fall of primary commodity prices in 2015 and early 2016. There are also weak factors such as aggregate technological shocks, similar national policies intended at raising the level of technology, interaction effects through trade or other networks, the Arab Spring in 2011 and conflicts among neighbouring countries on the continent which represent spatial spillover effects. These common shocks induce unobserved time-varying heterogeneity across countries which in turn introduces cross-sectional dependency between regression error terms and variable series. Such time-varying heterogeneity can lead to inconsistencies in standard panel estimators (Eberhardt & Teal, 2011; Pesaran, 2006)

Economic and financial integration, the financial crisis of 2007-08 and war and conflict among neighbouring countries had varying adverse effects on the financial development, institutional

quality and economic growth in the countries under study. Therefore, a cross-country macroeconomic panel study performing a cross-sectional dependence test is a vital step. Due to situations like this there has been increasing research interest in characterizing and modeling cross-sectional dependence and its impacts on estimation.

Econometrically speaking, this paper uses a simple test suggested by Pesaran (2004) for each of the variables and for OLS regression residuals to determine the presence of cross-sectional dependence (CD). In the case regression residuals, the CD test statistic is based on the average of all pairwise correlations (for cross-section pairs) of the OLS residuals from the individual regressions of the panel data model:

$$y_{it} = \hat{\alpha}_i + \hat{\beta}_i' x_{it} + \hat{\mu}_{it} \tag{9}$$

where y_{it} is the dependent variable, (i=1,...,N), N is the number of panel members, (t=1,...,T) is time period and x_{it} is the vector of observed explanatory variables. $\hat{\alpha}_i$ and $\hat{\beta}_i$ refer to the estimated intercepts and the slope coefficients which can vary across panel members.

The test statistics for the Pesaran (2004) CD-test can generally be expressed as:

$$CD_\rho = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \Rightarrow N(0,1) \tag{10}$$

where $\hat{\rho}_{ij}$ refers to the sample estimate of the pairwise correlation of the OLS residuals, $\hat{\mu}_{it}$ and $\hat{\mu}_{jt}$ associated with Eqn. (9) as shown below

$$\hat{\rho}_{ij} = \frac{\sum_{t=1}^{T}\hat{\mu}_{it}\hat{\mu}_{jt}}{\sqrt{\sum_{t=1}^{T}\hat{\mu}_{it}^2}\sqrt{\sum_{t=1}^{T}\hat{\mu}_{jt}^2}} = \hat{\rho}_{ji} \tag{11}$$

(in the case where the test is applied to an individual variable, $\hat{\rho}_{ij}$ above would instead refer to the sample estimate of the pairwise correlation of the variable for two panel units i and j). The null hypothesis for this test is cross-sectional independence among the panel units, while the alternative hypothesis claims that there is cross-sectional dependence among the panel units (Pesaran, 2004).

The CD-test statistic can be applied to both balanced and unbalanced panels and it is robust to non-stationarity, parameter heterogeneity, to single or multiple structural breaks in the slope coefficients and the error variance of the individual regressions, and above all, they perform well in small samples (Burret et al., 2016, Pesaran, 2004).

3.3.2. The panel unit root test

In macro-panel data analysis, another important pre-analysis that needs to be carried out in addition to cross-sectional dependence is the panel unit root test to determine the order of integration of the macroeconomic variables. Most of the panel unit root tests are an extension of the most common augmented Dickey-Fuller (ADF) unit root test in univariate analysis. To analyze the integration order of the variables this paper uses the CIPS test proposed by Pesaran (2007), which is an extension of the Im et al. (2003) test. The CIPS test is a second-generation unit root test that relaxes the restrictive assumption of cross-sectional independence. It is based on a cross-sectionally augmented ADF (CADF) regression, for which lagged cross-sectional means of individuals, $\bar{X}_t$, are included to capture the effects of a cross-section common factor as follows:

$$\Delta X_{it} = \alpha_i + \beta_i X_{i,t-1} + \varphi_i \bar{X}_{t-1} + \gamma_i \Delta \bar{X}_{t-1} + \varepsilon_{it} \qquad (12)$$

where subscripts i and t denote panel individuals and time period and $\bar{X}_t$ indicates the cross-sectional mean of X_{it}, that is, $\bar{X}_t = \sum_{i=1}^{N} X_{it} / N$. From Eqn. (12) a *t*-statistic (the CADF test statistic) is obtained for each of the estimated β_i parameters. The test statistic for the CIPS test is the mean of these *t*-statistics:

$$CIPS(N,T) = \sum_{i=1}^{N} t_i(N,T)/N \quad \text{where } t_i(N,T) \text{ indicates the } t \text{ statistics of } \beta_i . \qquad (13)$$

For this test, the null hypothesis is that the series does not have unit root, so it is stationary, while the alternative hypothesis is that the series has unit root for some panel individuals. Pesaran (2007) provides the critical values for the CIPS test statistics. In comparison to the first-generation panel unit root tests, the CIPS test provides more precise and reliable results in the presence of cross-sectional dependence.

3.3.3. The panel cointegration test

The idea of cointegration was first introduced in the literature by Engle and Granger (1987). Cointegration means the existence of a long-run relationship among two or more non-stationary variables. The principle of testing for cointegration is to show if the variables in question move together over time so that a short-term sudden shock will be corrected in the long-run, with the variables in the long-run returning to a steady-state linear relationship. Otherwise, if two or more variables are not cointegrated, they may randomly wander far away from each other.

To determine the existence of a long-run equilibrium relationship among the variables in panel data, two groups of cointegration tests have been developed in panel cointegration literature. The first group consists of first-generation panel cointegration tests developed by Pedroni (1999, 2001, 2004), which solve the problem of small samples and allow for heterogeneity in the intercepts and slopes across the different members of the panel. However, these tests ignore cross-sectional dependence in cross-country panel analyses. Pedroni developed seven panel cointegration test statistics based on the residuals of the Engle and Granger (1987) cointegrating regression in a panel data model that allows for considerable heterogeneity. Four of these statistics are based on the within-dimension ('panel') approach, namely panel ν-statistics, panel ρ-statistics, panel PP-statistics and panel ADF-statistics and the other three statistics are based on between-dimension ('group') test statistics that includes group ρ, group PP and group ADF statistics. The panel ν-statistics are related to one-size tests where large positive values reject the null hypothesis of no cointegration. All seven tests are conducted on the estimated residuals from Eqn. (9) and in all cases the null hypothesis being tested is no cointegration.[5]

The second group of tests is second-generation cointegration tests developed by Westerlund (2007) which are robust to structural breaks and take cross-sectional dependence into account (Westerlund & Edgerton, 2008). The Westerlund tests consist of four panel cointegration tests based on an error correction model. These panel cointegration tests are based on an error-correction model, not on residual dynamics and consequently impose no restriction of common factors. These tests test the null hypothesis of no cointegration inferring whether the error correction term in an error correction model equals zero. Two of the test statistics are group mean statistics, $G_\tau$and G_α, which

[5]Since the seven Pedroni panel cointegration statistics have been extensively discussed in the literature all the procedures are not discussed in this paper.

investigate cointegration in at least one panel, and the other two test statistics are panel statistics P_τ and P_α, which investigate cointegration for panel members as a whole. G_τ and P_τ are computed with the conventional standard error of the parameters of the error correction model whereas G_α and P_α are adjusted for heteroscedasticity and autocorrelations based on two standard errors developed by Newey and West (1994).

The second-generation panel cointegration tests have the following advantages. First, they allow for a large degree of heterogeneity both in the long-run cointegration relation and in short-run dynamics and can deal with different integration levels in the variables as long as the dependent variable is not I (0) (Persyn & Westerlund, 2008). Second, these tests take into account structural breaks, slope heterogeneities and cross-sectional dependence among the members of the panel. Third, there is an optional bootstrap procedure developed for the tests which is quite robust against cross-sectional dependence, thereby allowing for various forms of heterogeneity. Fourth, the Westerlund panel cointegration tests show both better size accuracy and higher power than the residual-based tests developed by Pedroni. The difference in power arises mainly because the residual-based tests ignore potentially valuable information by imposing a possibly invalid common factor restriction whereas the Westerlund tests take into account the common factor restriction problem.

Hence, this paper uses Westerlund's (2007) error-correction-based cointegration tests in addition to Pedroni's (2004) tests to examine the long-run relationship between economic growth, financial development, institutional quality and globalization for the entire sample and for the different income groups. The Westerlund tests are based on estimates from the error-correction model given by:

$$\Delta y_{it} = \alpha_i' d_t + \phi_i \left(y_{it-1} - \beta_i' x_{it} \right) + \sum_{j=1}^{p_i} \lambda_{ij} \Delta y_{it-j} + \sum_{j=-q_i}^{p_i} \theta_{ij}' \Delta x_{it-j} + \varepsilon_{it} \qquad (14)$$

where t=1,2....,T and i=1,2,…,N are respectively the time-period index and cross-sectional index, p_i and q_i represent the number of lags and leads respectively, d_t is a variable that includes any deterministic components and x_{it} is a variable that includes a set of exogenous variables. We can rewrite Eqn. (14) as:

$$\Delta y_{it} = \alpha_i' d_t + \phi_i y_{it-1} - \phi_i \beta_i' x_{it} + \sum_{j=1}^{p_i} \lambda_{ij} \Delta y_{it-j} + \sum_{j=-q_i}^{p_i} \theta_{ij} \Delta x_{it-j} + \varepsilon_{it} \qquad (15)$$

which can then be used for the estimation instead. In Eqns. (14) and (15), the deterministic component, d_t, has three distinct possibilities. The first case is when $d_t = 0$, in which case Eqns. (14) and (15) have no deterministic term. Second, when $d_t = 1$, the implication is that Eqns. (14) and (15) have a constant intercept term but no trend. Third, having $d_t = (1, t)$ indicates that Eqns. (14) and (15) have both a constant intercept and a trend. Moreover, ϕ_i is the parameter for the error-correction term and determines the speed at which the system returns back to the long-run equilibrium relationship $y_{it-1} - \beta_i' x_{it} = 0$ after a sudden shock. Therefore, given that β_i is not a zero vector, if the value of $\phi_i < 0$, then the model is error correcting which implies that y_{it} and x_{it} are cointegrated whereas if the value $\phi_i = 0$ then the model is not error correcting and thus there is no cointegration among the variables.

The two group cointegration tests state the null hypothesis of no cointegration as $H_0 : \phi_i = 0$ for all i and the alternative hypothesis $H_1 : \phi_i < 0$ for at least one i. In other words, the group's mean statistics G_τ and G_α are used to test the null hypothesis of no cointegration against the alternative hypothesis of at least one element of panel cointegration. The rejection of the null hypothesis indicates the presence of cointegration for at least one cross-sectional unit in the panel. In contrast, the panel cointegration tests state the null hypothesis of no cointegration as $H_0 : \phi_i = 0$ for all i, with the alternative hypothesis being that cointegration is present among the whole panel, that is, $H_1 : \phi_i = \phi < 0$ for all i. In other words, the statistics P_τ and P_α are used to test the null hypothesis of no cointegration against the simultaneous alternative of panel cointegration. The rejection of the null hypothesis means the rejection of no cointegration for the panel as a whole. In summary, based on the group mean and panel tests, rejection of H_0 should be taken as evidence of cointegration in at least one of the cross-sectional units or for the whole panel respectively.

3.3.4. Empirical estimation technique

This paper's estimation strategy largely follows an extended version of the Pesaran (2006) CCE estimator which allows for cross-sectionally heterogeneous coefficients based in the panel ARDL model that is suitable for assessing both short- and long-run relationships. Such models can be estimated if the variables are I (0), I (1), or a mixture of both regardless of whether the variables

are cointegrated or not. The CCE estimator has been used in empirical applications in Bond and Eberhardt (2013); Eberhardt (2012); LeMay-Boucher and Rommerskirchen (2015); and McNabb and LeMay-Boucher (2014) in panel models with strictly exogenous regressors. Pesaran's (2006) baseline specification given independent explanatory variables and unobserved common factors are:

$$\begin{aligned} y_{it} &= \alpha_i + \beta_i' x_{it} + \mu_{it} \\ \mu_{it} &= \alpha_{1i} + \gamma_i' f_t + \varepsilon_{it} \\ x_{it} &= \alpha_{2i} + \phi_i' f_t + \lambda_i' g_t + \nu_{it} \end{aligned} \tag{16}$$

where y_{it}, as used in this paper, for example, is the logarithm of per capita real gross domestic product for country *i* at time *t*; x_{it} is a vector of regressors; f_t and g_t are vectors of unobserved and observed common factors respectively, with country-specific heterogeneous factor loadings γ_i, ϕ_i and λ_i, α_{1i} and α_{2i} are country-specific fixed effects which capture time-invariant heterogeneity across panel units, and ε_{it} and ν_{it} are independent and identically distributed error terms with mean zero and finite constant variance.

The common-factors terms f_t and g_t induce cross-sectional dependency in both the regressor and the error term. Moreover, since the vector of explanatory variables x_{it} and the error term μ_{it} share a set of common factors f_t, then μ_{it} and the regressors x_{it} are correlated if on average the factor loading parameters are non-zero, under which circumstances the usual panel estimators will be biased and inconsistent as shown in Eberhardt et al. (2013).

For non-dynamic models with strictly explanatory variables in which there is cross-sectional dependency, Pesaran (2006) suggests a correction of mean-group (MG) estimators by augmenting the regression model with cross-sectional means of the dependent as well as explanatory variables, resulting in the CCE estimator which is consistent only in non-dynamic panels (Chudik & Pesaran, 2015; Everaert & De Groote, 2016). However, the CCE estimator is inconsistant when the lagged dependent variable is included as a regressor since the lagged dependent variable is no longer strictly exogenous and it is inconsistent when there are any weakly exogenous regressors.

Chudik et al., (2015) extended the CCE estimator into the DCCE estimator that allows for lags in the dependent variables, weakly exogenous regressors and slope heterogeneity. In this model, the slope heterogeneity can be controlled for by first estimating the country-specific parameters; the MG estimator is subsequently used to obtain the average coefficients. A dynamic panel model where the lagged dependent variable is added as a regressor to Eqn. (16) is given as:

$$y_{it} = \alpha_i + \lambda_i y_{i,t-1} + \beta_i x_{it} + \mu_{it} \tag{17}$$

where the idiosyncratic errors μ_{it} are cross-sectionally weakly dependent and the mean of the coefficients of the one-time lag of the dependent variable is homogenous. The lagged dependent variable in Eqn. (17) is no longer strictly exogenous and hence the coefficient estimates become inconsistent. However, Chudik et al., (2015) show that these estimates become consistent by adding $\sqrt[3]{T}$ lags of the cross-sectional means of the dependent and explanatory variables in the model. With this addition, the regression equation is given as:

$$y_{it} = \alpha_i + \lambda_i y_{i,t-1} + \beta_i x_{it} + \sum_{l=0}^{q} \delta'_{i,l} \bar{z}_{t-l} + \varepsilon_{it} \tag{18}$$

where $\bar{z}_t$ represents a vector of the cross-sectional means of the dependent and independent variables with q time lags of the $\bar{z}$ vector. Moreover, Chudik and Pesaran (2015) used a 'half-panel' jack-knife and recursive mean adjustment to help correct for the small sample bias. This approach is based on the distributed lag and an error-correction model (ECM) representation of Eqn. (18), which can be easily written as:

$$\Delta y_{it} = \alpha_i + \theta_i \left(y_{i,t-1} - \beta_i x_{it-1} \right) + \sum_{l=1}^{q} \phi_{i,l} \Delta y_{i,t-l} + \sum_{l=0}^{q} \psi'_{i,l} \Delta x_{t-l} + \sum_{l=0}^{q} \delta'_{i,l} \bar{z}_{t-l} + \varepsilon_{it} \tag{19}$$

Eqn. (19) can be rewritten as:

$$\Delta y_{it} = \alpha_i + \theta_i y_{i,t-1} + \gamma_i x_{it-1} + \sum_{l=1}^{q} \phi_{i,l} \Delta y_{i,t-l} + \sum_{l=0}^{q} \psi'_{i,l} \Delta x_{t-l} + \sum_{l=0}^{q} \delta'_{i,l} \bar{z}_{t-l} + \varepsilon_{it} \tag{20}$$

where $\gamma_i = -\theta_i \beta_i$

In general, Eqn. (20) can be estimated using Pesaran et al.'s (1999) pooled mean group estimator (PMG) or Pesaran and Smith's (1995) mean group estimator (MG) depending on the long-run coefficient characteristics. PMG's main characteristic is that it allows short-run parameters, error correction coefficients and error variances to be heterogeneous across countries, while the long-

run parameters are homogenous across countries. The MG estimation introduced by Pesaran and Smith (1995) does not impose any restrictions, that is, it allows heterogeneous long-run and short-run parameters that vary across countries. In MG, a separate regression is run for each cross-sectional unit and estimators of the heterogonous intercept and slope are derived by unweighted means of the estimated coefficients. The PMG estimator provides more efficient estimates compared to the MG estimator under the assumption of long-run homogeneity. Furthermore, the PMG estimator has more freedom compared to the MG estimator when the time dimension is long enough.

The Hausman test is used to test whether there is a significant difference between the PMG and MG estimators. The null hypothesis of this test is that the difference between PMG and MG estimation is not significant, in other words, the long-run coefficients are homogeneous. If the null hypothesis is not rejected, then the PMG estimator is an efficient and more appropriate method. The DCCE estimator proposed by Chudik and Pesaran (2015) extends the CCE estimator to allow for cross-sectional dependence, static and dynamic specifications, endogenous regressors and fixed and country-specific coefficients.

4. Empirical analysis

This section presents descriptive statistics to give a clear and generalized view of the dataset. It also reports the cross-sectional dependency tests based on Pesaran (2004) and the panel unit root tests for the entire sample as well as sub-groups of countries based on income levels. Furthermore, this section presents the results of Pedroni and Westerlund panel cointegration tests, which are used to investigate the existence of a long-run relationship among the variables and gives the estimates of the DCCE model.

4.1. Descriptive statistics

This sub-section gives simple descriptive statistics of the raw data of 1,400 observations used in this study. As shown in Table 2.2, the mean logged per capita GDP and per capita income growth in 40 African countries over the period of 1980-2014 for the entire panel of countries is 7.65 (equivalent to $1,096) and 1.01 percent respectively. The mean for the financial development index is about 0.13 with the first quartile being 0.08 and the third quartile being 0.15. Table 2.2 also reports that the means of the institutional indicator from Freedom House and the globalization indices are 3.27 and 37.14 respectively and shows that the mean for the logarithmic of the per

capita physical capital stock index is 8.25, where the first quartile is 7.42 and the third quartile is 9.13.

Table 2.2: Descriptive statistics (1980–2014) for the entire sample of 40 African countries

Dependent variable	*N*	mean	*SD*	p25	p50	p75
Log of per capita GDP	1400	7.65	0.89	6.97	7.53	8.22
Growth of per capita GDP	1400	1.01	6.12	-1.04	1.40	3.55
Independent variables						
Log of stock of physical capital per capita	1400	8.25	1.28	7.42	8.17	9.13
Financial development indices *(0= lowest level of financial development and 1= highest)*						
Financial development index (sub-indices below)	1400	0.13	0.08	0.08	0.11	0.15
Financial institutions index	1400	0.21	0.11	0.15	0.18	0.25
Financial markets index	1400	0.04	0.08	0.00	0.01	0.04
Globalization indices *(1= lowest level of globalization and 100 = highest)*						
Globalization index (sub-indices below)	1400	37.74	10.52	29.57	37.80	44.76
Economic globalization index	1400	40.32	14.82	28.96	39.48	50.64
Social globalization index	1400	24.02	10.79	16.11	21.85	31.02
Political globalization index	1400	52.90	18.65	37.11	49.02	67.70
Institutional quality indices *(1= worst institutional quality and 7=best)*						
Institutional quality index (average of PR & CL)	1400	3.27	1.50	2.50	3.00	4.00
Political rights index (PR)	1400	3.16	1.73	2.00	3.00	4.00
Civil liberties index (CL)	1400	3.38	1.38	2.00	3.00	4.00

Notes: *N* is number of observations in the panel (*n*=40 and *T*=35). SD is standard dilation. p25, p50 and p75 are quartiles. GDP and stock of physical capital are measured in constant 2011 US$.
Source: Author's calculations based on raw data.

Moreover, mean values for the logarithm of physical capital stock, the financial development index, the institutional quality index and the globalization index are higher in upper-middle income countries as compared to the low-and lower-middle income countries (detailed descriptive statistics are provided for all income categories in Table A2 in the Appendix).[6]

A correlation matrix among the dependent and independent variables and their level of significance is reported in Table 2.3. The results indicate that all the variables—log of per capita GDP, the indices for financial development, globalization, institutional quality and log of per capita capital stock — have positively significant correlations with each other at the 5 percent level of significance. The correlation coefficient results for the three sub-income categories are reported in

[6] Furthermore, as can be seen from Figures A1 and A2 in the Appendix, countries in the upper-middle income category have higher levels of financial development and institutional quality indicators.

Table A3 in the Appendix, which reveal that there are considerable variations across the income categories.

Table 2.3: Pairwise correlations of important variables for the full sample of 40 African countries

No.	Variables	1	2	3	4	5
1	Log of per capita GDP	1				
2	Log of per capita stock of capital	0.81*	1			
3	Financial development index	0.63*	0.52*	1		
4	Globalization index	0.67*	0.70*	0.58*	1	
5	Institutional quality index	0.41*	0.26*	0.35*	0.43*	1

Notes: * at the 5 percent level of significance. GDP and stock of physical capital are measured in constant 2011 US$.

Figure 2.1 gives information about the overall financial development, financial institutions' development and financial markets' development by income groups. As can be seen, financial institutions' development is relatively higher than financial markets' development in all income groups. The overall financial development index and its components on average improve with higher incomes.

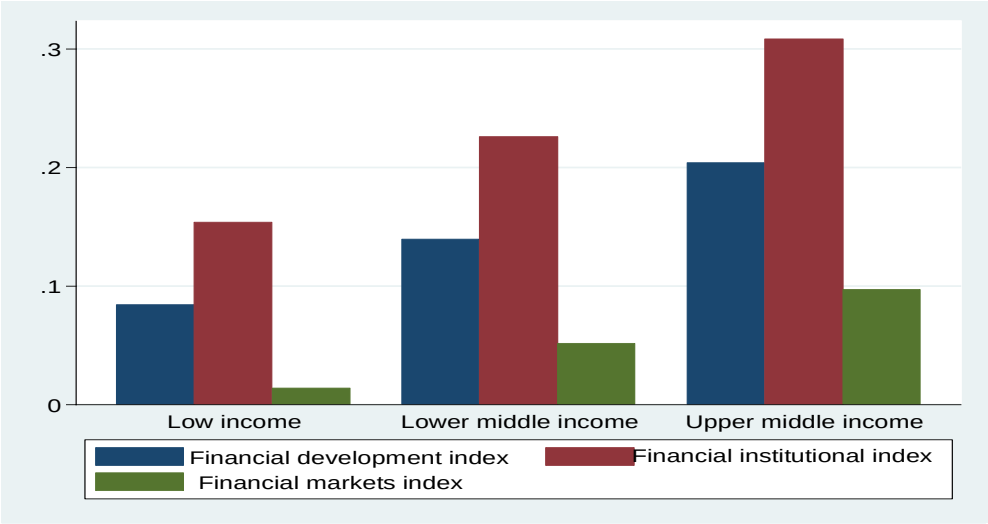


Figure 2.1: Financial development and its sub-component indicators by income groups for 40 African countries
Source: Author's calculations based on data from the International Monetary Fund (IMF).

Figure 2.2 shows a plot of mean values over the sample period on indicators of institutional quality for different income levels. As can be seen in the figure, each Freedom House's quality indicator

is the highest in upper-middle income countries, followed in order by lower-middle income and low-income countries.

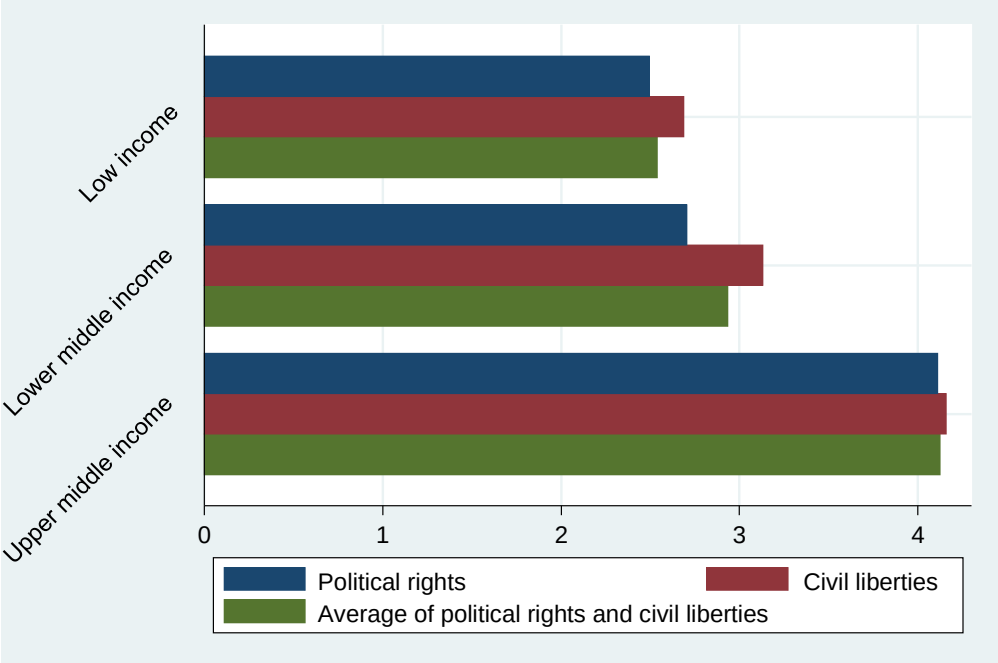


Figure 2.2: Institutional quality by income group mean over the period 1980-2014
Source: Author's calculations based on the Freedom House dataset.

4.2. The cross-sectional dependence tests

Table 2.4 gives CD statistics and their p-values along with information on the cross-sectional correlation for each variable where ρ measures the magnitude of correlation and 'mean $|\rho|$' indicates the mean of the absolute value of the contemporaneous correlation across countries. The null hypothesis that there is no cross-sectional dependence can be rejected at the 1 percent significance level for all of the variables as shown in Table 2.4 (see CD test results by income category in Table A4 in the Appendix). The test statistics for cross-sectional dependence clearly reveal that the null hypothesis of no cross-sectional dependence is rejected for all significance levels. More precisely, this implies that there is cross-sectional dependence among the full sample of 40 countries in the panel. Any shock in one country is transmitted to others; therefore, the econometric strategy employed should incorporate this in the estimation process to reduce the potential problem of producing biased estimates. The dynamic common correlated effect estimator, the second-generation panel unit root and cointegration tests are more appropriate than the first-generation panel unit root and cointegration tests.

The results suggest that even after including the regressors that are expected to affect economic growth in each country in later regressions, the regression disturbance terms among the countries will also affect one another. The third column in Table 2.4 presents the mean pairwise (between countries) cross-sectional correlation coefficients for each variable. It shows that the coefficients of correlation are the highest in the case of the average globalization index, followed by stock of per capita physical capital. This shows that all countries in the sample are influenced by globalization and have common economic characteristics for cross-sectional dependence.

Table 2.4: Pesaran's (2004) CD test results for the entire sample of countries

Variables	CD-test	p-value	mean ρ	mean abs(ρ)
Log of per capita GDP	49.4	0.000	0.30	0.47
Log of per capita stock of physical capital	83.6	0.000	0.51	0.70
Financial development index (sub-indices below)	22.3	0.000	0.13	0.42
Financial institutions index	26.5	0.000	0.16	0.40
Financial markets index	9.0	0.000	0.05	0.39
Average globalization index (sub-indices below)	141.0	0.000	0.85	0.85
Economic globalization index)	82.3	0.000	0.50	0.55
Social globalization index	111.2	0.000	0.68	0.74
Political globalization index	113.3	0.000	0.69	0.70
Institutional quality index (average of PR & CL)	30.3	0.000	0.18	0.41
Political rights index (PR)	14.8	0.000	0.09	0.39
Civil liberties index (CL)	49.1	0.000	0.30	0.44

Note:

1. ρ is the cross-sectional correlation of the variable and abs(ρ) is the absolute value of the correlation.
2. Under the null hypothesis of cross-sectional independence, CD ~ N (0, 1), p-values close to zero indicate that the data are correlated across panel groups.
3. I use the Stata routine 'xtcd' developed by Eberhardt (2011) in Stata 14.
4. GDP and stock of physical capital are measured in constant 2011 US$.

4.3. The panel unit root test allowing for cross-sectional dependence

Since the previous sub-section clearly shows that all the variables being considered for later regressions face a cross-sectional dependence problem, applying standard panel unit root tests to them will suffer from significant size distortions, resulting in over-rejecting the null of non-stationarity (Eberhardt & Presbitero, 2015; Pesaran, 2007). Thus, I used the 'CIPS' test suggested by Pesaran (2007) that accommodates such dependence to investigate the integration levels of the variables. CIPS tests were carried out including an intercept only as well as with an intercept and

linear trend in levels and in first differences for all income categories. As indicated in Table 2.5, when using the full sample of countries all the presented variables appear non-stationary in levels, except financial development under the specification without trend and the institutional quality indicator from Freedom House, but all variables are stationary in the first-difference under the specifications without trend (constant only) and with trend (constant and trend) at the 1 percent level of significance. In other words, the panel unit root test's results confirm that no variable is I (2).

Table 2.5: Pesaran's (2007) panel unit root test results for the full sample of countries

Variables	Specification without trend		Specification with trend	
	Zt-bar	p-value	Zt-bar	p-value
	In Level			
Log of per capita GDP	-0.08	0.467	3.39	0.897
Log of per capita stock of physical capital	1.39	0.918	-2.29	0.411
Financial development index	-4.61	0.000	-1.21	0.113
Financial institutions index	-3.83	0.000	-3.42	0.000
Financial markets index	-0.61	0.270	-0.24	0.406
Globalization index	-1.24	0.108	-0.56	0.289
Institutional quality index	-1.41	0.079	-2.38	0.009
	In first difference			
Log of per capita GDP	-3.84	0.000	-1.72	0.043
Log of stock per capita of physical capital	-2.40	0.003	1.33	0.026
Financial development index	-10.75	0.000	-9.87	0.000
Financial institutions index	-10.27	0.000	-7.68	0.000
Financial markets index	-9.82	0.000	-7.56	0.000
Globalization index	-7.99	0.000	-5.28	0.000
Institutional quality index	-7.27	0.000	-5.06	0.000

Notes: The Stata routine 'multipurt' developed by Eberhardt (2011) is employed. The number of lags was determined by the AIC and BIC integral average of the individual panel that is the optimal lag length of one. GDP and stock of physical capital are measured in constant 2011 US$.

The CIPS test's results for low-income, lower-middle income and upper-middle income countries are presented in Table A5 in the Appendix. These results also show that all the variables are stationary in first difference, but in levels they are I (0) or I (1).

4.4. The panel cointegration test allowing for cross-sectional dependence

The previous sections have shown that there is typically cross-sectional dependence based on the Pesaran (2004) test and the some of the variables, including per capita GDP, appear to be non-

stationary in levels based on Pesaran's (2007) CIPS test. Following the CD and CIPS tests, the next step is to check the existence of cointegration among the variables. For this purpose, I performed Pedroni's (1999, 2004) cointegration test for panel data based on residuals, and the Westerlund (2007) cointegration tests for panel data based on an error-correction model.

The Pedroni-test results in Table 2.6 indicate that when considering cointegration between the log of per capita GDP and the four explanatory variables (log of per capita capital stock, the financial development index, the institutional quality index and the globalization index) the null hypothesis of no cointegration is rejected for six out of the seven statistics when the test includes both the constant and trend term, and it is rejected for five out of the seven statistics when the specifications include a constant but no trend term. This implies that these variables have a significant long-run relationship. The Pedroni test uses the Bayesian information criterion (BIC) to automatically select the appropriate lag length (maximum set to 8).

Table 2.6: First and second-generation panel cointegration tests

Pedroni's cointegration test			Westerlund's cointegration test				
Statistics	Without time trend						
	Panel	Group	Statistics	Value	z-value	p-value	Robust p-value
V-statistic	0.251	.	Gt	-5.45	-21.37	0.000	0.002
Rho-statistic	0.689	2.583***	Ga	-44.50	-35.76	0.000	0.014
T-statistic	-2.486**	2.350***	Pt	-28.17	-20.25	0.000	0.012
ADF-statistic	-2.155**	2.993***	Pa	-44.30	-45.23	0.000	0.012
	With time trend						
V-statistic	0.3053	.	Gt	-5.41	-19.75	0.000	0.018
Rho-statistic	1.72**	3.417***	Ga	-44.36	-25.36	0.000	0.060
T-statistic	-2.774***	-2.341***	Pt	-27.93	-19.74	0.000	0.066
ADF-statistic	-2.557***	-2.192**	Pa	-44.15	-30.62	0.000	0.090

Notes:

1. *The variables included are the log of per capita GDP, log of per capita capital stock, the financial development index, the average institutional index and the average globalization index. GDP and stock of physical capital are measured in constant 2011 US$.*
2. *In Pedroni statistics. 'All test statistics are distributed N (0,1) under a null of no cointegration, and diverge to negative infinity [under the alternative] (save for panel v)' (Neal, 2014).*
3. ****, **, and * represent a 1 percent, 5 percent and 10 percent level of significance respectively.*
4. *The tests are done using STATA 14 with the 'xtpedroni' (Neal, 2014) and the 'xtwest' command (Persyn & Westerlund, 2008).*
5. *Bootstrapped p-values robust against cross-sectional dependencies are obtained from bootstrapping 500 times in the Westerlund test.*

To account for cross-sectional dependence across the entire sample of 40 countries and all sub-groups of countries, it is more robust to apply Westerlund's (2007) panel cointegration test. Under the presence of cross-sectional dependence, recent papers have shown that the asymptotic p-values without bootstrapping are inefficient and inconsistent as compared to the robust p-values with bootstrapping. The Westerlund test based on the ECM approach using asymptotic p-values and robust p-values based on 500 bootstrap replications are reported in Table 2.6. The results clearly reject the null of no cointegration and confirm that cointegration exists between the core variables of the study.

4.5. Long and short run estimations using the panel error correction model

Table 2.7 reports for the full sample of countries the results of estimated error correction models in which the log of per capita GDP has a long-run relationship with the per capita stock of physical capital (in logarithm), the financial development index, the globalization index and the institutional quality index. Columns 1 and 2 in Table 2.7 report the results for the pooled-mean group (Pesaran et al., 1999) and mean-group (Pesaran & Smith, 1995) estimated models respectively. I used the Hausman test to choose an efficient and consistent estimator between the PMG and MG estimators. According to the test results, presented in Table A7 in the Appendix, the calculated Hausman statistic is 2.57 with a p-value of 0.633 and is distributed $\chi^2(4)$, so the null hypothesis of long-run homogeneity across countries cannot be rejected. This indicates that PMG is a more suitable and efficient estimator as compared to the MG estimator. The PMG method considers homogeneity in the long-run coefficients while still allowing for heterogeneity of the short-run coefficients and error variances.

According to the PMG results in the first column, which follow Pesaran et al.'s (1999), maximum-likelihood strategy, any increase in the per capita physical capital stock, financial development, globalization or institutional quality has a long-run positive impact on economic growth while an increase in physical capital has a significant positive impact on economic growth in the short-run. The third column presents PMG estimates like those in first with the crucial difference that the estimates are performed using ordinary least squares (OLS) as advocated by Ditzen (2016), so these estimates are referred to as PMG-OLS estimates.

As shown in Column 3, the null hypothesis of the absence of weak cross-sectional dependence is rejected at the 10 percent significance level for the PMG-OLS estimates, in which there is no attempt to correct for cross-sectional dependence, suggesting that the estimates in the column are inconsistent. Columns 4 and 5 modify the model given in Column 3 by augmenting it with cross-sectional means of the explanatory variables (current values and first, second and third lags),[7] with this augmentation being used to correct for common correlated effects. The resulting estimates are referred to as the Dynamic Common Correlated Effects (DCCE) estimates. Column 4 presents these estimates without small-sample time-series bias correction and Column 5 presents these estimates with jack-knife correction for such a bias. Extensive Monte Carlo experiments by Chudik and Pesaran (2015) show better size and power properties for tests using DCCE estimates with jack-knife correction for small-sample time-series bias than for tests without such correction. The p-values for the CD statistics in Columns 4 and 5 indicate a failure to reject the null hypothesis of cross-sectional dependence for the residuals at the 10 percent significance level, in contrast to the analaogous p-values in Column 3, which lends credence to the suggestion that the DCCE estimates are the most legitimate ones among those presented in Table 2.7.

The DCCE estimates with small-sample time-series bias correction, given in Column 5, show that any increase in the per capita physical capital stock, financial development or globalization has a positive and significant impact on economic growth in the long run and no impact on economic growth in the short run. The estimates of the error correction (speed of adjustment) coefficients are significantly negative in all the estimated models presented in Table 2.7, indicating the existence of stable and converging long-run relationships among the variables for the entire sample of 40 countries. This result confirms the cointegration relationship between the variables of interest (excluding institutional quality), implying that the linkages between economic growth and the explanatory variables are characterized by some long-run predictability, with the spread between logged per capita GDP and a linear combination of the explanatory variables being mean reverting. The estimates in Table 2.7 also indicate that institutional quality has a positive effect on per capita output on average (albeit insignificant in all models except PMG), while in the short run, better institutions will improve the economic performance of the countries in the panel (at the 10 percent significance level or lower).

[7] The optimal lag length is determined by $\sqrt[3]{T}$ where T=35 (as proposed by Chudik, 2015).

Table 2.7: Long run and short run estimations following the error correction model (Dependent variable: Log of per capita GDP)

Variables	PMG[a]	MG[b]	PMG-OLS[c]	DCCE[d]	
				Without jackknife	With jackknife
	(1)	(2)	(3)	(4)	(5)
Long-run coefficients					
Log capital stock per capita	0.1877***	0.3589**	0.1082	0.1711***	0.1364**
	(0.01)	(0.18)	(0.09)	(0.06)	(0.07)
Financial development index	2.8491***	0.6884	0.1056	2.5086**	2.6096**
	(0.56)	(2.13)	(1.32)	(1.05)	(1.06)
Globalization index	0.0205***	0.0197**	0.0289***	0.0191***	0.0225***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Institutional quality index	0.060***	0.0659	0.0572	0.03	0.04
	(0.01)	(0.08)	(0.05)	(0.03)	(0.03)
Short-run coefficients					
Speed of adjustment	-0.116***	-0.307***	-0.084***	-0.31***	-0.308***
	(0.02)	(0.03)	(0.01)	(0.04)	(0.03)
Δ Log of capital stock per capita	0.1118**	0.1713**	0.2086***	0.2753*	0.2193**
	(0.05)	(0.07)	(0.07)	(0.14)	(0.15)
Δ Financial development index [e]	0.029	0.0247	0.0775	0.2095	0.0047
	(0.18)	(0.25)	(0.5282)	(0.39)	(0.36)
Δ Globalization index [e]	0.0009	-0.0011	0.002	0.0006	-0.0013
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ Institutional quality index [e]	0.0179**	0.0150**	0.0207*	0.0289**	0.0307*
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Constant	0.446***	1.597***	0.3796***	1.9389***	1.8789***
	(0.08)	(0.27)	(0.01)	(0.03)	(0.03)
Number of observations	1400	1400	1400	1300	1200
Adjusted R^2		0.5412	0.295	0.315	0.578
CD test statistic [f]		5.30	1.76	-0.58	-1.36
(CD p-value) [f]		(0.000)	(0.08)	(0.56)	(0.17)

Note: ***, **, and * indicate significance at the 1 percent, 5 percent and 10 percent level respectively.
Columns 1 and 2 are based on the results from the STATA package xtpmg (by Edward F. Blackburne III and Mark W. Frank) and Columns 3 and 4 are based on results from the STATA package xtdcce2 (by Jan Ditzen).
GDP and stock of physical capital are measured in constant 2011 US$.

[a] *PMG: Estimates using pooled mean group estimator which does not account for cross-sectional dependency.*

[b] *MG: Estimates mean group estimators that take into account slope heterogeneity.*

[c] *PMG-OLS: Pooled-mean-group estimates using OLS estimates rather than maximum likelihood.*

[d] *DCCE: Pooled-mean-group estimates using OLS estimates, with standard CCE correction, using cross-sectional means for current, lag-one, lag-two and lag-three values. The results in Columns 4 and 5 are respectively those without and with a jack-knife bias correction for small-sample time-series bias.*

[e] Δ *is the first difference operator*: $\Delta x = x_t - x_{t-1}$

[f] *CD test statistic = Pesaran (2015) weakly cross-sectional dependence test statistic, and CD p-value = the associated p-value of the cross-sectional dependency test.*

Table 2.8 presents the jackknife-corrected DCCE regression results for financial development and its components—financial institutions' development and financial markets' development—in addition to institutional quality and globalization indices for the entire sample. The results reported in Column 1 in Table 2.8 show that increased financial development is positively related to economic growth in the long-run and it is statistically significant at the 5 percent level. All else being equal, a 0.1 unit increase in the financial development index leads to real per capita output growing by about 26 percent, which shows that improved financial development plays a vital role in increasing economic growth in the long run, a finding that is in line with Beck et al., (2014) and Loayza and Ranciere (2006). Similarly, the estimated results show that in the long-run, increases in the stock of per capita physical capital and greater globalization have significantly positive impacts on economic growth at the 5 percent significance level. About a 2.3 percent economic growth in the long-run is linked with a 1 unit increase in the globalization index.

To examine the role of financial development in economic growth it is better to consider the simultaneous and separate impact of financial institutions' development and financial markets' development across countries and income categories. The results in Column 2 in Table 2.8 indicate that greater financial institutions' development has a positive and significant impact on growth in the long run. However, the same cannot be said for greater financial markets' development. The estimated results reflect that African countries are predominantly financial institution-based economies and financial markets still lack enough development to be able to affect economic growth in Africa.

Column 4 in Table 2.8 includes the financial development-institutional quality interaction as an explanatory variable along with the financial development index. After including the interaction term, the long-run coefficients for the log of per capita capital stock and the globalization index remain significantly positive (at the 10 percent significance level), while the long-run coefficient estimate for the financial development index becomes insignificant. However, the results reveal a complementary relationship between financial development and intuitional quality in their associations with economic growth in the short run. This implies that financial development promotes economic growth in the short-run in countries with better institutional quality.

Table 2.8: Dynamic common correlated effects estimations, 40 African countries
(Dependent variable: Log of per capita GDP)

Variables	(1)	(2)	(3)	(4)
Long-run coefficients				
Log capital stock per capita	0.1364**	0.2544**	0.2287**	0.1505*
	(0.07)	(0.11)	(0.09)	(0.09)
Globalization index	0.0225***	0.0231*	0.0260**	0.0244**
	(0.01)	(0.01)	(0.01)	(0.01)
Institutional quality index	0.03	0.1263**	0.0826*	-0.0039
	(0.03)	(0.06)	(0.04)	(0.06)
Financial development index	2.6096**			0.1289
	(1.06)			(1.44)
Financial institutions index		2.2908**		
		(1.13)		
Financial markets index			-0.0144	
			(1.10)	
Financial development index and institutional quality index interaction				-0.1556
				(0.43)
Short-run coefficients				
Speed of adjustment	-0.308***	-0.242***	-0.333***	-0.341***
	(0.03)	(0.05)	(0.05)	(0.05)
Δ Log of capital stock per capita	0.2193**	0.1032	0.2891**	0.1591
	(0.15)	(0.13)	(0.14)	(0.19)
Δ Globalization index	-0.0013	0.0042	-0.0033	0.002
	(0.00)	(0.00)	(0.00)	(0.00)
Δ Institutional quality index	0.0307*	0.0363**	0.0303*	-0.1159
	(0.02)	(0.02)	(0.02)	(0.09)
Δ Financial development index	0.0047			12.0363
	(0.36)			(8.23)
Δ Financial institutions index		-0.2918		
		(0.33)		
Δ Financial markets index			-1.9284	
			(11.88)	
Δ Financial development index and institutional quality index interaction				0.2632**
				(0.13)
Constant	1.878***	1.251***	2.092***	2.096***
	(0.03)	(0.02)	(0.03)	(0.04)
Number of observations	1200	1200	1200	1200
Adjusted R^2	0.578	0.6185	0.614	0.5688
CD test statistic	-1.358	-0.7751	0.4545	0.1203
(CD p-value)	(0.1745)	(0.4383)	(0.6494)	(0.9042)

*Note: (1) ***, **, and * indicate significance at a 1 percent, 5 percent and 10 percent level respectively. (2) CD test statistic = Pesaran (2015) weakly cross-sectional dependence statistic, and CD p-value= the associated p-value of cross-sectional dependency test. (3)* Δ *represents the first difference operator:* $\Delta x = x_t - x_{t-1}$. *(4) GDP and stock of physical capital are measured in constant 2011 US$. (5) Jackknife used in estimates.*

I re-estimated these models for sub-income groups to examine the extent to which the coefficient estimates varied based on the degree of country development. The results presented in Tables 2.9-11 are the same as the ones given in Table 8 with the difference that Tables 2.9-2.11 present the estimates for each of the three sub-groups of countries -- low-income, lower-middle income and upper-middle income respectively.

The results in Tables 2.9 and 2.10 show that an increase in the financial institutions' index has a long-run positive and significant impact on economic growth in the low- and lower-middle income sub-groups, while improvements in aggregate financial development have an insignificant long-run effect on economic growth in these sub-groups. A plausible explanation for these results is that financial markets, particularly the bond market are relatively underdeveloped as is typical in developing countries. Under these circumstances, improvements in aggregate financial development have a positive effect on growth, but this is insignificant due to the underdevelopment of the financial markets sub-component of financial development in the low-income and lower-middle income countries in Africa. The empirical finding that increases in the financial institutions index have positive and significant effects on growth in the long-run in low- and lower-middle income countries is consistent with Calderón and Liu (2003) and Huang and Lin (2009). In contrast, Table 2.11 indicates that for the upper-middle income countries in Africa, improvements in aggregate financial development and in each of the sub-components of financial development, that is, increases in the financial institutions' index and the financial markets' index, significantly affect economic growth in the long run.

Under all specifications in Tables 2.9-2.11 the error-correction term is significant, which is consistent with the existence of long-run cointegration among the variables. The estimates for the error-correction term vary with the income level, ranging from -0.08 to -0.11 in low-income countries, -0.07 to -0.08 in lower-middle income countries and -0.24 to -0.38 in upper-middle income countries. This implies that the upper-middle income countries converge to the long-run equilibrium more quickly compared to the low and lower-middle income countries.

Table 2.9: Dynamic Common Correlated Effects estimates, 19 low-income countries
(Dependent variable: Log of per capita GDP)

Variables	(1)	(2)	(3)	(4)
Long-run coefficients				
Log capital stock per capita	1.0196*	0.9737**	0.5795**	0.9443*
	(0.56)	(0.48)	(0.27)	(0.50)
Globalization index	0.0814**	0.0696**	0.0585***	0.0931**
	(0.04)	(0.03)	(0.02)	(0.04)
Institutional quality index	0.0227	0.0255	-0.0608	0.2711
	(0.17)	(0.14)	(0.15)	(0.29)
Financial development index	2.5043			-8.025
	(4.08)			(11.16)
Financial institutions index		1.0309**		
		(0.03)		
Financial markets index			-0.6069	
			(0.53)	
Financial development index and				-0.9009
institutional quality index interaction				(1.22)
Short-run coefficients				
Speed of adjustment	-0.0755**	-0.0868**	-0.1143***	-0.0810**
	(0.03)	(0.03)	(0.03)	(0.03)
Δ Log of capital stock per capita	0.2508	0.2448*	0.2731	0.3496*
	(0.15)	(0.14)	(0.22)	(0.20)
Δ Globalization index	0.0023	0.0018	0.0043	0.0063
	(0.01)	(0.00)	(0.01)	(0.01)
Δ Institutional quality index	0.0336*	0.0337*	0.0394**	0.1275
	(0.02)	(0.02)	(0.02)	(0.08)
Δ Financial development index	0.5798			2.9508*
	(0.70)			(1.66)
Δ Financial institutions index		0.1179		
		(0.40)		
Δ Financial markets index			0.0433	
			(0.23)	
Δ Financial development index and				0.6023**
institutional quality index interaction				(0.26)
Constant	0.7135***	0.8173***	0.7941***	0.0.890***
	(0.03)	(0.03)	(0.03)	(0.03)
Number of observations	622	622	622	622
Adjusted R^2	0.4103	0.3994	0.3898	0.4454
CD test statistic	-0.0974	-0.4004	1.0473	-1.1372
(CD p-value)	(0.9224)	(0.6888)	(0.295)	(0.2555)

*Note: 1) ***, **, and * indicates significance at a 1 percent, 5 percent and 10 percent level respectively. 2) CD test statistic = Pesaran (2015) weakly cross-sectional dependence statistic, and CD p-value= the associated p-value of cross-sectional dependency test. 3)* Δ *is the first difference operator:* $\Delta x = x_t - x_{t-1}$*. 4) GDP and stock of physical capital are measured in constant 2011 US$. 5) Jackknife used in estimates.*

Table 2.10: Dynamic Common Correlated Effects estimates,14 lower-middle income countries (Dependent variable: Log of per capita GDP)

Variables	(1)	(2)	(3)	(4)
Long-run coefficients				
Log capital stock per capita	1.7451	1.8119	1.3827	3.5867
	(12.34)	(1.74)	(1.27)	(14.15)
Globalization index	0.0787***	0.0873***	0.0987**	0.0769**
	(0.02)	(0.02)	(0.04)	(0.03)
Institutional quality index	0.075	-0.5485	-0.5035	-0.7144
	(0.10)	(0.83)	(0.85)	(4.24)
Financial development index	2.3293			1.78
	(47.03)			(480.15)
Financial institutions index		0.9218**		
		(0.45)		
Financial markets index			0.1573	
			(7.78)	
Financial development index and				0.1325
institutional quality index interaction				(2.80)
Short-run coefficients				
Speed of adjustment	-0.082***	-0.081***	-0.071***	-0.066***
	(0.02)	(0.02)	(0.03)	(0.02)
Δ Log of capital stock per capita	0.4166**	0.3297**	0.119	0.4130**
	(0.16)	(0.15)	(0.20)	(0.16)
Δ Globalization index	0.0026	-0.003	-0.0007	-0.0032
	(0.00)	(0.00)	(0.00)	(0.00)
Δ Institutional quality index	-0.0072	-0.0101	-0.0129	-0.0088
	(0.01)	(0.01)	(0.01)	(0.10)
Δ Financial development index	0.1819			-0.5348
	(0.31)			(4.14)
Δ Financial institutions index		0.3626		
		(0.33)		
Δ Financial markets index			-5.1809	
			(4.66)	
Δ Financial development index and				-0.1751
institutional quality index interaction				(0.78)
Constant	0.025***	0.099***	0.289***	0.045***
	(0.01)	(0.02)	(0.01)	(0.01)
Number of observations	464	464	464	464
Adjusted R^2	0.5983	0.616	0.5938	0.6154
CD test statistic	-2.1997	-2.3691	-3.1546	0.0059
(CD p-value)	(0.0278)	(0.0178)	(0.0016)	(0.9953)

*Note: 1) ***, **, and * significant at a 1 percent, 5 percent and 10 percent level of significance respectively. 2) CD test statistic = Pesaran (2015) weakly cross-sectional dependence statistic, and CD p-value= the related p-value of cross-sectional dependency test. 3)* Δ *is the first difference operator:* $\Delta x = x_t - x_{t-1}$*. 4) GDP and stock of physical capital are measured in constant 2011 US$. 5) Jackknife used in estimates.*

Table 2.11: Dynamic Common Correlated Effects estimates, 7 upper-middle income countries (Dependent variable: Log of per capita)

Variables	(1)	(2)	(3)	(4)
Long-run coefficients				
Log capital stock per capita	0.2217*	0.2696**	0.3329**	0.3006***
	(0.11)	(0.13)	(0.12)	(0.10)
Globalization index	0.0209*	0.0154	0.0158	0.0207*
	(0.01)	(0.03)	(0.02)	(0.01)
Institutional quality index	0.0418	-0.0989	0.059	0.0896
	(0.06)	(0.09)	(0.07)	(0.11)
Financial development index	4.1679**			3.1888***
	(1.86)			(1.04)
Financial institutions index		3.3326**		
		(1.77)		
Financial markets index			1.6741*	
			(0.831)	
Financial development index and institutional quality index interaction				-0.2799
				(0.48)
Short-run coefficients				
Speed of adjustment	-0.294***	-0.244**	-0.378**	-0.338***
	(0.09)	(0.10)	(0.16)	(0.10)
Δ Log of capital stock per capita	0.7498***	0.9235**	0.6878**	0.6487
	(0.28)	(0.37)	(0.27)	(0.59)
Δ Globalization index	0.0135**	0.0003	0.0087*	0.0071**
	(0.01)	(0.01)	(0.00)	(0.00)
Δ Institutional quality index	-0.0549	0.0049	-0.0597	0.134
	(0.04)	(0.06)	(0.05)	(0.31)
Δ Financial development index	-1.7063			-17.7598
	(1.10)			(13.14)
Δ Financial institutions index		2.1753***		
		(0.56)		
Δ Financial markets index			2.9735	
			(4.02)	
Δ Financial development index and institutional quality index interaction				-2.128
				(2.60)
Constant	1.931***	1.501***	2.122***	1.961***
	(0.06)	(0.05)	(0.06)	(0.07)
Number of observations	229	229	229	229
Adjusted R^2	0.5354	0.5462	0.5144	0.5664
CD test statistic	0.7429	1.4749	0.2051	0.2654
(CD p-value)	(0.4576)	(0.1402)	(0.8375)	(0.7907)

*Note: 1) ***, **, and * indicate significance at the 1 percent, 5 percent and 10 percent level respectively. 2) CD test statistic = Pesaran (2015) weakly cross-sectional dependence statistic, and CD p-value= the associated p-value of cross-sectional dependency test. 3)* Δ *is the first difference operator:* $\Delta x = x_t - x_{t-1}$*. 4) GDP and stock of physical capital are measured in constant 2011 US$. 5) Jackknife used in estimates.*

An improvement in the institutional quality variable has a positive and significant impact on economic growth in the short-run in low-income countries as shown in Columns 1-3 in Table 2.9. In all the models and in all income categories, increased globalization has a positive long-run effect on economic growth and the relevant coefficient is significant at the 5 percent level in low-income and lower-middle income countries under all model specifications. This result of positive effects of globalization are consistent with several theoretical predictions and empirical findings in the literature (for example, Kilic, 2015; Ying et al., 2014).

The results in Column 4 in Tables 2.9-2.11 also indicate that when the interaction term between financial development and institutional quality is included as an explanatory variable along with the financial development index, the boost to economic growth in the short-run from increased financial development is significantly enhanced by better institutional quality in low-income countries only. This result reveals that increased financial development has a heterogeneous short-run impact on economic growth when it is complemented by institutional quality. It also sheds light on the importance of institutional quality in low-income countries in explaining cross-country heterogeneity in the study.

Over the last few decades African countries in general have made substantial progress in financial development particularly in financial institutions, but their financial markets are still underdeveloped as compared to other regions. In Africa, the financial system is an important instrument that channels the savings of surplus units to deficit units. In this process it helps promote capital formation, increases efficient investments and enhances productivity thereby leading to economic growth. The link between financial development and its sub-components and economic growth differs across different income groups. While increased financial development has a positive and significant long-run effect on economic growth in the whole sample, it has insignificant long-run effects on the low-income and lower-middle income countries and a significant effect on the upper-middle income countries. The long-run effects on per capita output from different sub-components of financial development, that is, the degree of development of financial institutions and financial markets, yields different results. The degree of development of financial institutions which predominantly captures the degree of development of the banking and insurance industries has a positive and significant effect on per capita output in all income categories, whereas the degree of development of financial markets which captures the degree of

development of the capital and bond markets, has significant effects on per capita output only for the upper-middle income countries.

5. Conclusion and policy recommendations

This paper has examined the short- and long-run relationships among financial development, institutional quality, globalization and economic growth for 40 African countries divided into three sub-groups (low-, lower-middle and upper-middle income panels) over the period 1980–2014. It used a new broad-based financial development index generated with the help of principal component analysis based on two sub-components (financial institutions and financial markets). It also used a broad measure of institutional quality, based on six dimensions of governance and a globalization index comprising economic, social and political globalization variables.

Furthermore, the study also used recently developed macro-econometric panel data estimation techniques to address the problems of cross-sectional dependency, variable non-stationarity, dynamics and slope heterogeneity. It first conducted a cross-sectional dependence test to decide appropriate panel unit root tests and panel cointegration tests. Depending on the CD results, appropriate panel unit root tests were conducted in the second step. In the third step, the potential long-run relationship among the variables was tested using the Pedroni and Westerlund cointegration tests. Finally, it used the Dynamic Commonly Correlated Effects estimator, developed by Chudik and Pesaran (2015), which allows for the inclusion of lagged dependent variables and weakly exogenous regressors in an extension of Pesaran's (2006) Common Correlated Effects estimator.

The empirical results indicate the existence of cross-sectional dependence among the variables and that the variable set consists of both I (0) and I (1) variables which is confirmed by second-generation panel unit root tests. The findings of both Pedroni and Westerlund cointegration tests have established that the log of per capita GDP, log of per capita capital stock, financial development, institutional quality and globalization have a long-run relationship. Furthermore, based on dynamic CCE estimates, my empirical results suggest that increases in financial development and the globalization indices have positive and significant effects on long-run economic growth when using the entire sample of countries. However, improved institutional quality affects economic growth positively in the short-run, with no significant long-run effect,

implying that the impact of institutional quality on economic growth varies from country to country in the short-run.

The findings after using different income categories demonstrate that the impact on economic growth from improvements in institutional quality and in financial development and its sub-components varies across income groups. The impact of financial development and institutional quality on economic growth varies across income levels and across countries due to the heterogeneous nature of their economic structures, the way they are integrated into the global economy, their institutional set-ups and their financial development.

This study has some specific policy implications. Countries should reform and strengthen their financial sectors to accelerate economic growth. A strong financial sector mainly relaxes credit constraints and provides instruments for withstanding adverse shocks. However, financial institutions should be monitored carefully because financial development might also increase the propagation and amplification of shocks. African governments must have strong legal and institutional frameworks to create an environment in which the financial sector stimulates and accelerates economic growth. Moreover, policymakers need to design and implement active development strategies to benefit from foreign direct investment flows, technological innovations and improvements in efficiency and economies of scale which result from globalization. However, policymakers also need to implement policies to counteract the negative effects of the immutable forces of globalization on social and political systems.

This study focused on macro-panel econometrics. Future researchers can complement this approach by investigating similar country-level issues using a time series analysis or similar firm-level issues using micro-panel data analysis.

Appendix

Table A1: List of Countries

Low-income countries	Lower-middle income countries	Upper-middle income
Benin	Cameroon	Algeria
Burkina Faso	Congo, Republic of	Angola
Burundi	Cote D'Ivoire	Botswana
Central African Republic.	Egypt	Gabon
Congo, Dem. Rep. of	Ghana	Mauritius
Ethiopia	Kenya	Namibia
Gambia, The	Lesotho	South Africa
Liberia	Mauritania	
Madagascar	Morocco	
Malawi	Nigeria	
Mali	Sudan	
Mozambique	Swaziland	
Niger	Tunisia	
Rwanda	Zambia	
Senegal		
Sierra Leone		
Tanzania		
Togo		
Uganda		

Table A2: Summary Statistics by Income Level

Variables	Low-income countries			Lower-middle income countries			Upper-middle income countries		
	N	mean	SD	N	mean	SD	N	mean	SD
Dependent variable									
Log of per capita GDP	665	6.96	0.42	490	7.92	0.59	245	8.95	0.53
Independent variables									
Log of per capita stock of physical capital	665	7.41	0.82	490	8.61	1.15	245	9.78	0.63
Financial development index	665	0.08	0.03	490	0.14	0.07	245	0.22	0.13
Financial institutions index	665	0.15	0.05	490	0.23	0.09	245	0.32	0.14
Financial markets index	665	0.01	0.02	490	0.05	0.08	245	0.10	0.13
Globalization index	665	31.82	8.89	490	41.74	8.89	245	45.84	8.19
Economic globalization index	665	32.51	10.85	490	43.61	13.60	234	55.63	12.33
Social globalization index	665	18.42	7.02	490	26.92	9.00	234	33.87	13.35
Political globalization index	665	48.94	16.18	490	59.54	20.28	234	50.22	17.84
Institutional quality index (average of PR and CL)	665	4.81	1.40	490	5.06	1.22	245	3.87	1.90
Political rights index (PR)	665	4.90	1.61	490	5.25	1.46	245	3.89	2.13
Civil Liberties index (CL)	665	4.72	1.32	490	4.87	1.11	245	3.85	1.73

Note: Summary statistics by income groups. GDP and stock of physical capital are measured in constant 2011 US$.

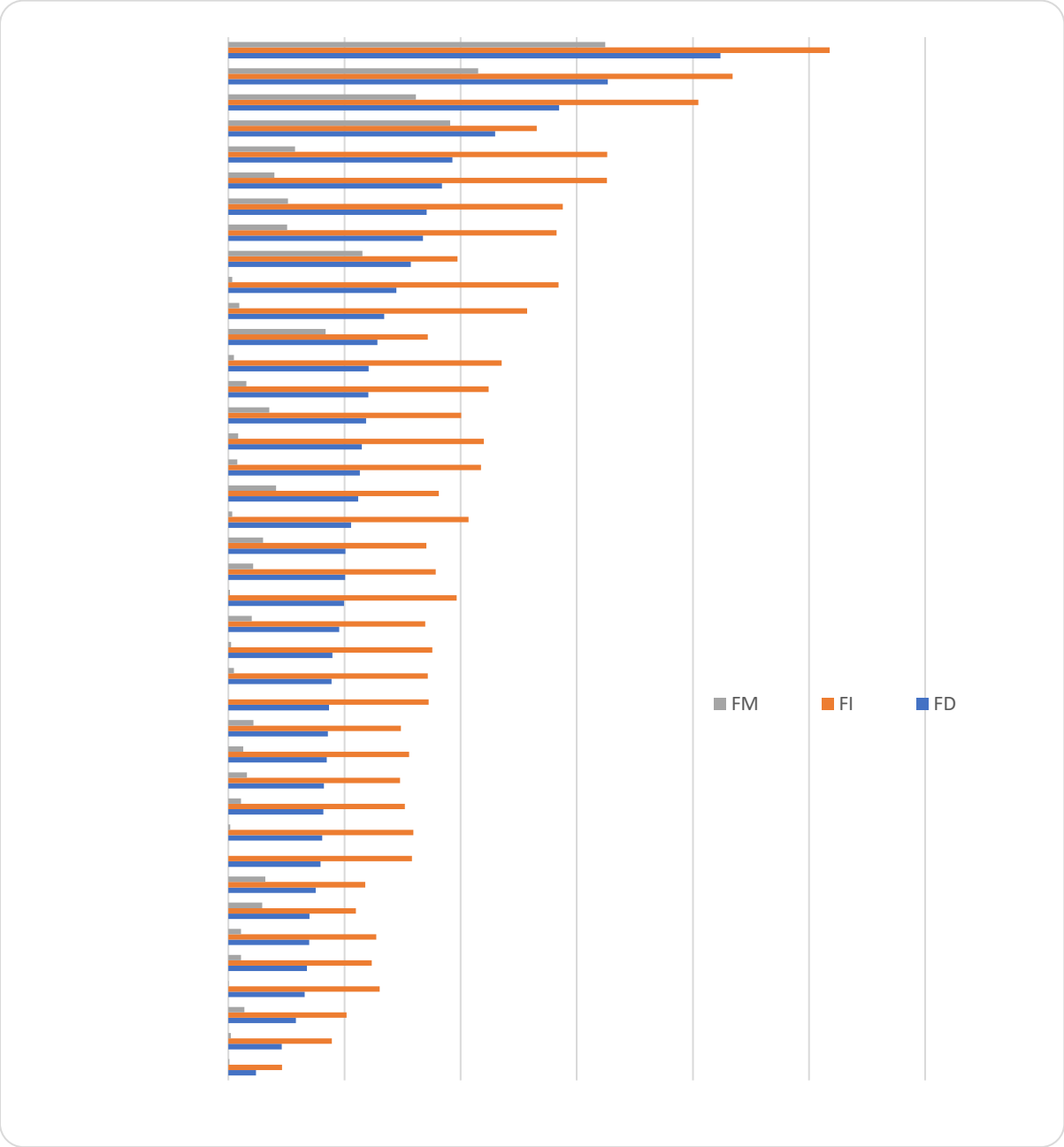
Table A3: Pairwise correlation of important variables by income categories

No.	Variables	Low-income countries				
		1	2	3	4	5
1	Log of per capita GDP	1				
2	Log of per capita stock of physical capital	0.4446*	1			
3	Financial development index	0.1083*	0.4261*	1		
4	Globalization index	0.4220*	0.5706*	0.2328*	1	
5	Institutional quality index	0.3852*	0.3961*	0.071	0.5092*	1
		Lower-middle-income countries				
1	Log of per capita GDP	1				
2	Log of per capita stock of physical capital	0.6358*	1			
3	Financial development index	0.5168*	0.2236*	1		
4	Globalization index	0.5731*	0.5542*	0.4950*	1	
5	Institutional quality index	-0.173*	-0.1491*	-0.0980*	-0.3465*	1
		Upper-middle-income counties				
1	Log of per capita GDP	1				
2	Log of per capita stock of physical capital	0.7122*	1			
3	Financial development index	0.3216*	0.2123*	1		
4	Globalization index	0.4738*	0.4714*	0.6406*	1	
5	Institutional quality index	-0.2994*	0.0387	-0.6351*	-0.5414*	1

Notes: * represents a 5 percent level of significance. GDP and stock of physical capital are measured in constant 2011 US$.

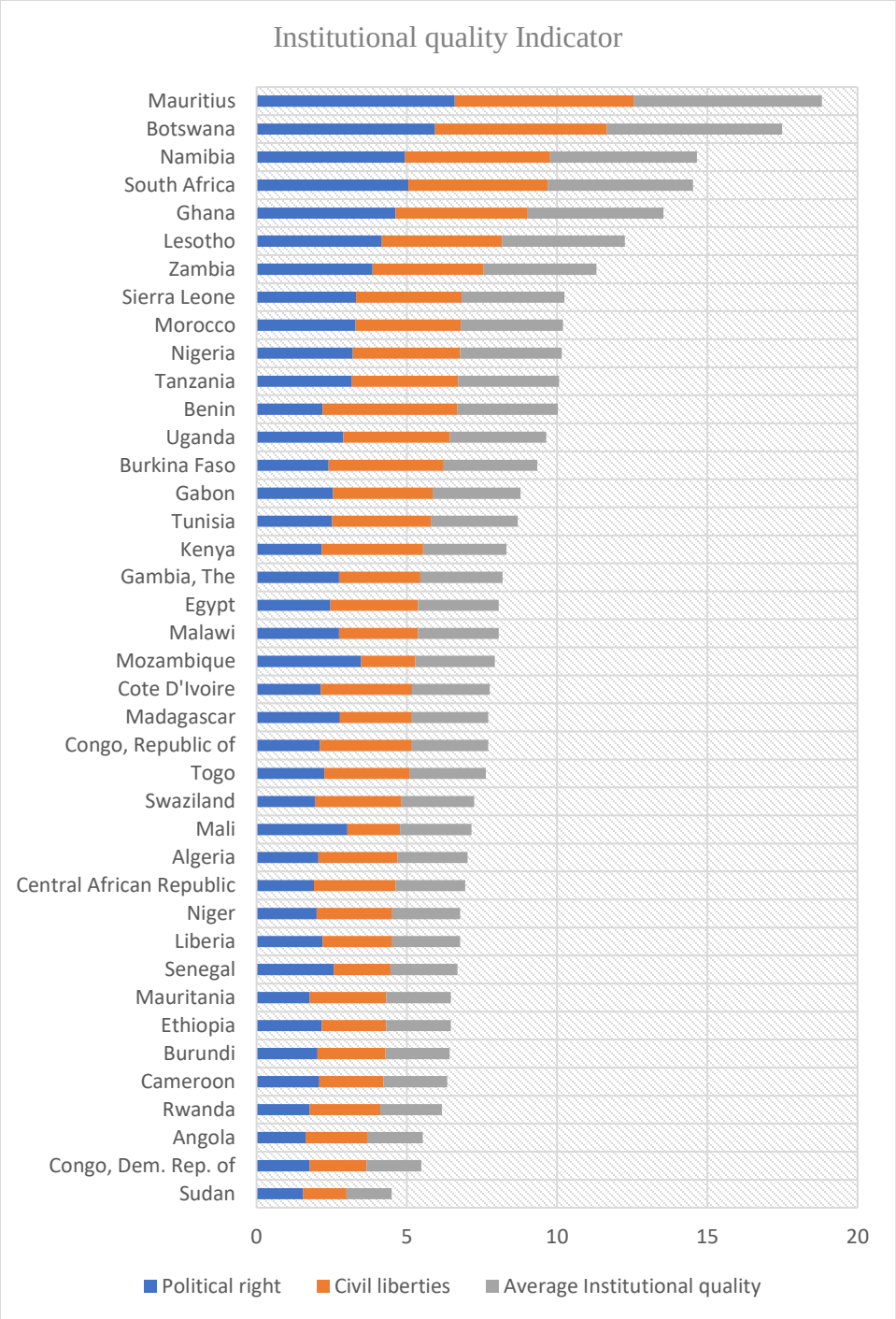
The summary statistics and ranking of countries on financial institutions and markets, and on the overall level of financial development are reported in Figure A1. The figure shows that the upper-middle income countries South Africa and Mauritius followed by the lower-middle income countries Morocco, Egypt and Tunisia have a higher level of financial indicators, while the low-income countries—the Democratic Republic of the Congo, Sierra Leone, Mozambique, Sudan and Uganda—are at the bottom. Likewise Figure A2 shows annual average of intuitional quality at the country level. Mauritius, Botswana, Namibia, South Africa from the upper-middle income countries, followed by Ghana, Lesotho and Zambia from the lower-middle income countries are the top six countries in terms of institutional quality, while Sudan, the Democratic Republic of Congo, Central Africa, Angola and Rwanda are among the countries with the lowest levels of institutional quality.

Figure A1: Financial development, financial institution and financial marketing in Africa countries (average 1980-2014)



Source: Author's calculations based on the IMF dataset.

Figure A2: Aggregate institutional quality indicator in Africa countries (average 1980-2014)



Source: Author's calculations based on the Freedom House dataset.

Table A4: Results of Pesaran's (2004) cross-sectional dependence test by income category

Variables	Low-income countries		Lower-middle-income countries		Lower-middle-income countries	
	CD-test	p-value	CD-test	p-value	CD-test	p-value
Log of per capita GDP	13.17	0.000	30.07	0.000	16.76	0.000
Log of per capita stock of physical capital	30.82	0.000	27.38	0.000	22.01	0.000
Financial development index	8.12	0.000	12.23	0.000	1.60	0.109
Financial institutions index	6.58	0.000	20.64	0.000	3.72	0.000
Financial markets index	3.47	0.001	4.21	0.000	3.49	0.000
Globalization index	68.83	0.000	49.08	0.000	20.91	0.000
Economic globalization	36.51	0.000	37.89	0.000	5.71	0.000
Social globalization	60.42	0.000	27.43	0.000	21.56	0.000
Political globalization	63.41	0.000	39.86	0.000	9.84	0.000
Institutional quality index (average of PR and CL)	26.39	0.000	4.98	0.000	12.93	0.000
Political rights index (PR)	16.88	0.000	5.78	0.000	6.52	0.000
Civil liberties index (CL)	31.53	0.000	4.61	0.000	15.62	0.000

Note:

1. ρ is the cross-sectional correlation of the variable and abs(ρ) is absolute value of the correlation.
2. Under the null hypothesis of cross-sectional independence, CD ~ N (0,1), p-values close to zero indicate that data is correlated across panel groups.
3. I use the Stata routine 'xtcd' developed by Eberhardt (2011) in Stata 14.
4. GDP and stock of physical capital are measured in constant 2011 US$.

Table A5: Results of Pesaran's (2007) Panel Unit Root test by income category

Variables	In level				in first difference			
	Without trend		With trend		Without trend		With trend	
	Zt-bar	p-value	Zt-bar	p-value	Zt-bar	p-value	Zt-bar	p-value
Low-income countries								
Log of per capita GDP	0.19	0.58	0.10	0.54	-9.66	0.000	-9.45	0.000
Log of per capita stock of physical capital	1.20	0.42	0.12	0.254	-1.02	0.000	-0.25	0.000
Financial development index	-2.90	0.00	-2.49	0.01	-9.83	0.000	-7.51	0.000
Financial institutions index	-2.97	0.00	-2.86	0.00	-10.16	0.000	-7.84	0.000
Financial markets index	1.75	0.96	1.89	0.97	-3.88	0.000	-2.24	0.013
Institutional quality index	2.34	0.99	3.33	1.00	-4.71	0.000	-4.60	0.000
Control of corruption	-1.24	0.11	-0.35	0.36	-7.18	0.000	-5.21	0.000
Government effectiveness	-1.88	0.03	-1.51	0.07	-8.73	0.000	-5.96	0.000
Political stability and absence of violence	-0.44	0.33	1.45	0.93	-6.36	0.000	-4.50	0.000
Regulatory quality	0.51	0.70	-2.32	0.01	-10.13	0.000	-7.67	0.000
Rule of law	0.14	0.56	0.36	0.64	-7.74	0.000	-6.66	0.000
Voice and accountability	-0.08	0.47	0.11	0.54	-10.13	0.000	-7.67	0.000
Globalization index	-0.83	0.20	-0.05	0.48	-9.42	0.000	-7.75	0.000
Economic globalization	0.47	0.68	1.97	0.98	-9.24	0.000	-8.86	0.000
Social globalization	-2.64	0.00	-2.48	0.01	-11.41	0.000	-8.55	0.000
Political globalization	-3.39	0.00	-1.17	0.12	-10.37	0.000	-8.77	0.000
Lower-middle income countries								
Log of per capita GDP	0.05	0.52	2.41	0.99	-4.60	0.000	-3.48	0.000
Log of per capita stock of physical capital	3.41	0.23	2.12	0.12	-2.51	0.000	-1.85	0.000
Financial development index	-2.39	0.01	-2.35	0.01	-11.28	0.000	-9.89	0.000
Financial institutions index	-2.45	0.01	-1.34	0.09	-8.84	0.000	-7.42	0.000
Financial markets index	-4.47	0.00	-3.52	0.00	-10.67	0.000	-8.49	0.000
Institutional quality index	-2.22	0.01	-1.01	0.16	-9.52	0.000	-8.17	0.000
Control of corruption	-1.68	0.05	-0.51	0.30	-9.76	0.000	-8.65	0.000
Government effectiveness	-1.98	0.02	-3.16	0.00	-11.45	0.000	-9.67	0.000
Political stability and absence of violence	-1.20	0.11	0.17	0.57	-8.15	0.000	-6.40	0.000
Regulatory quality	-1.06	0.15	-0.99	0.16	-10.24	0.000	-8.90	0.000
Rule of law	-0.28	0.39	0.23	0.59	-8.17	0.000	-7.15	0.000
Voice and accountability	-2.04	0.02	-0.02	0.49	-10.42	0.000	-9.30	0.000
Globalization index	-2.02	0.02	-2.65	0.00	-9.66	0.000	-7.77	0.000
Economic globalization	-4.05	0.00	-2.92	0.00	-10.06	0.000	-8.02	0.000
Social globalization	-0.85	0.20	-1.98	0.02	-7.47	0.000	-5.43	0.000
Political globalization	-1.74	0.04	-0.82	0.21	-9.41	0.000	-7.78	0.000

Upper-middle income countries								
Variables	In Level				in first difference			
	Without trend				With trend			
	Zt-bar	p-value	Zt-bar	p-value	Zt-bar	p-value	Zt-bar	p-value
Log of per capita GDP	1.44	0.93	0.81	0.79	-6.09	0.000	-5.43	0.000
Log of per capita stock of physical capital	3.75	0.67	3.18	0.48	-2.19	0.000	-1.54	0.000
Financial development index	-1.33	0.09	0.38	0.65	-6.98	0.000	-6.58	0.000
Financial institutions index	-1.06	0.15	-0.32	0.37	-7.57	0.000	-6.31	0.000
Financial markets index	-1.14	0.13	-0.65	0.26	-5.28	0.000	-4.19	0.000
Institutional quality index	2.49	0.99	2.29	0.99	-4.03	0.000	-2.48	0.007
Control of corruption	-1.02	0.15	-0.42	0.34	-6.30	0.000	-5.17	0.000
Government effectiveness	0.27	0.61	1.04	0.85	-5.51	0.000	-3.76	0.000
Political stability and absence of violence	1.42	0.92	1.70	0.96	-2.91	0.002	-1.66	0.048
Regulatory quality	-3.77	0.00	-2.48	0.01	-6.10	0.000	-4.46	0.000
Rule of law	0.86	0.81	0.67	0.75	-6.02	0.000	-4.56	0.000
Voice and accountability	0.73	0.77	-0.88	0.19	-5.91	0.000	-4.30	0.000
Globalization index	-2.53	0.01	-2.30	0.01	-6.54	0.000	-4.61	0.000
Economic globalization	1.81	0.97	2.31	0.99	-2.97	0.001	-3.28	0.001
Social globalization	-1.46	0.07	-1.53	0.06	-5.80	0.000	-4.56	0.000
Political globalization	-2.97	0.00	-1.94	0.03	-6.23	0.000	-4.87	0.000

Note: The null hypothesis is that all the series are stationary. I use the Stata routine *'*multipurt*'* by Eberhardt (2011). GDP and stock of physical capital are measured in constant 2011 US$.

Table A6: Westerlund's (2007) panel Cointegration tests by Income Category

Statistics	Low-Income Countries	Lower-Middle Income Countries	Upper-Middle Income Countries
Gt	-3.80**	-4.42***	-4.36***
Ga	-11.37***	-12.68***	-10.34**
Pt	-16.65**	-13.68***	-10.71**
Pa	-11.70**	-9.03**	-11.02**

Note:

1. *The variables included are the log of per capita GDP, log of per capita capital stock, the financial development index, the average institutional index and the average globalization index. GDP and stock of physical capital are measured in constant 2011 US$.*
2. *Bootstrapped p-values robust against cross-sectional dependencies are obtained from bootstrapping 500 times in the Westerlund test.*
3. ****, **, and * represent a 1 per cent, 5 per cent and 10 per cent level of significance respectively. The tests are employed using STATA 14 'xtwest' command (Persyn and & Westerlund, 2008).*

Table A7. Hausman test of the MG versus PMG Models

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       MG           PMG         Difference          S.E.
-------------+----------------------------------------------------------------
     logCKPC |    .3588575     .1897155         .169142        .2886634
         FDI |    1.187626    -1.547761        2.735387        3.403255
        OVGL |    .0093168     .0213804       -.0120636        .0134698
        INQ2 |   -.0254084     .0139349       -.0393433         .060183
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtpmg
            B = inconsistent under Ha, efficient under Ho; obtained from xtpmg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        2.57
                Prob>chi2 =      0.6330
```

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Paper Two

The Differential Impact of Trade Liberalization on Poverty in African Countries

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2

The Differential Impact of Trade Liberalization on Poverty in African Countries

Kahsay Berhane Lemma

Abstract

This paper examines the differentiated relationship between trade liberalization and poverty in African economies over the period 1980-2014. It uses recent advances in panel econometrics that allow for parameter heterogeneity and cross-sectional dependence in its panel common-factor estimates to avoid biased and inconsistent estimates. The study finds that on average trade openness has a positive and significant effect on poverty reduction. However, the country-specific empirical results reveal that the effect of trade openness on poverty varies across countries. In most of the countries, greater trade openness seems to reduce poverty, while in some countries it has an insignificant effect on poverty and in a few countries trade openness has a negative and significant effect on poverty. This suggests that the effect of trade liberalization on poverty is heterogeneous and depends on country-specific characteristics in terms of trade policy and poverty reduction strategies.

Keywords: Poverty reduction, trade liberalization, dynamic heterogeneous panel analysis, African countries.

The Differential Impact of Trade Liberalization on Poverty in African Countries

1. Introduction

Over the last three decades African countries have been largely engaged in widespread trade liberalization and in implementation of poverty reduction strategies. The process of trade liberalization in African countries started in the second half of the 1980s and most African countries have undertaken a structural adjustment program (SAP) designed by the World Bank and the International Monetary Fund (IMF) to increase the free flow of goods and services among their trading partners. Since then, most African countries have implemented comprehensive trade liberalization both in global multilateral trade processes such as the World Trade Organization (WTO) and through Regional Economic Communities (RECs)[8] within Africa like the Community of Sahel–Saharan States (CEN-SAD), the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC), the Economic Community of Central African States (ECCAS), the Economic Community of West African States (ECOWAS), the Intergovernmental Authority on Development (IGAD), the Southern African Development Community (SADC) and the Arab Maghreb Union (UMA).

Economists and policymakers in developing countries have often considered trade liberalization as being favorable for economic growth through increased efficiency of resource utilization that improves productivity. In addition to the comparative advantage argument of the classical economists, trade liberalization provides benefits in the form of enhancing competition, promoting a larger market for firms' products so they can take further advantage of the economies of scale, and inducing transfer of technology, thereby increasing efficiency in production. Increased efficiency and productivity lead to structural transformation and welfare enhancement as laborers move to the more productive sectors of the economy to earn more income. Thus, many developing countries have undertaken multilateral and regional efforts to liberalize trade by reducing tariff and non-tariff barriers and by providing more uniform levels of protection among member countries to reap the benefits of trade openness.

[8] In Africa there are eight regional economic communities (RECs) which were recognized by the African Union in 2016 -- AMU, CEN-SAD, COMESA, EAC, ECCAS, ECOWAS, IGAD and SADC

Despite the African countries' engagement with economic openness and trade liberalization since the late 1980s, Africa still remains the poorest continent in the world. According to Beegle et al. (2015), even though the percentage of Africans in extreme poverty (living on less than $1.90 a day, based on 2011 international purchasing power parity) declined from 57 percent in 1990 to 43 percent in 2012, the number of people in extreme poverty increased from approximately 280 million to over 330 million, mainly due to rapid population growth. Moreover, the 2016 edition of the Brookings Institution's annual Foresight Africa projections report also shows that the world's poor will be gradually more concentrated in Africa, keeping the continent at the forefront of the global poverty agenda even in an era of globalization.

African policymakers use trade liberalization to support sustainable economic growth and for coming up with poverty reduction strategies on the continent. However, the theoretical and empirical results regarding the impact of trade liberalization on the poor remains uncertain; in fact, there are conflicting views on the effect of trade liberalization on poverty in developing countries. The first view argues that, in the long run open economies are better than closed economies for the expansion of the most productive firms and the reallocation of resources from the less efficient sectors to the more efficient ones, and relatively open economic policies contribute significantly to reducing poverty (Abuka et al., 2007, Carneiro & Arbache, 2003). Even if trade liberalization and open economic policies do not directly enhance poverty reduction, economists have argued that they do so indirectly by promoting economic growth which opens avenues for the poor to earn more income. This is in line with the trickle-down theory which has received widespread support in the literature (see, for example, Dollar & Kraay, 2002; Ravallion & Datt, 2002).

According to the second view, trade liberalization tends to make the poor poorer and the rich richer, thus widening income inequalities among the people, and even in the longer run successful open countries may leave some people behind in poverty (Evans, 2001; Harrison et al., 2003; Lofgren, 2000). Theoretical and empirical studies also show that developing countries do not gain equally from the opportunities arising out of increased access to international markets in the developed world (Bown & Crowley, 2016; Goldberg & Pavcnik, 2016; Surugiu & Surugiu, 2015).

This paper contributes to the literature on the impact of trade liberalization on poverty in Africa in three ways. First, from an estimation point of view this paper follows a novel approach by applying

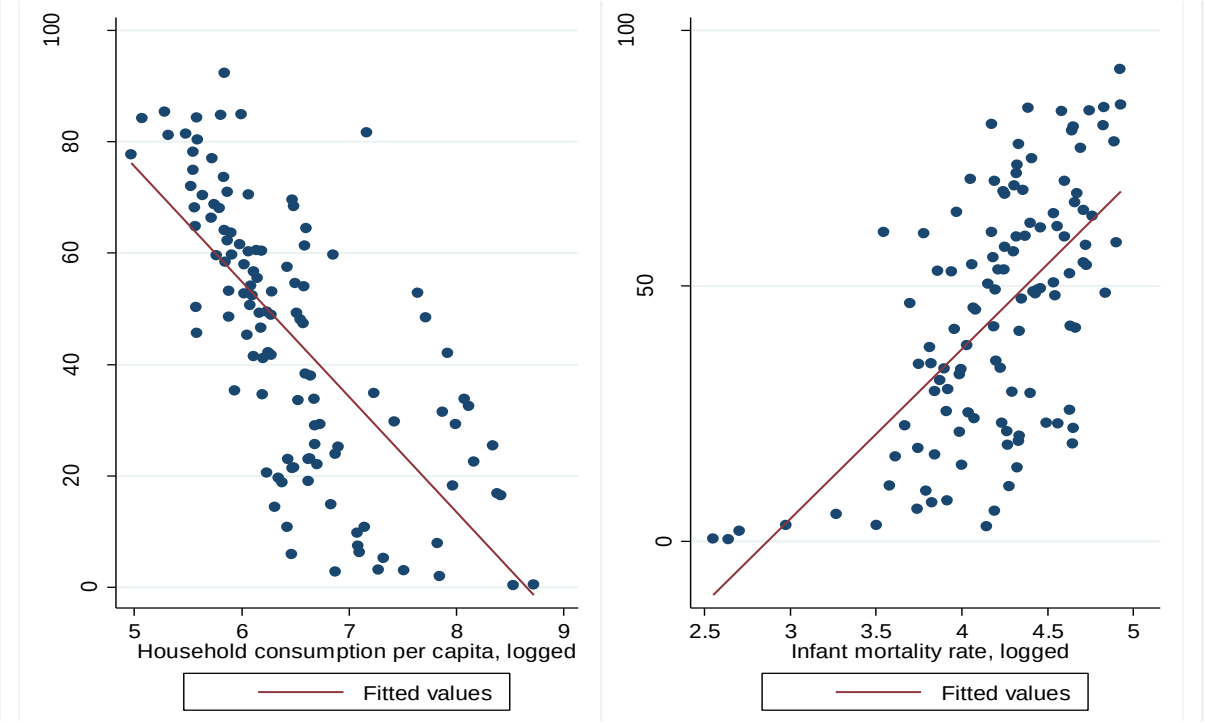
Pesaran's (2006) recently-developed common correlated effects mean group (CCEMG) estimator and the augmented mean group (AMG) estimator (Bond & Eberhardt, 2013; Eberhardt & Bond, 2009; Eberhardt & Teal, 2010). Considering the existence of cross-sectional dependency and slope heterogeneity, this paper produces more robust and credible country-specific results. Second, compared to previous studies the analysis uses a larger sample of countries (43 countries, including North African countries; see Table A1 in the appendix for a list of African countries studied) with a longer and more up-to-date time span (covering the period 1980-2014).[9]

Third, this study uses two proxies for poverty – per capita household consumption expenditure and the infant mortality rate. These are only two of the various poverty proxies that have been suggested in the literature and their use was necessitated by the lack of time-series data on poverty measures in developing countries. According to national account statistics, household-consumption expenditure is based in part on the market value of purchased goods and services, including the purchase of durable products (such as house furniture, electronics and car) by a household in one year. It also includes the imputed housing rent for owner-occupied dwellings and payments and fees to the government for permits and licenses. Therefore, consumption of goods and services can be considered a fundamental determinant of human welfare and is used as a proxy of poverty in this study because it is consistent with the World Bank's definition of poverty as "the inability to attain a minimal standard of living" measured in terms of individuals' basic consumption needs (the World Bank, 1990). Several previous studies have also used per capita household consumption expenditure as a proxy for poverty because consumption expenditure among the poor is usually more reliably reported and is more stable than income in many developing countries (Datt & Ravallion, 1992; Odhiambo, 2009, 2010; Quartey, 2008; Sehrawat & Giri, 2016a, 2016b; Uddin et al., 2014).

The second poverty proxy variable that this paper uses is the infant mortality rate that was a global priority in the UN's Millennium Development Goals (MDGs) and has been incorporated in the Sustainable Development Goals (SDGs). The infant mortality rate is a non-monetary dimension of poverty. Other studies that have used the infant mortality rate as a proxy for poverty are Dursun and Ogunleye (2016), Odhiambo (2016) and Polat et al., (2015).

[9] In comparison, Le Goff and Singh's (2014) study covered 30 countries in sub-Saharan Africa during the period 1981-2010.

The two competing proxy measures for poverty are correlated with the standard extreme poverty headcount ratio, the percentage of people living below the international poverty line at $1.90 a day using 2011 PPP conversion rates. where the conversion rates are used to adjust the international poverty line for cross-country differences in the exchange rate market, prices and inflation. The poverty headcount ratio is shown in Figure 3.1 to be negatively correlated across countries with per capita household consumption and positively correlated with the infant mortality rate. In other words, countries with a larger percentage of the population below the international poverty line tend to consume less and their infant mortality rates also tend to be higher. This provides some justification for using the per capita household expenditure and the infant mortality rate proxies for poverty.

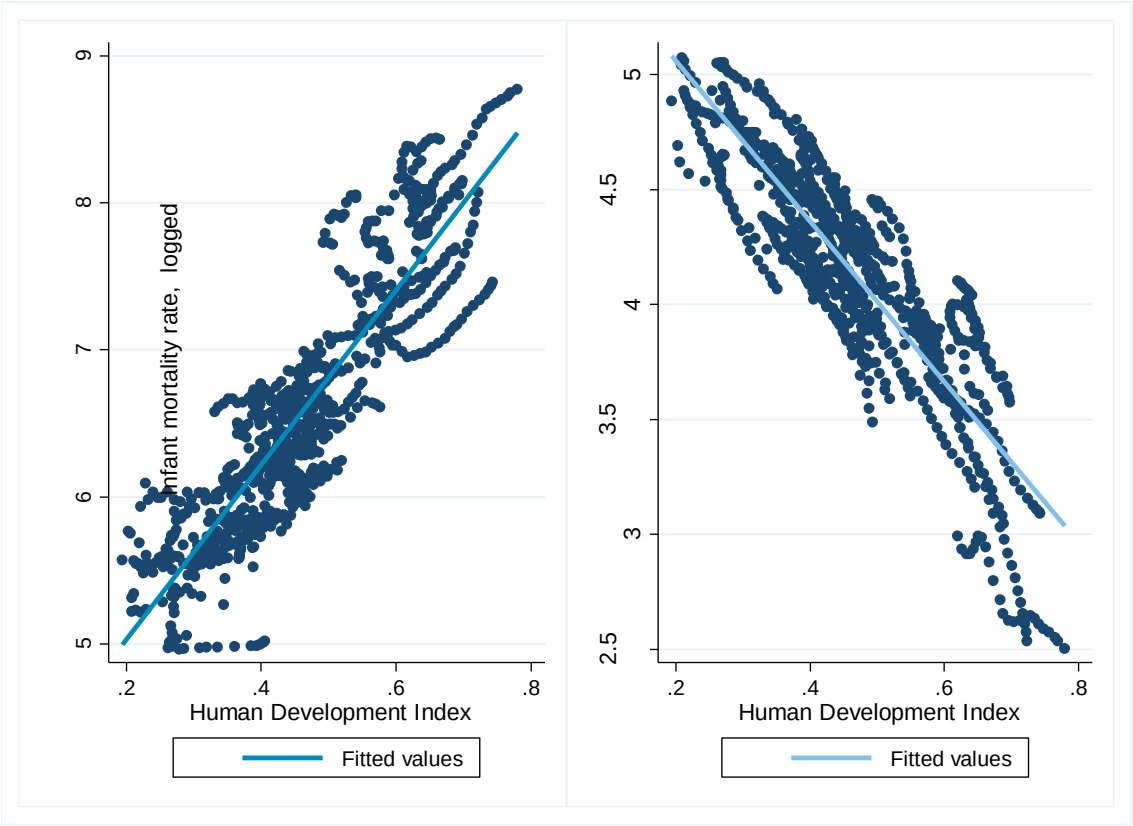


(a) (b)

Figure 3.3. Scatter plot and fitted value of poverty headcount ratio at $1.90 per day versus the log of household consumption per capita and the log of infant mortality rate in panels (a) and (b) respectively across African countries for various years in 1980-2014
Data source: *The World Bank's World Development Indicators*.

Furthermore, both of the competing proxy measures for poverty are also correlated with society's social well-being measured by the Human Development Index (HDI) which is not used in the current study due to data availability. It is published in the Human Development Report (HDR) only from 1990. The HDI is calculated as a geometric mean of normalized indices for each of the

three key dimensions of human development: a long and health life, being knowledgeable and having a decent standard of living. This index is the most widely used one as a measure of well-being and as a poverty indicator in previous studies (Çilingirtürk & Koçak, 2017; Hall, 2013; Hou at el., 2015). Scatter plots of per capita household consumption expenditure with both the HDI and the infant mortality rate are reported in Figure 3.2 which shows that higher HDI values are associated with lower values for the infant mortality rate and with higher per capita household consumption. Hence, both per capita household consumption expenditure and the infant mortality rate capture information similar to that in HDI, that is, the most common social well-being and poverty indicator.



(a) (b)

Figure 3.4. Scatter plots of household consumption per capita and infant mortality rate versus HDI over 1990-2014 for 40 African countries
Data sources: UNDP's Human Development Index and the World Bank's World Development Indicators for per capita household consumption expenditure and infant mortality rate.
Note: Three countries are not included in panels (a) and (b) due to lack of HDI data.

Trade liberalization plays an important role in improving poverty and welfare in a given country. Trade openness can impact poverty directly through the cost of living, employment and wages,

and investment of the government's tax revenues in public goods and services. There are also potential indirect linkages between poverty and welfare through improvements in productive capacities. Moreover, trade policies that reduce tariff and non-tariff barriers can generate benefits in terms of both resource allocations and economic growth. However, trade policies have a differentiated effect in developing countries and trade openness in particular is unlikely to have even benefits across these countries (Bown & Crowley, 2016; Goldberg & Pavcnik, 2007, 2016; Santos-paulino, 2017; Winters et al., 2004).

The rest of the paper is organized as follows. The next section presents the theoretical and empirical literature on trade openness and poverty. It then takes a detailed look at the channels through which trade policy can affect poverty levels. Section 3 presents the model specifications, data sources and methodology used to estimate the potential effect of trade openness on poverty reduction in Africa. The data is analyzed in Section 4. The final section provides a conclusion and gives policy recommendations.

2. Literature Review

Though many international trade theories exist in the literature (both old ones and newer ones that are more relevant in today's era of globalization), economic theory does not provide a framework for analyzing the effects of trade reforms on poverty. Any change in trade policy such as reducing tariff and non-tariff barriers can offer considerable opportunities for improving poor households' living standards but at the same time these changes can also increase their vulnerabilities to external shocks that have short- to medium-term adverse impacts. For example, changes in trade policy effect consumer prices, factor incomes, employment, productivity, economic growth, government revenues and government spending; all these are discussed in the literature.

These theories are powerful, but they fail to explain the impact of trade liberalization when other things such as non-tradable goods, specific factors or segmented labor markets are taken into account (Winters, 2002). Moreover, trade openness can have two counteracting effects. On the one hand, in labor-abundant countries it induces the development of labor-intensive sectors and creates employment and income for a large part of the population, particularly for poor individuals. But on the other hand, openness in trade may hurt protected industries and their employment status, resulting in income redistribution. To offset this and to ensure net overall gains, trade adjustment

assistance is often recommended as a reimbursement for losses arising due to trade liberalization (Cicowiez & Conconi, 2008). Therefore, properly addressing the impact of trade policy on the well-being of the poor needs a thorough investigation of its consequences and the possible channels through which the benefits of trade openness trickle down to the poor.

The rest of this section reviews the most common transmission channels developed by Winters et al. (2004). These are presented with some slight modifications. The framework identifies four general channels through which trade reforms affect poverty. It first reviews linkages between trade, growth and poverty. Second, it focuses on how poverty is affected by household consumption and production through changes in prices of goods and services. Third, it discusses the labor market through factor price and employment. Finally, it examines how changes in the prices of goods and services and in factor prices affect government revenues and thus possibly the scope for spending more on the poor. Loss in government revenue induced by these price changes may lead to taxation that may put a disproportionate burden on the poor due to trade reforms. Considering these four channels will help us understand and identify the effects that trade liberalization has on the poor.

Economic growth: The per capita income growth link to poverty reduction

Economists agree that economic growth is potentially the most important channel for reducing poverty and that trade may play a vital role in this process. To validate this argument, we first need to study the relationship between trade openness and economic growth and then demonstrate how trade-induced economic growth might affect poverty in developing countries.

The association between trade openness and economic growth is linked through static and dynamic efficiency channels. Static efficiency gains from greater trade openness are explained by Heckscher-Ohlin-Samuelson trade theory which suggests that greater openness to international trade may generate substantial gains by efficiently reallocating resources between the tradable and non-tradable sectors. The dynamic efficiency gains from greater trade openness are explained by various factors, such as economies of scale, diffusion of information, transfers of technology and knowledge, as well as intertemporal trade gains from borrowing and lending across regions for enhancing investments (Grossman & Helpman, 1991; Krugman, 1980).

Moreover, under monopolistic competition models with heterogenous firms, the less efficient firms exit out of the market while the more efficient and productive firms produce more for exports

after trade liberalization which leads to accelerated economic growth (Melitz, 2003). Other theoretical models suggest that free trade may hurt growth in incomes in underdeveloped or agrarian economies due to external competition and shocks by widening income inequalities (Bhagwati, 1958).

Despite vast empirical literature, there is still no general consensus regarding the relationship between trade openness and growth. Several empirical studies show a positive and significant relationship between the two, suggesting that trade openness promotes economic growth. For example, Sikwila et al. (2014) in Kenya, Kalu et al. (2016) in Nigeria and Khobai et al. (2018) in Ghana and Nigeria examined the relationship between trade openness and economic growth using time series data. They all found that trade openness boosted economic growth. Similarly, Myint (1958) revealed that openness to international trade in developing economies provides an efficient means of overcoming the narrowness of the domestic market and provides a market for production beyond that which can be supported by domestic demand. Daumal and Özyurt (2010) also showed that an open economy can improve the labor force's skills and effectiveness through the learning-by-exporting hypothesis. Furthermore, opening-up to the external sector leads to the integration of the economy with global innovations and international marketing which in turn provides ideas to local producers to innovate, imitate and develop new products.

Trejos and Barboza (2015) used static OLS and dynamic ECM estimations to determine the causal relationship between trade liberalization and economic growth in 23 Asian countries. Their findings show that higher trade openness positively affected per capita income growth due to increases in the trading sector's productivity.

On the other hand, Billmeier and Nannicini (2013) analyzed the relationship between trade liberalization and economic growth using a synthetic control method and found that trade liberalization had no significant impact on economic growth in Africa due to greater competition for exports of labor-intensive goods (such as agricultural products or textiles) and lack of growth-enhancing institutions. Young (1991) discussed a negative effect of openness, asserting that trade liberalization makes it possible for some economies to specialize in low value-added activities such as extraction and exploration of natural resources and production of primary goods. These non-dynamic sectors have faced a tendency for a low amount of technological improvements

which is unfavorable for long-run economic growth. Rodriguez and Rodrik (2001) and Harrison (1996) also indicated uncertainty about the robustness and significance of the positive growth effect of openness. According to Rodriguez and Rodrik (2001) the various indicators of openness used by researchers are poor measures of trade barriers. After a methodological review of studies such as those by Ben-David (1993), Dollar (1992), Edwards (1998) and Sachs et al. (1995) they found little evidence that openness to international trade was significantly associated with economic growth.

Eriș and Ulașan (2013) used a Bayesian model-averaging technique on a cross-section of countries over the period 1960–2000. Their results show no evidence that trade openness is directly and robustly correlated with economic growth in the long run. Similarly, Tekin (2012) showed that there is no significant causality relation between openness to trade and economic growth based on a panel of least developed countries (LDCs) using a Granger causality testing approach and taking into account cross-sectional dependence and slope heterogeneity. Amadou (2013) examined the causal relationship between openness and economic growth in the West African Economic and Monetary Union (WAEMU) countries and found that except for Côte d'Ivoire, trade openness did not lead to economic growth in these countries. A more recent study by Ulaşan (2015) used a dynamic panel data framework to investigate the openness-growth nexus using various openness indicators. His findings show that lower trade barriers are not linked with higher economic growth, implying that trade openness by itself does not enhance economic growth. Therefore, to show how trade openness affects poverty via growth, one needs to examine how trade-induced economic growth affects poverty, a link which is very difficult to establish. In general, economic growth is important for reducing poverty, but it needs complimentary policies to do so. Poor people benefit from trade-induced economic growth when that growth is distributed by proper institutions and when governments use policy interventions to facilitate employment-centered structural transformations of their economies at the most important stages (Dollar & Kraay, 2002, 2004)

Price transferring channel and accessibility of goods and services

Trade liberalization policies can affect the poor through the effects that tariff changes have on relative prices of goods and services. Price variations in goods and services affect poor people in direct and indirect ways as their effects depend on a wide range of factors including institutions, infrastructure, trade facilities, world price levels, exchange rates, domestic taxes and market

integration over time and space. The direct impact of changes in prices on poverty mainly depends on whether households are net consumers or net producers of the goods and services in the international market. The poor may also benefit from accessibility of goods and services due to relaxation and removal of export and import bans and duties in the international market. An open trade regime also permits the import of technologies that can help the poor in the production process such as the provision of improved seeds and fertilizers, water purification chemicals, simple packaging processes for perishable goods (Bannister & Thugge, 2001). However, there are also indirect effects that should be taken into consideration as price shocks are transmitted into other markets and have multiplier effects or have local spillovers. A consumer can benefit from a decrease in price levels, but a producer loses and vice versa. Hence, the effect of price reductions depends on the resulting net gains or losses for consumers and producers within the country.

Labor markets: The factor price, income and employment link

Trade openness can affect households via factor prices, wages and employment. Winters et al. (2004) noticed that being employed is often a vital factor for whether an individual is to be considered poor or not since most individuals get their income from labor work. Based on the traditional trade theory of the Heckscher-Ohlin model, export of labor-intensive goods will lead to an increased demand for labor (Krugman et al., 2015). Depending on the elasticity of labor supply, two extremes can occur in the labor market: an increase in demand for labor will lead either to an increase in wages or to an increase in the level of employment. However, there is also the possibility of ending up between these two extreme outcomes, that is, employment and wages might increase at the same time (Winters et al., 2004). Moreover, country studies show that labor is not as mobile from one sector to another as the Heckscher-Ohlin trade theory model assumes; for comparative-advantage-based trade to increase incomes of unskilled laborers, they need to be able to shift from contracting sectors to expanding sectors. Another explanation why the poor may not gain from trade liberalization is that developing countries have historically protected sectors that use unskilled labor such as those producing agricultural, textile and apparel products.

Barlow (2018) found from a review of a number of empirical studies, including Krugman & Obstfeld (2009), Blouin et al. (2009), De Vogli (2011) and Autor et al. (2013) that trade liberalization can lead to widening wage inequality, deteriorating working conditions, greater job

insecurity and more volatile prices, especially among those working in import competing sectors thereby worsening poverty.

The government revenue and spending channel

The effect of trade openness on government revenue losses has been identified as one of the key transmission channels for many developing countries (Winters et al., 2004). The share of trade taxes in total revenue is negatively associated with the level of trade liberalization and many low-income countries earn half or more of their revenues from trade taxes. However, the effect of trade reforms on government revenue is complex. If initial tariffs are prohibitively high, reducing them and eliminating non-tariff barriers can result in higher trade flows and reduce incentives for smuggling and corruption thus boosting revenue. Simplifying tariff rules to create a more homogeneous structure with just a few tariff rates improves collective efficiency which could increase government tax revenues. These changes can provide a fiscal financial resource for funding public infrastructure that increases per capita household consumption and improves access to good health and education, thereby helping decrease the infant mortality rate (Blouin et al., 2009; Levine & Rothman, 2006; McNeill et al., 2017).

To compensate for tax losses due to tariff reductions the government may use alternative sources of revenue, such as value-added taxes and widening the tax base, which may adversely affect the poor (Hertel & Reimer, 2005). Empirical evidence indicates that developing countries have not managed to fully recover lost tariff revenue from tariff reduction. However, empirical studies have also shown contrasting results regarding the association between trade-tax revenues and poverty levels depending on the methodology and data used. Keen and Baunsgaard (2005) analyzed data on tax revenues in their investigation on whether countries actually recovered the revenues lost from other sources during past episodes of trade liberalization. They found that high-income countries had clearly done so and that for middle-income countries, the recovery was of the order of 45-60 percent. Such losses in government revenue lead to a decline in fiscal resources for financing public services, public goods and health facilities, thereby worsening poverty and transmitting poverty from generation to generation (Baunsgaard & Keen, 2010; McNeill et al., 2017).

3. Theoretical model, data sources and variables

This section presents the theoretical model used for an investigation of trade liberalization's effect on poverty along with data sources and descriptions of the variables used in the paper.

3.1 Theoretical model

The impact of trade liberalization on poverty is emphasized in a number of studies using different model specifications (see, for example, Agénor, 2004, 2005; Anyanwu & Erhijakpor, 2009, 2010; Berg & Krueger, 2003; Ghura et al., 2002; Kraay, 2006; Ravallion, 2005; Ravallion & Chen, 1997). To examine the relationship empirically this paper incorporates measures of trade openness, the countries' economic performance and a set of other control variables that affect two proxies for poverty: household consumption and infant mortality. Since household consumption and infant mortality in developing countries are highly persistent, this paper uses dynamic panel data specifications of the following equation in the analysis. The baseline model is given as:

$$Pov = f\left(TO, gPCI, X\right) \tag{1}$$

where Pov represents the poverty level, proxied (negatively) by per capita household consumption expenditure or (positively) by the infant mortality rate per 1,000 live births, TO is trade openness (that is, log of the ratio of exports and imports to GDP), gPCI is growth of per capita income as a measure for the rate of economic development and X is a vector of other control variables. The growth in per capita income can be explained by changes in labor productivity, in labor participation rates and in the ratio of the working age to the total population. Both trade liberalization and per capita growth are expected to have a positive effect on poverty in most of the countries included in this study.

3.2 Data and definition of variables

This paper uses panel data for 43 African countries with annual measurements over the full sample period of 1980-2014. Several sources were used to collect this data, in particular the World Development Indicators (the World Bank, 2015), the United Nations Development Programme (2017), the Penn World Tables (PWT 9.0) and the United Nations Conference on Trade and Development (UNCTAD, 2015). The period and the number of countries included in this study were dictated by the availability of consistent time series data for all the countries. The variables included are presented in Table 3.1.

Table 3.12: Variable descriptions and data sources

Variables	Symbol	Source
Per capita household consumption expenditure	Pov1	WDI of World bank
Mortality rate, infant (per 1,000 live births)	Pov2	WDI of World bank
Human development index	HDI	UNDP
Trade openness index as percentage of GDP	TOG	PWT9.0
Rural-urban income inequalities index	RUI	WDI of World bank
Growth of real GDP per capita	Gpci	WDI of World bank
Consumer price index growth	INF	WDI of World bank
Foreign direct investments as percentage of GDP	FDI	UNCTAD
National official development assistance	NODA	WDI of World bank

Poverty proxies: Per capita household consumption expenditure and the infant mortality rate

There are many definitions and measures of poverty, but the most popular indicator is the poverty headcount index which measures the percentage of the population with a person's consumption or income below a certain poverty line. This is a measure of absolute poverty. Another popular measure is the poverty gap, which measures the mean distance below the poverty line as a proportion of the poverty line. However, due to lack of time-series data on these poverty variables, this paper uses two proxies for poverty: per capita household consumption expenditure and infant mortality rate.

Using per capita household consumption expenditure as a (negative) proxy for poverty is consistent with the World Bank's definition of poverty as 'the inability to attain a minimal standard of living' measured in terms of meeting basic consumption needs (the World Bank, 1990). Per capita household consumption expenditure has been used as a proxy for poverty in several previous studies (for example, Datt & Ravallion, 1992; Odhiambo, 2009, 2010; Quartey, 2008; Sehrawat & Giri, 2016a, 2016b; Uddin et al., 2014).

The infant mortality rate is the number of deaths per 1,000 live births. Demographic and economic factors, lack of access to affordable healthcare services, good nutrition and clean water and energy facilities have been identified as the major factors affecting the infant mortality rate. A United Nations Children's Fund report (UNICEF, 2018) shows that the infant mortality rate is closely linked to a country's income level. According to the report, high-income countries have an average of three deaths per 1,000 live births which is notably lower in comparison to low-income countries

which have an average of 27 deaths per 1,000 live births. Consequently, in addition to per capita household consumption, the infant mortality rate is also a plausible proxy for poverty in Africa.

Trade openness

Trade's share in GDP (that is, (exports+imports)/GDP) is the most commonly used proxy for trade openness as a country's trade performance captures the most important dimension of openness in general. Generally speaking, trade openness appears to be beneficial for economic growth although its effect varies considerably across countries and depends on a variety of conditions related to the structure of the economy and its institutions.

Rate of economic development: Growth in per capita real GDP

The level of a country's economic development is measured via per capita gross domestic product, that is, the value of all goods and services produced by a country in one year divided by the country's mid-year population size. To measure the rate of economic development, that is, the growth of per capita real GDP this paper uses the first difference of the natural logarithm of per capita real GDP.

Control variables

The control variables used in this paper are rural-urban income inequality, inflation, foreign direct investments and official development assistance (NODA). Most of the previous empirical studies on poverty include one or more of these control variables.

The first control variable, rural-urban income inequality, is measured by the ratio of agricultural value added to the summation of industrial and services value-added. The ratio of agricultural to industrial value added as a share of GDP has also been used as proxy for rural–urban income inequalities by Baliamoune-Lutz and Lutz (2005), Shahbaz et al. (2007),Tiwari et al. (2013), and Sehrawat and Giri (2016b). Typically, in African countries the incomes of people living in rural areas depends on the agricultural sector which is relatively much lower in productivity than the non-agricultural sector which mainly drives the incomes of urban dwellers. This implies that reallocation of resources from the agricultural to the non-agricultural sector is growth enhancing. Through this channel economic growth can contribute significantly to poverty reduction by generating productive employment and improving earnings of individuals engaged in both the non-agricultural sector and in the agricultural sector (Hasan et al., 2013; Page & Shimeles, 2015).

Therefore, declining rural-urban income inequalities implies an expansion of the relatively more productive sectors which accelerates economic growth and reduces poverty. Likewise, an increase in the ratio of agriculture value added to the summation of industry and services value added implies that more of the economic activities are in rural areas as compared to urban areas. In developing countries, most of the rural areas have no or low access to clean water, sanitation and health facilities and this contributes to high infant mortality rates. Hence, higher (lower) rural-urban income inequality should be expected to be associated with a higher (lower) infant mortality rates in developing countries.

The second control variable is inflation to control for macroeconomic instability. Inflation is expected to worsen poverty because it reduces the purchasing power of all individuals, but it is more harmful for the poor and the middle-income population than it is for the rich because wealthy individuals can reduce their risks by hedging their exposure to inflationary situations by accessing financial services (see Easterly & Fischer, 2001; Kpodar & Singh, 2011). Inflation is measured by the annual percentage change in the consumer price index.

The third control variable is foreign direct investment (FDI), which can affect poverty through an increase in FDI-generated government tax revenue which can be used for financing poverty-reducing projects and through spillover effects of technology, innovations and knowledge from FDI-based firms to the local economy. Hence, FDI can enhance economic growth and create new jobs, thereby reducing the level of poverty in the host country.

The fourth control variable is official development assistance (NODA). In the last few decades, significant volumes of foreign aid have been channeled to African countries to stimulate economic growth and poverty reduction. A large number of studies have investigated the association between NODA and economic growth and poverty (Ali & Isse, 2005; Alvi & Senbeta, 2012; Arndt & Jones, 2015; Museru et al., 2014). Using dynamic panel estimation, Alvi and Senbeta (2012) found that aid had a significant poverty-reducing effect even after controlling for the income levels of the countries covered in their study.

4. Econometric methodology

This section discusses the estimation methods that address major potential problems of the long macro-econometrics panel model used in this paper. First, since the panel dataset has a reasonably long-time dimension, non-stationarity of the variables in the model needs to be addressed. In addition, since this is a macroeconomic panel data study on the determination of per capita household consumption expenditure and infant mortality rate (proxies for poverty), where many of the determinants cannot be fully included due to data availability, an appropriate model must be used to control for the omitted variable bias. Hence, it uses the lagged value of the dependent variable as a regressor to reduce the problem of omitted variable bias. Moreover, inclusion of the lagged dependent variable allows for control controlling of the persistent nature of poverty over time. Furthermore, if the common observable and common unobservable factors are correlated, then an endogeneity problem arises, and we end up with inconsistent and biased estimates.

Therefore, methods to allow the effects of explanatory variables and unobserved common factors to vary across countries are discussed in this section. The discussion in subsection 4.1 below establishes the general estimation procedures for a multifactor residual model that takes into account the slope heterogeneous and cross-sectional dependence. Subsection 4.2 discusses testing of cross-sectional dependence and subsection 4.3 deals with the issue of determining the stationarity of the variables to be included in the model to be estimated.

4.1 Model estimation methods

Consider the equation:

$$y_{it} = \alpha_i + \beta_i x_{it} + \mu_{it} \qquad (2)$$

where *i* is the country index (*i*=1, ..., *N*), *t* is the year index (*t*=1, ..., *T*), y_{it} is the dependent variable, x_{it} is a vector of observed explanatory variables and μ_{it} represents the error term. α_i and β_i refer to the intercepts and the slope coefficients that may vary across panel members. The pooled ordinary least squares (pooled OLS) estimator uses a conventional least squares regression based on pooling all the observations, imposing the constraints that $\beta_i = \beta$ and $\alpha_i = \alpha$, and assuming that the μ_{it} terms are independent random variables. This estimator's lack of consideration of any country-specific effects could lead to biased estimates. For the fixed-effects (FE) and random-

effects (RE) estimators, time-invariant country-specific effects (α_i varying across countries) are allowed and treated as fixed and random in the regression respectively, but the μ_{it} terms are still assumed to be independent random variables. Unobserved common factors can be considered by introducing time dummies into the pooled OLS, fixed-effects or random-effects regression models.

Unfortunately, the pooled OLS, FE and RE estimators encounter a number of econometric issues with large macro-panel datasets as all of them fail to account for the presence of cross-sectional dependence and parameter heterogeneity across countries. Hence, to address the problem of cross-sectional dependence and the issue of parameter heterogeneity, this paper applies a set of more novel methods including the mean group (MG) estimator (Pesaran & Smith, 1995), the common correlated effects mean group (CCEMG) estimator (Pesaran, 2006), and the augmented mean group (AMG) estimator (Bond & Eberhardt, 2013; Eberhardt & Bond, 2009; Eberhardt & Teal, 2010). Hence, the baseline specification for estimating the heterogeneous coefficients with multifactor error terms, especially taking into account cross-sectional dependence is given as:

$$\begin{aligned} y_{it} &= \alpha_i + \beta_i' x_{it} + \mu_{it} \\ \mu_{it} &= \alpha_{1i} + \gamma_i' f_t + \varepsilon_{it} \\ x_{it} &= \alpha_{2i} + \phi_i' f_t + \lambda_i' g_t + \nu_{it} \end{aligned} \qquad (3)$$

where α_{1i} and α_{2i} are country-specific fixed-effects which capture cross-country heterogeneity that is time-invariant; the vectors f_t and g_t consist of unobserved common factors; γ_i, ϕ_i and λ_i are heterogeneous country-specific factor loadings; and ε_{it} and ν_{it} are independent and identically-distributed error terms with mean zero and finite constant variance.

The unobserved common-factor vectors f_t and g_t bring about cross-sectional dependency in both the error term and the regressor. Moreover, since the vector of explanatory variables x_{it} and the error term μ_{it} share a set of common factors f_t, the explanatory variables and that error term will be correlated if the factor loading terms are non-zero on average, so the typical panel estimators will display bias and inconsistency, as Eberhardt et al. (2013) demonstrates.

In estimating this model, the MG method applies time-series OLS to each panel (or country in this paper) separately, including an intercept to capture time-variant unobservable variables and a linear trend, and then averages the estimated individual-specific slopes with or without weights. In the dynamic case, when the coefficients are heterogeneous across groups, the MG estimators are consistent for large *T* and *N* (Pesaran & Smith, 1995), but still the MG estimator does not incorporate any information on common factors that may be present in the panel dataset. Common factors are time-specific effects that are common across countries. By adding the cross-sectional averages of the dependent and independent variables as additional regressors when applying OLS to each unit, the common correlated effects mean group (CCEMG) estimator allows for cross-sectional dependence and time-variant unobservable common factors with heterogeneous impact across panel members (Pesaran, 2006). Represented by these cross-sectional averages, the unobserved common factors can be any fixed number. Having satisfactory small-sample properties and being a robust estimator of short-run dynamics, the CCEMG estimator is also very robust to structural breaks, non-stationarity, non-cointegrated common factors and certain types of serial correlations (Kapetanios et al., 2011).

In addition to the CCEMG estimators, this paper also uses the augmented mean group (AMG) estimator developed by Bond and Eberhardt (2013), which also accounts for unobserved common factors. This method is implemented in three steps: in the first stage, first-order difference OLS is used to estimate a pooled regression model augmented with year dummy variables, that is, the following equation is estimated:

$$\Delta y_{it} = \Phi \Delta x_{it} + \sum_{t=2}^{T} \mu_t \Delta yearD_t + \zeta_{it} \qquad (4)$$

where Δ denotes the first difference operator, $yearD_t$ represents the year dummy for year *t* (there are $T-1$ year dummies), Φ and μ_t are constants and ζ_{it} is the error term. Estimates of the coefficients for the year dummies are collected to form a new variable $\hat{\mu}_t$ that represents the common dynamic process and represents an average estimate of the common factors. In the second stage, $\hat{\mu}_t$ is used as an additional regressor for each group-specific regression model apart from an intercept to capture time-invariant fixed effects, so the following equation is estimated:

$$y_{it} = \alpha_i + \beta_i x_{it} + \theta_i \hat{\mu}_t + \omega_{it} \quad (5)$$

in which θ_i is a constant parameter and ω_{it} is the error term. Finally, as for the MG and CCEMG estimators, the group-specific parameters of the model are averaged across panel members.

The advantage of the AMG approach over the CCEMG approach is that treating the set of unobservable common factors as a common dynamic process instead of a nuisance may, depending upon the context, have useful interpretations. For example, in this study it can be argued that the common dynamic process obtained from the year dummies in the poverty analysis represents an average of the country-specific non-stationary processes omitted from the estimation model and/or due to some common factors to all countries in poverty reduction. In addition, Bond and Eberhardt (2013) show through Monte Carlo simulations that the AMG estimator is unbiased and is often a more efficient estimator compared to the MG and CCEMG estimators for different combinations of *N* and *T*. However, they found that the bias of the MG estimator increases in *T* and decreases in *N*. This implies that this estimator may be more suitable for a panel where *N*>*T*.

Before estimating the MG, CCEMG and AMG models, two vital steps are needed in the empirical investigation. First, a cross-sectional dependency test is needed to determine if the unobserved common factors need to be accounted for in deciding an appropriate unit-root test. Second, appropriate panel unit-root tests are applied to determine the time series properties of the data. Once the time-series properties of each variable are determined, pooled OLS, FE and RE models are estimated and a cross-sectional dependency test is applied to the residuals to determine if the unobserved common factors need to be accounted for in the estimation process, and if that is the case, the MG, CCEMG and AMG models are estimated and compared.

4.2 The cross-sectional dependence test

To determine the presence of cross-sectional dependence (CD hereafter) in the data used in this paper, I did a simple test suggested by Pesaran (2004). The test statistics for the Pesaran (2004) CD test can be written generally as:

$$CD_\rho = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \rightarrow N(0,1) \quad (6)$$

where $\hat{\rho}_{ij}$ stands for the sample estimate of the correlation of panel variables V_{it} and V_{ij} for panel members *i* and *j* (these variables could, for example, be ones used in panel regression or residuals from those regressions), that is:

$$\hat{\rho}_{ij} = \frac{\sum_{t=1}^{T} V_{it} V_{jt}}{\left(\sum_{t=1}^{T} V_{it}^2\right)^{1/2} \left(\sum_{t=1}^{T} V_{jt}^2\right)^{1/2}} = \hat{\rho}_{ji} \tag{7}$$

The CD test's null hypothesis is that cross-sectional independence exists among the panel members, and cross-sectional dependence among these units is the alternative hypothesis. The CD-test statistic is distributed as standard normal for $N \to \infty$ and T sufficiently large. This test may be used with either balanced or unbalanced panels and it has robustness to non-stationarity. When applied to residuals, this test has robustness to heterogeneity in the parameters, to one or more structural breaks in the slope coefficients and to the individual regression's error variance. It also has good small-sample performance (Burret et al., 2016; Pesaran, 2004).

4.3 Panel unit root tests

In addition to testing for the existence of cross-sectional dependence, another vital analysis that should be performed prior to panel estimation is panel unit-root testing to determine the variables' orders of integration. As will be shown, cross-sectional dependence is present for the variables in this study, which leads to the use of an extension of the panel unit root test by Im et al. (2003) (hereafter IPS), that is, the Pesaran (2007) panel unit root test which takes into account cross-sectional dependence among panel members (known as the CIPS test).

The IPS panel unit root test combines information from the time-series dimension with that from the cross-section dimension such that fewer time observations are required for the test to have reasonable power. Researchers in economics have found the IPS test to have superior test power in analyzing long-run relationships in panel data. For the IPS test, a separate augmented Dickey-Fuller (ADF) regression is performed for each panel unit with individual effects and no time trends, so the following is estimated:

$$\Delta y_{it} = c_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_i} \Omega_{ij} \Delta y_{i,t-j} + u_{i,t} \tag{8}$$

where $i = 1, \ldots, N$; $t = 1, \ldots, T$; $y_{i,t}$ is one of the variables under consideration for the country i at time t; c_i, ρ_i and Ω_{ij} are constants and u_{it} is the error term. The null hypothesis is that all the time series of the variable under consideration contain a unit root, that is, $\rho_i = 0$ for all i (with $i= 1, 2, \ldots, N$), while the alternative hypothesis assumes that some of the N panel units are stationary in this variable with individual specific autoregressive coefficients. Im et al. (2003) proposed a test based on the average of the ADF statistics (the t statistics on the estimated ρ_i terms) computed for each individual in the panel.

Since the IPS test is based on the restrictive assumption that the series are independent across the panel units, it suffers from serious size distortions and restricted power in the presence of cross-sectional dependence. To overcome this, Pesaran (2007) suggested the CIPS test which controls for the possible presence of cross-sectional dependence.

The null hypothesis in the CIPS test is that all panels (here, countries) have a unit root for the tested variable while the alternative hypothesis is that a fraction of the panels are stationary. Based on the CIPS test, when we fail to reject the null hypothesis the tested variable is considered non-stationary for all countries and we need to take the difference until it becomes stationary. However, when the null hypothesis is rejected then the tested variable is found to be stationary for a positive fraction of countries which implies that the tested variable may be non-stationary for some of the countries. In an analysis of time series data, a spurious regression is a potential problem arising from a regression involving non-stationary variables. However, the mean group estimator and the augmented mean group estimator can solve the problem of spurious regression arising from regressions with non-stationary variables by including the mean values of the dependent and independent variables in the former estimator and by including the common dynamic process as regressors in the latter estimator (Burdisso & Sangiácomo, 2016).

The method of the CIPS test is based on augmenting the standard ADF regression with the cross-section averages of lagged levels and first-differences of the individual series to capture cross-sectional dependence. Pesaran calls this a cross-sectionally augmented Dickey-Fuller (CADF) test. The simple CADF regression equation used for the i^{th} cross-sectional unit is defined as:

$$\Delta y_{it} = c_i + \rho_i y_{i,t-1} + m_i \bar{y}_{i,t-1} + \sum_{j=0}^{p_i} \psi_{ij} \Delta \bar{y}_{i,t-j} + \sum_{j=1}^{p_i} \Lambda_{ij} \Delta y_{i,t-j} + u_{it} \quad (9)$$

where $\bar{y}_{t-j} = N^{-1} \sum_{i=1}^{N} y_{i,t-j}$ and $\Delta \bar{y}_{t-j} = \bar{y}_{t-j} - \bar{y}_{t-j-1}$, m_i, ψ_{ij}, and Λ_{ij} are constants, and u_{it} is the error term.

For each of the estimated ρ_i terms in Eqn. (9) a *t*-statistic is determined. The test statistic for the CIPS test is the mean of these *t*-statistics:

$$CIPS(N,T) = \sum_{i=1}^{N} t_i(N,T) / N \text{ where } t_i(N,T) \text{ indicates the } t \text{ statistics of } \rho_i . \quad (10)$$

Simulated critical values of the CIPS test are listed in Pesaran (2007). Baltagi et al., (2007) show that the CIPS test is robust to the presence of various sources of cross-sectional dependence, including spatial or geographic proximity.

5. Empirical results and discussion

As mentioned earlier, previous studies have used static and dynamic model specifications to examine trade liberalization's effects on poverty. The static model's specifications take resources and technology as given, whereas the dynamic model's specifications consider economic growth effects and the evolution of poverty over time in the trade openness- poverty analysis (Le Goff & Singh, 2014). The dominant theoretical argument is that greater trade liberalization is associated with increased economic growth, leading to poverty alleviation over time. To account for poverty's persistent nature, the lagged value of poverty is included as a regressor because past levels of poverty explain a great deal of its present and future levels.

Hence, the estimable dynamic panel specification of the theoretical model in Eqn. (1) with inclusion of the lagged value of the dependent variable as the regressor to reduce the omitted variable problem and also to consider the evolution of poverty over time is:

$$\ln Pov_{it} = b_0 + b_{1i} \ln Pov_{it-1} + b_{2i} \ln TO_{it} + b_{3i} gPCI_{it} + B_i X_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (11)$$

where γ_t and μ_i correspond to time specific effects and unobserved country-specific effects respectively, b_0 , b_{1i} , b_{2i} , b_{3i} are constant scalars; B_i is a vector of constants and ε_{it} is the regression error term.

In this specification, all the observed variables except the growth of per capita real GDP and the inflation rate are log transformed which reduces heteroscedasticity problems, creates a more normal distribution and facilitates the interpretation of the coefficients to be estimated. The descriptive statistics of the variables used in the regression model are reported in Table 3.2, prior to log transformations (if any), along with the per capita real GDP level.

Table 3.2 shows the average per capita household consumption expenditure to be about 787 US dollars with a substantial gap in consumption patterns across countries. It also reports that the average value of infant mortality per 1,000 live births is 79 children, where the minimum is 12 and maximum is 175 children per 1,000 live births. This table also shows that the average values for trade openness as percentage of GDP and rural-urban income inequality are 54 percent and 0.44 respectively.

Table 3.13: Descriptive summary statistics

Variables	*N*T*	Mean	Min	Max	St. dev.
Household per capita final consumption expenditure (constant 2010 US$)	1505	786.53	204.99	2629.07	102.94
Infant mortality rate (per 1,000 live births)	1505	79.30	11.90	174.60	34.50
Trade openness (% of GDP)	1505	54.05	6.32	125.02	15.43
Rural-urban income inequality	1505	0.44	0.02	2.58	0.35
Per capita GDP per capita (constant 2010 US$)	1505	4019	351	25218	4587
Growth of per capita GDP (constant 2010 US$)	1462	0.02	-0.65	0.32	0.05
Inflation, consumer prices (annual %)	1505	10.23	-22.24	47.54	12.54
Foreign direct investment (% of GDP)	1505	18.59	2.62	40.06	4.78
Net ODA received per capita (current US$)	1505	58.48	0.97	691.92	53.34

Note: *N* is number of countries and *T* is the time dimension.

Table 3.3 presents the correlation coefficients among the same variables as those in Table 3.2 with most logged to more closely match the variable forms used in the regressions later. These correlations reveal some interesting associations. For example, per capita logged household consumption and the infant mortality rate show a negative and significant correlation. This implies

that households that are poorer (as indicated by having a lower level of per capita consumption expenditure) tend to have a larger number of children dying in infancy. Moreover, trade openness and per capita GDP growth are positively associated with household consumption expenditure, but they are negatively related to infant mortality. This suggests that both these variables are associated with reducing poverty.

Table 3.14: Pairwise correlations of important variables

No.	Variables	1	2	3	4	5	6	7
1	Log of per capita household final consumption expenditure	1						
2	Log of infant mortality rate	-0.70**	1					
3	Log of trade openness	0.50**	-0.43**	1				
4	Log of rural-urban income inequality	-0.78**	0.66**	-0.58**	1			
5	Log of per capita GDP	0.94**	-0.70**	0.50**	-0.85	1		
6	Growth of per capita GDP	0.11**	-0.19**	0.15**	-0.10**	0.11**	1	
7	Inflation, consumer prices	-0.03	0.02	-0.01	0.04	-0.03	-0.1**	1
8	Log foreign direct investments	0.21**	-0.32**	0.44**	-0.27**	0.23**	0.21**	-0.1

Note: ** indicates a 5 percent level of significance. Household final consumption expenditure and GDP are measured in constant 2010 US$.

The results of CD tests on each of the variables included in Tables 3.2 and 3.3 are given in Table 3.4. These results clearly show that the null hypothesis of cross-sectional independence is rejected at the 1 percent significance level for all variables.

Table 3.15: The Pesaran (2004) CD test and average correlation coefficients

Variables	CD-test	p-value	mean ρ	mean abs(ρ)
Log of per capita household final consumption expenditure	44.31	0.000	0.25	0.43
Log of infant mortality rate (per 1,000)	143.36	0.000	0.81	0.81
Log of trade openness (% of GDP)	26.05	0.000	0.15	0.33
Log of rural-urban income inequality	27.31	0.000	0.15	0.45
Log of per capita GDP	185.76	0.000	0.86	0.88
Growth of per capita GDP	16.43	0.000	0.1	0.17
Inflation, consumer prices (annual %)	26.21	0.000	0.15	0.27
Log of foreign direct investment (% of GDP)	49.45	0.000	0.29	0.35

Note: Under the null hypothesis of cross-sectional independence CD_{ρ} ~ N (0,1). Household final consumption expenditure and GDP are measured in constant 2010 US$.

Since the CD test confirms the existence of cross-sectional dependence for these variables, the CIPS unit root test is implemented as this test allows for the heterogeneity of autoregressive coefficients across panels and can control for cross-sectional dependence (Pesaran, 2007).

The results of the CIPS testing reported in Table 3.5 show that all variables across the panel member countries are stationary at the percent significance level, except non-stationarity is indicated for the infant mortality rate under the specification without a trend and for per capita GDP,[10] both without a trend and with a trend. However, since the table gives different results regarding the stationarity properties of infant mortality under the specifications without and with a trend, this variable was plotted over time to determine which of the two specifications is better to rely on. This plot, presented in Appendix Figure A1, indicates a downward trend over time in infant mortality in each country, so the CIPS unit root test with a trend included is used with the conclusion that in levels the variable is trend stationary. Hence, in subsequent regression estimates, time is included as an additional explanatory variable when infant mortality is used as the dependent variable in the regression.

Table 3.16: Pesaran (2007) panel unit root test (CIPS)

Variable	Specification without trend		Specification with trend	
	Zt-bar	p-value	Zt-bar	p-value
In level				
Log of household per capita final consumption expenditure	-3.71	0.000	-3.64	0.000
Log of infant mortality rate	-0.61	0.273	-5.72	0.000
Log of trade openness (% of GDP)	-3.88	0.000	-2.25	0.012
Log of Rural-urban income inequality	-3.33	0.000	-2.70	0.003
Log of per capita GDP	-0.46	0.322	-1.15	0.126
Net ODA received per capita in log	-3.31	0.000	-2.24	0.013
Inflation, consumer prices (annual %)	-8.16	0.00	-7.75	0.000
In first difference				
Log of per capita GDP ♣	14.617	0.000	11.824	0.000

Notes**:** Household final consumption expenditure and GDP are measured in constant 2010 US$. The Pesaran (2007) runs a test for unit root in a heterogeneous panel with cross-sectional dependence. The null hypothesis assumes that all series are non-stationary and the Stata 14 command 'multipurt' was used to compute the CIPS test. ♣ the first difference of per capita GDP represents the growth in per capita GDP.

[10] The CIPS test for logged per capita GDP shows that it is non-stationary in levels, but it becomes stationary in first differences. The first difference of the natural logarithm of per capita GDP is approximately the growth rate of per capita GDP, and this is used as one of the explanatory variables in the next estimations.

The CD tests on the residuals from standard pooled, RE and FE panel regressions (as special cases of Eqn. (11)) indicate the existence of cross-sectional dependence in each case (see Appendix Table A2), which violates the assumption of the independently and identically distributed error terms. In the presence of cross-sectional dependence, the conventional panel data estimates are inefficient, and their standard errors are biased, most likely leading to misleading inferences. Hence, this paper uses the Mean Group (MG) estimator (Pesaran & Smith, 1995), which allows for a heterogeneous panel and it also applies the Common Correlated Effects Mean Group (CCEMG) estimator (Pesaran, 2006) and the Augmented Mean Group (AMG) estimator (Bond & Eberhardt, 2013; Eberhardt & Bond, 2009; Eberhardt & Teal, 2010), both of which allow for the presence of unobserved factors with heterogeneous slope estimates.

The results of the MG, CCEMG and the AMG estimates including their root mean squared errors, and the results from the CD test and the CIPS test on the residuals from these estimated models, are presented in Table 3.6. The results indicate that the root mean-square errors resulting from the MG and CCEMG estimates are larger than those resulting from the corresponding AMG estimates. Moreover, the MG estimates are less satisfactory than the CCEMG and AMG estimates because the MG estimates do not attempt to correct for cross-sectional dependence. This explains why in Table 3.6 the residuals-based CD-test statistics using the MG estimates have a p-value of 0.003, indicating cross-sectional dependence in the residuals. Regarding the residual series obtained from the models estimated by CCEMG and AMG, the CD test results show that the hypothesis of cross-sectional dependence cannot be rejected at even the 10 percent level of significance, and the CIPS test indicates that the residuals are stationary using either methodology. Hence, the CCEMG and AMG models, which take into account cross-sectional dependency and slope heterogeneity across countries, are appropriate estimators.

This paper focuses on the AMG estimates since the unobservable common factors are treated in AMG estimation as a common dynamic process which provides useful interpretations and since Monte Carlo simulations have shown that the AMG estimator is unbiased and is the most efficient estimator for different combinations of N and T as compared to the CCEMG estimator (Bond & Eberhardt, 2013).

Table 3.17: Dynamic heterogeneous estimation results
(dependent variable: Log of per capita household consumption)

Variables	MG	CCEMG	AMG
Log of per capita household consumption (*t*-1)	0.7972***	0.7726***	0.460***
	(0.12)	(0.04)	(0.06)
Log of trade openness	2.5459***	0.6254***	0.463***
	(0.44)	(0.10)	(0.09)
Growth of per capita GDP	0.0571	0.050***	0.0360***
	(0.10)	(0.06)	(0.01)
Log of rural-urban income inequalities	-0.1911	-0.2573	-0.493**
	(0.45)	(0.26)	(0.20)
Inflation (consumer price index growth)	-0.001	-0.006	-0.0028***
	(0.00)	(0.00)	(0.00)
Log of foreign direct investments as % of GDP	0.0483	0.0151***	0.0181***
	(0.05)	(0.00)	(0.01)
Log of national official development assistance	-0.6474***	-0.0015	-0.0069
	(0.12)	(0.02)	(0.02)
Common dynamic processes			0.425***
			(0.08)
Constant	4.3379***	-0.5683	1.2019***
	(1.21)	(0.51)	(0.40)
Observations	1400	1400	1400
Root mean squared error	0.0578	0.0412	0.048
CD statistics	13.172	-1.587	-0.675
CD p-value	0.003	0.112	0.612
CIPS statistics	-20.277	-15.104	-9.523
CIPS p-value	0.000	0.000	0.000

Notes: Standard errors are in parentheses. * **, **, and * indicate a 1 percent, 5 percent and 10 percent level of significance respectively. Household [final] consumption expenditure and GDP are measured in constant 2010 US$. MG, CCEMG and AMG refer to Mean Group, Common Correlate Mean Group and Augmented Mean Group respectively. Estimates based on Eqn. (11). ♠ (*t*-1) represents a 1-year lag in the indicated variable.

The empirical results of the AMG estimator are presented in Table 3.7 for the two different poverty proxy variables, that is, per capita household consumption expenditure and the infant mortality rate. In both the cases, the AMG estimates confirm the existence of a common dynamic process as being a statistically significant part of a long-run pattern of poverty that allows for heterogeneous country effects and possible cross-country spillover effects.

The results of the AMG estimation presented in Column 1 show that when poverty is proxied (negatively) by per capita household consumption, the estimated coefficients of the log of the trade openness index and the growth of per capita GDP are significantly positive at the 1 percent

significance level. A 1 percent increase in trade openness increases per capita household consumption expenditure on average by 0.46 percent. Greater trade openness can bring structural changes that shift resources from the low-productive agricultural sector to a more-productive manufacturing sector, with low-skilled workers benefiting from the expansion of labor-intensive exporting industries. This affects poverty through an increase in the relative wage rate. In addition, as countries open their markets the availability and quality of goods and services increases which helps reduce poverty. A one percentage unit increase in the growth of per capita GDP increases per capita household consumption expenditure by 3.6 percent on average.

The findings in Table 3.7 also show that reduction in rural-urban income inequalities on average increase per capita household consumption expenditure at the 5 percent significance level. This is consistent with the theoretical observation that when the economy is transforming, and the resources are shifting from agricultural production to the industrial and services sectors, which are more productive in terms of value added compared to the agricultural sector, more income is generated in the economy which helps reduce poverty levels.

Moreover, the first column in Table 3.7 shows that the coefficient estimates for inflation and logged foreign direct investment as percentage of GDP are pretty small but statistically significant, with respectively negative and positive effects on per capita household consumption. The former implies that greater inflation will decrease per capita household consumption arguably due to a general price increase leading on average to households having lower real income and purchasing power. On the other hand, an increase in foreign direct investment will help relieve poverty arguably due to the investment creating more job opportunities and inducing relatively higher wages that increase per capita household consumption.

Column 2 in Table 3.7 presents the results of AMG estimation when poverty is proxied (positively) by infant mortality. In contrast to the first column, the inflation and foreign direct investment variables are not used as explanatory variables for the regression presented in the second column in Table 3.7 because these variables do not affect the infant mortality rate directly.

Table 3.18: AMG estimates for the entire set of countries, 1980-2014

Variables	Dependent variables	
	Log of per capita household consumption	Log of infant mortality rate
	(1)	(2)
Log of per capita household consumption (t-1) ♣	0.460***	
	(0.06)	
Log of infant mortality rate (*t*-1) ♣		0.757***
		(0.05)
Log of trade openness as % GDP	0.463***	-3.39**
	(0.09)	(1.54)
Growth of per capita GDP	0.0360***	-0.0288***
	(0.01)	(0.00)
Log of rural-urban income inequalities	-0.493**	2.021**
	(0.20)	(0.98)
Inflation	-0.0028***	
	(0.00)	
Log of foreign direct investments as % of GDP	0.0181***	
	(0.01)	
Log of national official development assistance	-0.0069	-0.016
	(0.02)	(0.01)
Common dynamic processes	0.425***	0.5678***
	(0.08)	(0.13)
Constant	1.2019***	-0.1595**
	(0.40)	(0.08)
Trend	No	Yes
Observations	1400	1400
Root mean squared error	0.048	0.008
CD statistics	-0.675	0.452
CD p-value	0.612	0.321
CIPS statistics	-9.523	-6.231
CIPS p-value	0.000	0.000

Notes: Standard errors are in parentheses. * **, **, and * indicate a 1 percent, 5 percent and 10 percent level of significance respectively. Household [final] consumption expenditure and GDP are measured in constant 2010 US$. ♠ (*t*-1) represents a 1-year lag in the indicated variable.

The log of the trade openness index, the log of the rural-urban inequality measure and the growth in per capita GDP are shown to have a significant negative effect on the infant mortality rate, the first two at the 5 percent significance level and the last at the 1 percent significance level. Both

trade openness and growth in per capita income have a negative estimated relationship with infant mortality, whereas rural-urban inequality has an estimated positive relationship with infant mortality. These estimated signs are consistent with the analogous ones in Column 1 since infant mortality is a positive proxy for poverty, while per capita household consumption is a negative proxy for poverty.

The fact that the coefficient estimates for growth in per capita GDP are positive when the log of per capita household consumption is the dependent variable and is negative when the infant mortality rate is the dependent variable suggests that poverty is countercyclical (keeping in mind that all these variables are treated as stationary or trend stationary in the panel based on the CIPS testing). A possible explanation for this is that having per capita GDP growing faster than its trend pushes down unemployment and allows for a spurt in investments on education, health and sanitation—thereby reducing poverty—whereas having per capita GDP growing more slowly than its trend pushes up unemployment—thereby increasing poverty.

Furthermore, the results of this paper also suggest that the previous-year poverty value (past per capita household consumption or the infant mortality rate) has a significant and positive effect on the current poverty measure's value. This implies that the past poverty reduction efforts of each country contribute to its current poverty levels.

The countries included in this study differ in their level of trade liberalization, level of regional and global trade engagements, import-protection policies and degree of economic development. Hence, the average effect of trade openness on poverty may mask important differences across countries. Due to such differences, the effects of trade openness on poverty may be highly heterogeneous across the countries. To examine the heterogeneous effects of trade openness on poverty across countries, Table 3.8 presents the individual-country AMG estimates of the coefficients on trade openness for countries in which that estimate is statistically significant at the 10 percent level or lower.

Table 3.19: Country-specific coefficient estimates on logged trade openness as a % of GDP

		Dependent variables as a proxy for poverty					
No.	Countries	Log of per capita household consumption		No.	Countries	Log of infant mortality rate	
		Coeff.	p-value			Coeff.	p-value
1	Algeria	0.74	0.071	1	Algeria	-1.47	0.000
2	Botswana	2.10	0.044	2	Benin	-0.82	0.003
3	Burkina Faso	0.82	0.006	3	Burkina Faso	-0.97	0.000
4	Cameroon	1.09	0.000	4	Burundi	-0.59	0.000
5	Chad	0.82	0.001	5	Cameroon	-0.48	0.026
6	Cote d'Ivoire	0.99	0.032	6	Chad	-0.35	0.001
7	Ethiopia	1.15	0.002	7	Congo, Dem. Rep.	-0.37	0.000
8	Gabon	1.12	0.002	8	Cote d'Ivoire	-0.85	0.001
9	Gambia	-0.66	0.001	9	Egypt, Arab Rep.	-1.55	0.000
10	Ghana	0.42	0.001	10	Ethiopia	-1.42	0.000
11	Guinea	0.64	0.057	11	Ghana	-0.60	0.000
12	Lesotho	0.98	0.048	12	Guinea	-1.76	0.000
13	Mauritania	0.47	0.009	13	Kenya	-1.03	0.006
14	Namibia	1.55	0.000	14	Madagascar	-1.37	0.000
15	Nigeria	1.44	0.000	15	Malawi	-0.59	0.013
16	Senegal	-0.86	0.092	16	Mali	-2.11	0.000
17	Seychelles	1.91	0.000	17	Mauritius	-1.47	0.000
18	Sierra Leone	1.62	0.000	18	Morocco	-3.47	0.000
19	Sudan	0.3	0.076	19	Mozambique	-0.69	0.000
20	Swaziland	0.79	0.007	20	Niger	-1.18	0.000
21	Togo	0.73	0.013	21	Nigeria	-0.25	0.029
22	Zambia	-0.83	0.014	22	Seychelles	-0.68	0.000
23	Zimbabwe	-0.86	0.000	23	Sierra Leone	-0.31	0.009
				24	Sudan	-0.41	0.000
				25	Tunisia	-4.32	0.000
				26	Uganda	-1.71	0.000
				27	Zambia	-0.89	0.000

Notes: Estimates provided only for countries with coefficient estimates significant at less than the 10 percent level. Household [final] consumption expenditure is measured in constant 2010 US$.

One of the advantages of the AMG estimator is that it makes it possible to see how variations in the explanatory variables for the specific countries affect the outcome variable. As we can see from Table 3.8, the coefficient estimates on the logged trade openness index range from 0.86 for Zimbabwe to 2.10 for Botswana when per capita household consumption is used as a proxy for

poverty, and the coefficient varies from -4.32 for Tunisia to -0.25 for Nigeria when the infant mortality rate is used as a proxy for poverty. This result clearly indicates that the impact of trade openness on poverty has substantial variation across countries. Such variation is expected due to the differences in country characteristics noted in the previous paragraph. Nevertheless, it is noteworthy that trade openness has a positive and significant effect on per capita household consumption for 19 of the 23 countries where significance is shown, and that trade openness reduces infant mortality in all the 27 countries where significance is shown. Thus, greater trade openness in general appears to be associated with improved poverty levels, most notably when infant mortality is used as the proxy variable for poverty.

6. Conclusion and policy recommendations

While it is well-established that trade liberalization is an important component of growth and poverty reduction strategies in developing countries, its impact on poverty is ambiguous both theoretically and empirically. This study contributes to filling this gap in the literature by examining the differential impact of trade liberalization on poverty in a panel of 43 African countries over the period 1980-2014 using a couple of recently developed methodologies – the common correlated effects mean group (CCEMG) estimator (Pesaran, 2006) and the augmented mean group (AMG) estimator (Bond & Eberhardt, 2013; Eberhardt & Bond, 2009; Eberhardt & Teal, 2010).

This paper used per capita household consumption and the infant mortality rate as proxies for poverty (negative and positive proxies respectively). The findings show that, on average, both greater trade openness and greater per capita income growth have positive and significant associations with poverty reduction, while greater rural-urban inequality is significantly and negatively associated with poverty reduction. Moreover, the impact of trade openness on poverty varies from country to country, suggesting that the one-policy-fits-all approach will not work in Africa.

These results are consistent with recent literature that shows that trade liberalization is an engine for economic growth and for creating new job opportunities thereby reducing poverty levels. Hence, trade liberalization policies should be designed to encourage investments in human capital, acquisition of new skills, innovations and inward flows of foreign direct investment so that employment levels increase, and workers benefit from greater demand for their services and higher

relative wages. Such policies would allow resources to be reallocated away from less productive activities to more promising ones. Trade liberalization should not be seen in isolation; additional policies are also needed to enhance its positive impact, including on poverty reduction. Also, not only do poor policies and institutions, low human capital levels and limited financial development negatively affect a country's welfare but they also prevent the poor in developing countries from benefiting from the gains of trade liberalization.

To enhance the positive effects of trade openness on poverty, countries need to support reforms that encourage economic growth and strengthen competitive firms and labor to adjust easily within a more dynamic and competitive global environment. Africa's trade performance is relatively low due to various factors like weak institutional set-ups, insufficient infrastructure, lack of skilled labor and high costs of intermediate inputs. All these factors need to be considered to ensure sustainability in both economic growth and export growth. Moreover, in addition to trade liberalization, structural transformation which encourages the movement of resources, including labor, from the agricultural sector to the industrial and services sectors will help reduce poverty on the continent.

Appendix

Table A1: List of countries covered in the study

No.		No.	
1	Algeria	23	Mali
2	Benin	24	Mauritania
3	Botswana	25	Mauritius
4	Burkina Faso	26	Morocco
5	Burundi	27	Mozambique
6	Cameroon	28	Namibia
7	Central African Republic	29	Niger
8	Chad	30	Nigeria
9	Congo, Dem. Rep.	31	Rwanda
10	Congo, Rep.	32	Senegal
11	Cote d'Ivoire	33	Seychelles
12	Egypt, Arab Rep.	34	Sierra Leone
13	Ethiopia	35	South Africa
14	Gabon	36	Sudan
15	Gambia, The	37	Swaziland
16	Ghana	38	Tanzania
17	Guinea	39	Togo
18	Guinea-Bissau	40	Tunisia
19	Kenya	41	Uganda
20	Lesotho	42	Zambia
21	Madagascar	43	Zimbabwe
22	Malawi		

Table A2: Dynamic homogeneous estimation results using POLS, FE and RE estimators

Dependent variable: Log of per capita household consumption

Variables	POLS	FE	RE
Log of per capita household consumption (t-1)	-0.0951***	-0.4010***	-0.0951***
	(0.01)	(0.02)	(0.01)
Log of trade openness	0.0621***	0.4932***	0.0621***
	(0.02)	(0.04)	(0.02)
Log of rural-urban income inequalities	0.0056	0.0485**	0.0056
	(0.01)	(0.02)	(0.01)
Growth of per capita GDP	0.0699***	0.0742***	0.0699***
	(0.01)	(0.02)	(0.01)
Inflation	0.0003	-0.0001	0.0003
	(0.0002)	(0.0002)	(0.0002)
Log of foreign direct investment as % of GDP	0.0063	-0.0146***	0.0063
	(0.00)	(0.00)	(0.00)
Log of national official development assistance	0.0006	-0.0023	0.0006
	(0.00)	(0.00)	(0.00)
Constant	0.0605	-0.0004	0.0605
	(0.04)	(0.11)	(0.04)
Number of observation	1200	1200	1200
CD statistics	5.718	2.647	5.719
CD p-value	0.000	0.008	0.000
CIPS statistics	-8.854	-4.186	-8.854
CIPS p-value	0.000	0.000	0.000

Notes:

1) POLS, FE, and RE refer to pooled OLS, fixed effects and random effect, respectively.
2) Authors' calculations based on secondary data.
3) *, ** and *** indicate statistical significance at the 10 percent, 5 percent and 1 percent levels respectively.
4) Standard error statistics are given in parentheses.
5) The null hypothesis of CIPS is non-stationarity.
6) The CD test show that residuals are cross-sectional dependent.
7) Household [final] consumption expenditure and GDP are measured in constant 2010 US$.
8) (*t*-1) represents a 1-year lag in the indicated variable.

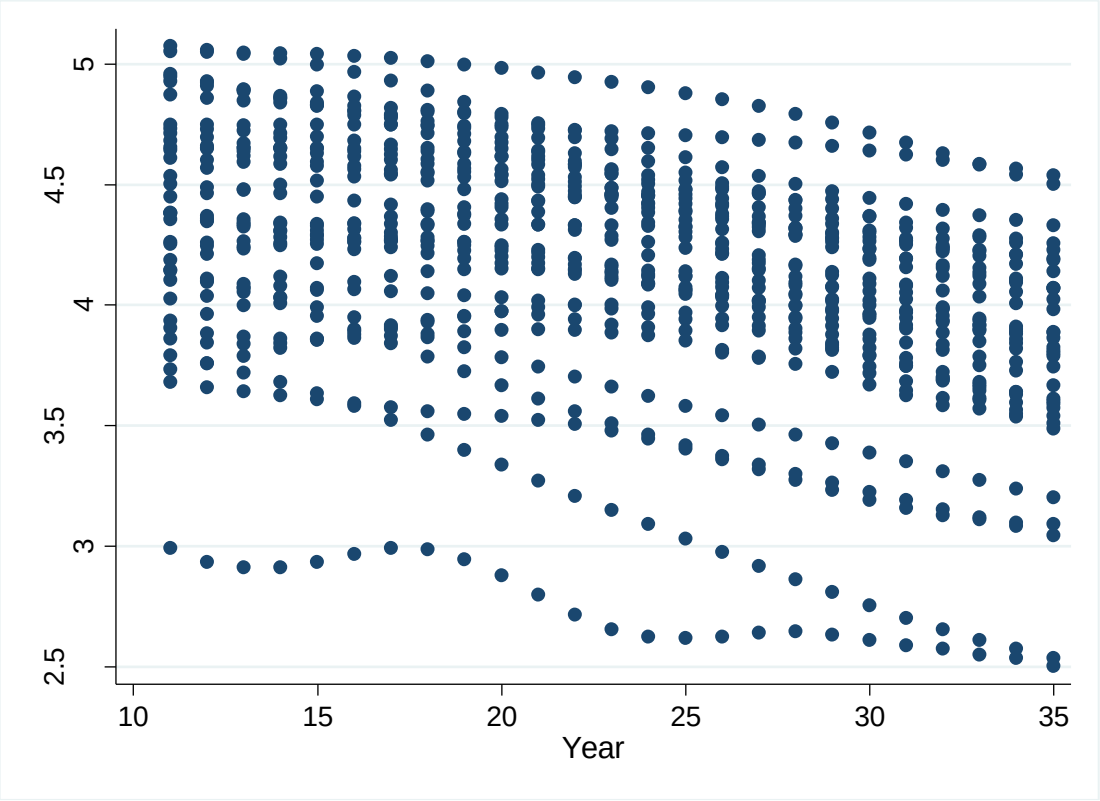


Figure A1: Scatter plot of infant mortality over time

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Paper Three

The Impact of Nutrition, Health and Wealth on Children's Educational Performance

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3

The Impact of Nutrition, Health and Wealth on Children's Educational Performance

Kahsay Berhane Lemma

Abstract

This paper uses data from the Young Lives survey in five regions of Ethiopia to examine the effect of a child-nutrition-and-health indicator and the household wealth index on children's cognitive achievements as measured by the Peabody Picture Vocabulary Test (PPVT) score. The paper uses longitudinal data from this survey held in 2006 and 2009 on two age cohorts of children in Ethiopia. It uses cross-sectional regressions for each of the four age groups (two age-group cohorts in two different rounds) and regressions on changes in variables across three years for these two age-cohorts. The results show that the child-nutrition-and-health indicator had a positive and significant effect on children's cognitive skills in the younger cohort, while it had a positive and insignificant effect on the older cohort under the cross-sectional and panel estimations. The study also finds that the household wealth index had a positive and significant relationship with a child's educational performance for all ages considered using both estimation techniques. The findings also show that child labor had a negative effect on a child's academic achievements in the older cohort and that the effect was stronger for girls than for boys of a similar age. Therefore, it is crucial to invest in improving early child nutrition and designing policy measures to raise household wealth.

Keywords: Child nutrition and health, household wealth index, children's cognitive skills, panel data analysis, Young Lives dataset for Ethiopia.

The Impact of Nutrition, Health and Wealth on Children's Educational Performance

1. Introduction

A large number of research studies in economics, psychology and other disciplines have demonstrated that the effects of malnutrition during a child's first 1,000 days,[11] from conception until the child's second birthday, has a devastating impact on her/his skills and future development. The term malnutrition literally means 'bad nutrition' and technically encompasses both under and overnutrition. Developing countries like Ethiopia experience more undernutrition, which is one of the world's most serious issues in current development policies. Reducing all forms of child malnutrition, especially during these 1,000 days, provides an opportunity not only for improving a child's cognitive skills but it also contributes to the child achieving other goals like school completion, escaping from poverty, improving adult wages and triggering productivity gains that further accelerate economic growth (Fink et al., 2016; Hoddinott et al., 2008, 2011; Martorell et al., 2010). Moreover, malnutrition affects children not only by directly damaging their bodies and their cognitive development, but also by reducing their confidence about learning and leading to lower self-esteem, self-confidence and career aspirations (Dercon & Sánchez, 2013; Dercon & Singh, 2013; Krishnan & Krutikova, 2013). Previous research has shown that reducing early child malnutrition has a positive effect on learning outcomes in developing countries (Ampaabeng & Tan, 2013; Duc, 2009; Duc & Behrman, 2017; Glewwe & Miguel, 2007; Haile et al., 2016; Martorell et al., 2010; Sánchez, 2017; Sanchez, 2009; Spears, 2012; Tooley et al., 2016; Woldehanna et al., 2017).

This paper expands our understanding of the role of malnutrition on cognitive skills in Ethiopia at different ages based on data collected through the Young Lives survey on 5-year-olds and 12-year-

[11]This 1,000-day window is a critical time for structural brain development. Good maternal nutrition is essential; pregnant or breastfeeding mothers who cannot access the right nutrients are more likely to have children with compromised brain development who suffer from poor cognitive performance. The World Food Programme (WFP) defines malnutrition as 'a state in which the physical function of an individual is impaired to the point where he or she can no longer maintain adequate bodily performance process such as growth, pregnancy, lactation, physical work and resisting and recovering from disease' (World Food Programme, 2000).

olds in 2006 and on the same children in 2009. The study also investigates the role of malnutrition in educational achievements at different ages; these are issues which have been neglected in previous studies. Many development organizations believe that improving the socioeconomic status of a household and breaking the cycle of poverty is one way of improving child development outcomes. Family investments are particularly consequential for later development and have large returns as they raise the rate of returns from later investments – known as the 'skills beget skills' argument (Cunha & Heckman, 2007). Many studies have also shown that investments in children during their crucial early period of biological, neurological, psychological, social and emotional growth are more vital for their future development than later more-expensive interventions when they are teenagers or young adults (Black et al., 2003, 2013; Cunha & Heckman, 2008; Glewwe et al., 2001).

Greater household wealth may provide families with additional finances so that they can choose to send their children to the best-performing schools or use them for funding private schooling and other education-enhancing activities and getting learning material for their children. Sufficiently-high household wealth also enables a child to spend his or her time studying rather than working to supplement household income. Greater household wealth can help mitigate the negative effects of unintended shocks (for example, droughts, food inflation, unemployment and illnesses) on educational outcomes. Furthermore, greater household wealth gives a child confidence and the ability to aspire for more.

Motivated by the importance of early child investments for later child-development outcomes and the initial and contemporaneous impact of household wealth on a child's cognitive skills, this paper contributes to existing literature by filling a number of gaps. First, instead of the commonly used household income as a proxy for family economic resources in intergenerational income transmission literature, this study uses an aggregate household wealth index that is constructed from three different composite proxy indicators of household economic conditions: an index of households' access to services, an index of housing quality and an index of ownership of various consumer durables. The aggregate household wealth index is constructed as a weighted average of these sub-indices using principal component analysis to assign a weight to each sub-index based on its relative contribution to total variance. In addition to the aggregate wealth index, this paper also explores whether or not the three indices on which the aggregate wealth index is built have

different effects on children's cognitive skills. Second, this is one of the few studies that takes advantage of the longitudinal dimension of data from the second and third rounds of the Young Lives survey in Ethiopia. Estimating the impact of household wealth, malnutrition and health on educational achievements is not straightforward as there may be unobserved heterogeneity in parents' decision-making that impacts both children's health outcomes and educational achievements. This potential endogeneity poses a challenge in estimating the impact of household wealth and childhood malnutrition on educational outcomes. Longitudinal research has many advantages over other designs since it enables us to examine the dynamics of educational performance over time and to solve the potential problem of endogeneity. This study uses two types of regressions: cross-sectional regressions on data in a single round for each age cohort and regressions focusing primarily on first-differences (changes) in the variables between rounds.

Third, this paper extends existing literature by examining the differential impact of child malnutrition and household wealth and other control variables on a children's cognitive skills at different age levels.

The rest of the chapter is organized as follows. The next section presents a background of child malnutrition globally and in Ethiopia in particular; it also discusses Ethiopia's recent policies and economic performance. Section 3 discusses related literature on the determinants of cognitive skills. Section 4 describes the dataset and discusses the theoretical and empirical model. Section 5 presents the main empirical results from different perspectives. Section 6 gives the conclusion.

2. Background

Globally, 155 million children were stunted (low height-for-age) in 2016. While this was a decline from 40 percent in 1990 to 23 percent in 2016 globally, progress in reducing the amount of stunting has been varied and uneven around the world with persistent regional differences. South Asia and sub-Saharan Africa remained above the global average both in terms of prevalence and the number of stunted children. Figures from South Asia show that around 35.8 percent of all children under the age of 5 years were stunted in 2016; this figure decreased from 61 percent in 1990. Surprisingly, despite a drop child stunting in sub-Saharan Africa from 49 percent in 1990 to 34 percent in 2016, the total number of stunted children increased by 11.6 million during the same period as a result of high fertility rates and lower rates of decline in stunting (Global Nutrition Report, 2017).

Among the most significant social problems in many developing countries, including in Ethiopia, are widespread child malnutrition, high infant mortality rates, low literacy rates and persistent poverty. Child malnutrition is a leading cause of child deaths in developing countries (Black et al., 2003) and reducing child mortality is among the major priorities included in the Sustainable Development Goals (SDGs). The transformational vision of the 2030 Agenda for Sustainable Development and the United Nations Decade of Action on Nutrition (2016 –25) call for new research and joint efforts in ending hunger and all forms of malnutrition.

During the last two decades, Ethiopia has been implementing comprehensive economic reforms to meet the Millennium Development Goals (MDGs) and currently the SDGs on which the world is working to achieve sustainable economic growth while reducing poverty, child mortality and ill-health by 2030. The Ethiopian government is currently contextualizing and mainstreaming the SDGs in the second phase of its Growth and Transformation Plan II (GTP II) which will run from 2015-16 to 2019-20. GTP II's aims are to continue improving physical infrastructure through public investment projects (for example, energy, telecommunications, roads and railways), to transform the country into a manufacturing hub and to invest in education and affordable health services in the plan period. GTP II has a strong focus on the SDGs, with an overarching goal of improving the health of mothers, neonates and children. It gives high priority to human development and to turning Ethiopia into a lower-middle income country by 2025. In line with GTP II, the Federal Ministry of Health has developed a comprehensive nutrition plan, which includes taking various actions so that barriers can be removed, and children's nutritional needs can be addressed starting from an early age till they become productive members of society.

Ethiopia has achieved remarkable and sustainable economic growth and has made considerable progress in poverty reduction and has also shown improvements in key human development indicators. According to the World Bank's (2015) poverty assessment, poverty reduction in Ethiopia has accelerated and the poverty headcount fell from 44 percent in 2000 to 39 percent in 2004. Similarly, based on the household consumption expenditure survey of 2011[12] poverty levels further declined to 30 percent in 2011. This decline was underpinned by high and consistent economic growth. Ethiopia has achieved significant and consistent economic growth over the past

[12] The national poverty line is defined with reference to the recommended 2,200 calories per adult per day. An adult equivalent scale is used to adjust for household size and the age composition and is also adjusted for inflation.

decade, recording an average of 10.8 percent growth per year in 2003/04-2014/15 (the World Bank, 2017). A strong commitment by the government to eradicating extreme poverty and achieving shared prosperity through investments in agriculture, expanding the provision of education and health services, investment infrastructure and substantial improvements in the provision of safety nets and other basic pro-poor services had also been done during this period.

However, despite steady economic growth and poverty reduction in the last 10 years, widespread child malnutrition, high infant mortality, low literacy rates and persistent poverty continue to be key risk factors for child development outcomes and development policies in Ethiopia. The poor nutritional status of pre-school children has been commonly measured by three anthropometric z-scores: height-for-age (zhfa), weight-for-height (zwfh) and weight-for-age (zwfa).[13] Compared to the distribution of the international reference population (provided by the US National Center for Health Statistics and recommended by the World Health Organization (WHO) and the US Center for Disease Control and Prevention), each z-score indicates how many standard deviations (SDs) the associated measurement of a given child is above (or when negative, below) the median of the reference population, calculated for each age category in Ethiopia from the Ethiopian Demographic Health Survey (EDHS). Based on the 2016 EDHS, around 38 percent of Ethiopian pre-school children were short for their age or stunted, that is, the height-for-age z-scores (zhfa) was -2 SD or less and around 18 percent were severely stunted (zhfa $\leq$ -3.0 SD). The second yardstick, the weight-for-height (zwfh) score is an indicator of acute or recent nutritional deficits. Based on this indicator, 10 percent children in Ethiopia were wasted, that is, with a zwfh indicator below -2 SD, and 3 percent were severely wasted, with the zwfa indicator below -3 SD. The third measure, the weight-for-age z-score (zwfa), is a composite index of weight-for-height and height-for-age and thus does not distinguish between acute malnutrition (wasting) and chronic malnutrition (stunting). Children can be underweighted for their age because they are stunted, wasted, or both. Hence, the weight-for-age z-score is an overall indicator of a population's nutritional health. About 24 percent of all children in Ethiopia were underweight (below-2 SD) and 7 percent were severely underweight (below -3 SD) (Global Nutrition Report, 2016). Overall, Ethiopians are among the most undernourished populations in the world.

[13] More recently, a composite index of anthropometric failure (CIAF) was used from the 2014 Ethiopian Mini Demographic and Health Survey (EMDHS) to measure the prevalence of malnutrition which is a leading cause of child illnesses and deaths in Ethiopia (Endris et al., 2017).

Stunting rates (children with very low heights for their age) for children less than 5 years of age fell from 58 percent in 2000 to 44 percent in 2010 and to 40 percent in 2014. In their study of trends and determinants of child undernutrition in Ethiopia, Carranza and Gallegos (2013) found that patterns and trends in undernutrition declined between 2000 and 2011. Over this period, the number of severely stunted children fell by 38 percent and progress against child malnutrition was noticeable with the prevalence of stunting being reduced by 1.4 percentage points per year from 2000 to 2011, even though the progress has slowed down to 1.0 percentage point per year since 2011 (Headey, 2014).

The EDHS' results show that there are variations in child nutrition in rural and urban areas and across regions. Rural areas are more likely to have a higher percentage of stunted children (46 percent) than urban areas (36 percent) and the Amhara region had the highest percentage of stunted children (52 percent) followed by Tigray (51 percent), Afar (50 percent) and Benishangul-Gumuz (49 percent), while Addis Ababa and Gambela had the lowest rates (22 percent and 27 percent respectively) (USAID, 2016).

Well-planned early interventions that reduce child malnutrition and improve households' socioeconomic status can have a long-term positive impact on children's cognitive skills. That is why improving children's nutrition status has become an important policy priority for the Government of Ethiopia for better educational performance of its children. Economic analyses have reinforced research findings to support the compelling claim that access to quality care and education during early childhood is good for children's development, and improving such access is also consistent with helping the children realize their rights; it is also an important pro-poor strategy capable of increasing equity (Black et al., 2003).

3. Literature review

Many studies measure the effect of socioeconomic status and malnutrition, particularly of stunting, on cognitive, educational and socio-emotional development both during school-age years and in adult life. This section briefly reviews literature on the impact of household wealth, child nutrition and other factors on children's learning performance. It considers variables related to child nutrition and health, household economic welfare, household composition and education, access to services and food aid in single- and cross-country studies.

3.1 Child nutrition and learning performance

Investing in child nutrition can have important consequences for educational attainments and lifelong productivity. Intellectual development in early childhood can be an important determinant of success in later life (Chetty et al., 2011). Glewwe et al., (2001) looked at the impact of early childhood nutrition, as measured by height-for-age, on learning (measured by test scores), delayed entry and grade repetitions using a sample of 3,000 children's longitudinal data from the Philippines. The data collection started at the birth of a child and continued every two months for the first two years of the child's life. Additionally, there were follow-up surveys when the children were 8 and 11 years old. They found large effects of early childhood malnutrition on learning, delayed school enrolments and grade repetitions.

Literature on early childhood development in poor communities has generally focused on the consequences of early-life conditions (for example, on health and nutrition) for subsequent cognitive development which is also a major focus of the Young Lives panel data study in four developing countries. The analyses in previous literature have often used panel data to provide child-specific information on early-life conditions. For instance, Sanchez and Decrcon (2009) in Peru and Duc (2009) in Vietnam analyzed the Young Lives panel data and found a significant positive relation between early life malnutrition and a child's later development after controlling for other factors such as wealth and parental education. Both these studies found that the effect of stunting at around one year of age was associated with lower cognitive scores for children when they reached 5 years. In Vietnam, an increase in the height-for-age score by a standard deviation was found to lead to a 20 percent increase in quantitative cognitive achievements. Using panel data from rural Pakistan, Alderman et al., (2001) concluded that there was a significant positive effect of pre-school height on the probability of future school enrolments (controlling for geographical effects). The authors found that a child's height-for-age when he or she was 5-years old had a strong positive effect on the probability of his or her being enrolled in school at age 7, especially for girls.

Using panel data for 8,000 children from the four developing countries covered by the Young Lives survey (Ethiopia, India, Peru and Vietnam), Sanchez (2009) implemented a multivariate regression analysis to explore the linkages between nutritional status and later cognitive achievements of pre-school children. He found a positive association between early nutrition

(measured by height-for-age z-scores) and later pre-school cognitive achievements for school-age children in the four countries.

According to Maluccio et al., (2009) who used a longitudinal survey from rural Guatemala, a higher intake of nutrients during early childhood had a long-term, substantial impact on adult educational outcomes. According to their study, being stunted at 36 months of age was associated with going on to receive, on average, 3.6 fewer grades of schooling as compared to children who were not stunted and scoring significantly worse in reading and vocabulary. Additionally, improvements in child health can translate into large productivity gains later on in life. Estimates based on data on five different age cohorts in low- and middle-income countries suggest that children who were stunted at age 2 were 16 percent more likely to fail a grade than non-stunted children (Martorell et al., 2010).

Wisniewski's (2010) study in Sri Lanka estimated the impact of nutrition and health problems on test scores of fourth grade students. The author found that stunting and severe-stunting problems in children had both direct and indirect impacts on their tests scores. Since parents may adjust to small changes in nutrition and health by changing the educational inputs provided to their children, it is important to recognize that child health and nutrition are both affected by family and household decisions and characteristics.

3.2 The effect of household income and wealth on learning outcomes

It is well-known that household income and wealth are one of the most critical components of well-being and can be considered as a more accurate indicator of the longer term economic resources of the family and family's access to opportunities and advantages. There is particularly strong evidence that improving in household wealth and income are likely to increase parental education, improved parents' to invesst in goods and services, and reduce parental depression, which is known to be important for children's outcome. In comparison to economic and non-economic shocks, Prado and Dewey (2014) point out that nutritional and health factors, and policy interventions factors, household income and wealth, parental education and children's experiences and environment are more important for long-term their brain functioning, cognition, behavior and productivity. A child's nutrition and health, and the child's parents' education, income and wealth can influence the child's time allocated for education and labor (keeping in mind that the income generated from child labor can be used for protecting families against the adverse effects of income

shocks) and the way in which the child interacts with the environment and the communities in which he or she lives.

A large number of studies on high-income countries have established that wealthier households tend to invest more in human capital for their children thus improving their educational performance and well-being (Cunha & Heckman, 2007; Kelly et al., 2011). Conley (2001) and Huang (2013) used the Panel Study of Income Dynamics (PSID) in the United States to investigate the effects of household wealth on child educational achievements and found that children from asset-rich households performed better in educational outcomes. Similarly, Kim and Sherraden (2011) used the National Longitudinal Study of Youth 1979 to assess the effect of household asset holding on educational achievements of high school and college students in the United States and found a positive relationship between household wealth and children's education. In particular, they found that homeownership and more financial assets had positive associations with child educational attainments.

There is evidence from cross-sectional studies in lower- and middle-income countries on how the household wealth index affects child development outcomes. For example, significant differences in early cognitive development between children of high- and low-socioeconomic backgrounds are evident as early as 3–23 months of age in India, Indonesia, Peru and Senegal (Fernald et al., 2012). Pre-school children (3–6 years old) in Ecuador, five Latin American countries and the four Young Lives survey countries (Ethiopia, India, Peru and Vietnam) show significant gaps in receptive language ability (Engle et al., 2011; Paxson & Schady, 2007; Schady et al., 2015). Unfortunately, studies in developing countries are limited by the lack of longitudinal data with repeated indicators of child educational outcomes across critical and sensitive periods. Single-year cross-sectional studies cannot untangle issues of timing where age effects are confounded with cohort effects and cannot investigate the role of early malnutrition and skills on later child educational development.

The limited available longitudinal research supports cross-sectional findings that show significant differences in early cognitive development between children with high and low socioeconomic backgrounds in low- and middle-income countries. This is documented by Hamadani et al. (2014) in Bangladesh for children from age 0 till 5 years; Schady et al. (2015) in Ecuador for children from age 3–5 years till 10–12 years; Galasso et al. (2017) in Madagascar for children from age 3–

6 years till 7–10 years; Macours et al. (2012) in Nicaragua for children from age 3–6 years till 6–9 years; and Lopez Boo (2014) in the Young Lives countries–Ethiopia, India, Peru and Vietnam—for children from 5 years till 8 years of age.

Studies in developing countries have shown that children born within the poorest 40 percent of families are 2.8 times more likely to be malnourished than those born in the richest 10 percent (UNICEF, 2013). They are also more likely to earn less than their better-off and better-nourished peers later in life (Cobham, 2013). Birhan (2010) investigated the correlation between child malnutrition and household economic status. He found that children in poor households, on average, were at a higher risk of having malnutrition/health problems as compared to children from rich households. Better-off households have better access to food and higher cash incomes than poor households, allowing them better diets, better access to medical care and more money to spend on essential non-food items such as health, clothing, schooling and hygiene products.

Coming to developing countries, Deng et al., (2014) used data from the 2002 China Household Income Project and found a significant causal relationship between parents' asset holdings and their children's educational achievements. Similar results were reported by Chowa et al., (2013) who used baseline data from a field experiment among Ghanaian youth. Their findings indicate that households that owned at least one of the five key assets considered as primary indicators of a households' socioeconomic status (television, refrigerator, electric iron, electric or gas stove and kerosene) outperformed other households in English test scores by at least one point.

Using data from rural Bangladesh for 1988, Foster (1995) examined how prices and credit markets affected children's growth. He found that a child's growth depended on the household's expenditure on food which was dependent on the household's income and access to credit. In particular, lack of access to credit can interfere with a household's efforts to smooth consumption intertemporally which can interrupt the household's ability to provide nutritious food and sufficient medical attention to a child during the first year of her or his life. He also found that diarrheal diseases reduced child weight gains and that food prices had a negative impact on weight.

Household heads and adult household members also play an important role in child health and malnutrition. Other related studies, including literature on intra-household allocations, show that when women have power over decisions about how to invest household incomes, they tend to spend it in ways that improve the health and education of their children (Quisumbing, 2003).

Quisumbing et al., (1995) also show that women played a critical role in meeting the nutritional needs of their families through food production, economic access to food and nutritional security. Thomas (1997) found that increasing women's control over income in households was associated with larger budget shares spent on a 'human capital' on aggregate and on health and education which are included in that aggregate and it also led to higher nutritional value in the food consumed which consequently led to a higher anthropometric status of children. Parents in developing countries not only play an important role in their children's early nutritional status, but also in their educational achievements. Alderman and King (1998) hypothesize that investments in early schooling may in part be determined by parental empathy and that in general mothers may be more concerned about their children. Parents in general and mothers in particular play an important role in early child nutrition, health and educational achievements.

Therefore, the impact of household wealth, nutrition and health on learning outcomes is also greatly attenuated when considering mediating factors. However, there is a broad disagreement on the role of the various linkages through which household wealth, child malnutrition and health impact learning outcomes at various ages and across different genders.

3.3 Child labor and educational performance

In recent years, in addition to the theoretical literature a substantial amount of empirical literature has also emerged that looks at the link between child work and educational outcomes. Children from disadvantaged families spend more time on paid work outside the household, unpaid work for the household (on family farms, cattle herding, shepherding or other family business), domestic chores (fetching water, firewood, cleaning, cooking, washing or shopping) and on caring for other household members (younger siblings, elderly or ill household members) as compared to advantaged children. This has negative consequences for school participation and educational attainments among disadvantaged children (Basu, 2017; Emerson et al., 2017; Gunnarsson et al., 2006; He, 2016; Holgado et al., 2014; Morrow et al., 2017; Thu Le & Homel, 2015). Gunnarsson et al., (2006) and Bezerra et al., (2009) used data from nine Latin American countries and cross-sectional Brazilian data respectively and found that working had a negative and significant effect on students' test scores.

Another study on children aged 7-14 years from 30 low- and middle-income developing countries by Putnick and Bornstein (2015) also found significant negative associations between different

kinds of child labor (working outside the home, family work and excessive household chores) and school enrolments with these associations being more consistent for family work and household chores than work outside the home. Le and Homel (2015) examined the impact of child labor on children's educational outcomes in rural Vietnam using the 1998 Vietnam Living Standard Survey. They found that that child labor lowered children's academic performance and this negative impact was bigger for girls. Likewise, He (2016) analyzed the link between child labor using the Gansu Survey of Children and Families (GSCF) in China, which provides multi-level data for two survey years: 2000 and 2004. He found that after controlling for a child's academic talent, over one hour per day of housework by the child in the earlier survey year negatively affected his/her academic achievements in the later survey year. A more recent study by Emerson et al., (2017) using panel data from São Paulo municipal schools also shows that child labor negatively impacted math and Portuguese-language proficiency scores among children.

3.4 Studies on the determinants of child malnutrition in Ethiopia

In Ethiopia various studies have investigated the impact of economic shocks (for example, droughts and food price inflation), non-economic shocks (for example, divorce and family separation) and policy interventions (for example, the safety net program put in place in 2005) particularly on child welfare outcomes (mainly, nutrition, health and cognition) (Alderman et al., 2006; Alderman & Walker, 2014; Debela & Holden, 2014; Dercon & Sanchez, 2008; Dercon & Porter, 2014; Berhane et al., 2015).

Most studies in this area have focused on the determinants of child malnutrition trends in Ethiopia (Berhane et al., 2017; Yamano et al., 2005). A few studies have also dealt with how children's learning outcomes in Ethiopia have been affected by negative shocks (like a drought, food-price inflation and family separation) and by Ethiopia's Productive Safety Net Program (PSNP) (Debela & Holden, 2014; Favara et al., 2016; Berhane et al., 2015). They have found that drought, food-price inflation and family separation reduced children's cognitive skills while the safety net program put in place in 2005 had positive and significant effects on mitigating the reduction in cognitive skills resulting from these shocks. More recently, using the Young Lives longitudinal dataset, Woldehanna et al., (2017) evaluated the effect of early stunting on children's cognitive achievements at the age of 8-years using propensity score matching (PSM). The authors found that keeping other confounding variables constant, early childhood stunting had a negative and statistically significant association with a child's cognitive skills. Although a number of studies in

Ethiopia have documented the irreversible impact of malnutrition on cognitive development, they do not cover the aspect that growth recovery is possible, and it is positively associated with cognitive achievements (Fink & Rockers, 2014; Georgiadis, 2017; Georgiadis et al., 2016, 2017).

4. Data and methodology

This paper uses two rounds of survey data from the Young Lives survey on the same children across survey waves living in 20 sentinel sites from five major Ethiopian regions (Addis Ababa, Amhara, Oromia, SNNP and Tigray).

4.1. Data source and descriptive statistics

The Young Lives survey is a national cohort longitudinal study on poverty and child well-being that has collected data on 12,000 children in four developing countries (Ethiopia, India, Peru and Vietnam).[14] The Young Lives project, funded by UK Aid of the Department for International Development (DFID) and co-funded by the Netherlands Ministry of Foreign Affairs, is a long-term international research project to investigate the changing nature of child poverty over 15 years in these four low-income countries. The project follows two birth cohorts in each country, that is, a younger cohort and an older cohort. The Young Lives project in Ethiopia follows the lives of 3,000 children. Starting with the first round in 2002, the project has followed two cohorts of children: the 'younger cohort' of 2,000 children aged around one-year in 2002 and the 'older cohort' of 1,000 children aged around 8 years in 2002. In addition to the first round, the project has also collected data from three more rounds on these children -- Round 2 in 2006-07 (aged 5 and 12 years), Round 3 in 2009 (aged 8 and 15 years) and Round 4 in 2013 (aged 12 and 19 years). My study uses data from Rounds 2 and 3 for both the cohorts.

The Young Lives survey uses multi-stage, purposive and random sampling to select two cohorts of children. Children from 20 sentinel sites (12 rural and eight urban) in five major regions (Addis Ababa, Amhara, Oromia, the Southern Nations, Nationalities and People's Region (SNNP) and Tigray, accounting for around 90 percent of the total population) were purposively sampled to represent the differences between regions in Ethiopia and between rural and urban areas in a balanced way though with a pro-poor bias. The selected areas provide a balanced representation of the Ethiopian geographical, cultural and regional diversity. Three to five sentinel sites were

[14] The Young Lives study can be found at www.younglive.org.uk

selected in each region with a balanced representation of poor and less-poor households and urban and rural areas, and from each sentinel site about the same number of children were sampled within each age cohort. Even though the Young Lives survey is not nationally representative and cannot be used for monitoring welfare indicators over time (for example, as in the Demographic and Health Survey and the Welfare Monitoring Survey, WMS), it is noted that the survey is an appropriate and valuable medium for modeling, analyzing and understanding the dynamics of child welfare and educational outcomes in Ethiopia (Outes-Leon & Sanchez, 2008).

This paper uses information on children who took the Peabody Picture Vocabulary Test (PPVT) in both the rounds (Rounds 2 and 3), with the score on that test being an indicator of a child's cognitive skills. PPVT is a widely-used test of receptive vocabulary that has a strong association with several measures of a child's cognitive skills and has also been used as an indicator of a child cognitive-skills in similar studies on Ethiopia (Debela & Holden, 2014; Favara et al., 2016; Berhane et al., 2015, 2017; Yamano et al., 2005). Data on PPVT scores are available for both cohorts in the second and third rounds only. To focus on the children's cognitive skills' development, I tracked the same children across survey waves to ensure that my aggregated figures were not merely capturing the entry and exit of different children from the sample. Therefore, I restricted the sample to only those children who appeared in Rounds 2 and 3 of the survey.

This paper categorizes the determinants of a child's cognitive skills under three headings: household characteristics, child characteristics and other control variables. The household characteristics include household size, the household wealth index and food and non-food expenditure per adult. The variables for child characteristics include a malnutrition indicator and age in months. Furthermore¸ I also used four regional dummy variables, for Oromia, Amhara, SNNP and Tigray as explanatory variables with Addis Ababa being the benchmark because it is the best performing region in terms of educational attainments and nutritional status.

To further control for confounding factors, this paper also includes as explanatory variables an urban dummy (taking a value of 1 if the child resides in an urban area and 0 otherwise); how much time the child spent respectively on paid activity, in domestic tasks, on caring for household members and on studying; and dummy variables on the type of school in which the child is enrolled, with public schools that are owned and funded by the government as the benchmark. The dummy variables are 'private school that is owned and funded by private individuals' and 'other

religious school that is owned by religious institution like Catholic, Orthodox, Protestant, Muslim, churches and funded by the respective institutions.' Table 4.1 presents the list of variables used.

Table 4.20: Explanatory variables used in the empirical analysis

Variables	Type	Description
Dependent variable		
Peabody Picture Vocabulary Test (PPVT)	Continuous	Vocabulary test score of each child is a proxy for the child's cognitive skills
Independent variables		
Height-for-age z-score (zhfa)	Continuous	zhfa is measured in terms of standard deviations and shows long-term or cumulative growth deficiencies in child nutrition and health.
Wealth index	Continuous	The household wealth index is constructed using principal component analysis on housing quality, access to services, and ownership of consumer durables.
Child's age in months	Continuous	The age of the child measured in months at the time of interview
Monthly expenditure on food	Continuous	Food expenditure per adult per month, in 2006 Birr,[15] adjusted for adult-equivalence based on nutritional (caloric) requirements
Monthly expenditure on non-food items	Continuous	Non-food expenditure per household member in one month
Household size	Continuous	The number of people living in one house
Female household head	Dummy	1= Female, 0= Male
School type that the child is enrolled in	Dummy	1= public school, 2= private school 3= other religious schools
Addis Ababa	Dummy	HH lives in Addis Ababa
Amhara	Dummy	HH lives in Amhara
Oromia	Dummy	HH lives in Oromia
SNNP	Dummy	HH lives in SNNP
Tigray	Dummy	HH lives in Tigray
Urban	Dummy	1= Urban. 0= Rural
Female	Dummy	1= Female, 0= Male
Muslim	Dummy	1= if the child's religion is Muslim, 0= otherwise
Orthodox	Dummy	1= if the child's religion is Christian, 0= otherwise
Others	Dummy	1= if out of the above two, 0= otherwise
Time spent in paid activity	Continuous	Hours spent on paid activity per day
Time spent doing domestic tasks	Continuous	Hours spent on unpaid household activity per day
Time spent caring HH	Continuous	Hours spent on caring for household members per day
Time spent studying	Continuous	Hours spent on study per day

[15] Birr is the Ethiopian currency.

Before identifying the major determinants of cognitive skills, it is worthwhile to see the sample size, levels, trends and gaps in the PPVT scores and other explanatory variables. Table 4.2 gives the sample size in each round disaggregated across regions after cleaning the dataset for missing variables and creating a balanced dataset based on the child identification code. There are 1,792 children from the younger cohort and 444 children from the older cohort included in this study.

Table 4.21: Sample size by region over time (survey rounds)

Cohort	Round	Regions					**Total**
		Addis Ababa	Amhara	Oromia	SNNP*	Tigray	
Younger cohort	2	260	369	361	445	357	**1,792**
	3	258	369	364	444	357	**1,792**
	Total	**518**	**738**	**725**	**889**	**714**	**3,584**
Older cohort	2	138	178	27	100	1	**444**
	3	143	178	29	94	nd	**444**
	Total	**281**	**356**	**56**	**194**	**1**	**888**

Note: SNNP = Southern Nations, Nationalities and Peoples, which is one of the regional states in Ethiopia. nd = no data.

Table 4.3 presents the definitions and summary statistics of the variables used in the empirical analysis for each cohort. As expected, cognitive development improved with age. The data shows that the average PPVT score was around 21 and 80 in the younger cohort in Rounds 2 and 3 respectively. The PPVT scores increased to 82 and 155 in the older cohort for each round respectively.

Household characteristics include a wealth index, food and non-food expenditure (used as proxies for household income), household size and gender of household head. The wealth index takes on values between 0 and 1 based on a weighted average of the three indices for housing quality,[16] access to services,[17] and ownership of consumer durables,[18] with the weightage based on principal

[16] The housing quality index was calculated as a simple average of a 0-to-1 crowding index and an index for material for walls and an index for materials for the roof and floor (the latter two indices are dummy variables that take the value of 1 if the main material used satisfies basic quality norms).

[17]The index on access to services was estimated from a simple average of indices on access to a variety of services: electricity, safe drinking water, sanitation and adequate fuel for cooking.

[18] The consumer durables index was obtained from a simple average of a set of dummy variables regarding ownership of various items, taking the value of 1 if a household owned the item. Ten common items were

component analysis to assign a weight to each sub-index based on its relative contribution to total variance.[19] These indices were estimated consistently across rounds including variables that were common in both the rounds only.

In Round 2, the mean value of the wealth index in the younger cohort was 0.29; it was 0.34 in the older cohort. By Round 3, the mean value of the index had increased to 0.33 for the younger cohort and to 0.38 for the older cohort. Similarly, the household food and non-food expenditure showed an increase between the two rounds from 414 Birr to 820 Birr in the younger cohort and from 414 to 844 Birr in the older cohort. The average household size was about six children in both cohorts in each round.

Whether a child lived in an urban or rural setting and the type of school he/she was enrolled in (public, private or 'other religious' schools) can help account for the differences in educational quality particularly in Ethiopia. As shown in Table 4.3, around 40 percent of the children were from urban areas in the younger cohort while 57-59 percent in the older cohort were from urban areas. Regarding child nutrition and health indicators, 31 percent of the children in the younger cohort were stunted (8 percent severely) in the second round when they were 5 years of age, and in Round 3 three years later, 21 percent of these children were stunted (5 percent severely). Likewise, in the older cohort 24 percent of the children were stunted (7 percent severely) in the second round when they were 12 years of age, and in Round 3 three years later, 21 percent of these children were stunted (3 percent severely). The summary descriptive statistics for each cohort at the regional level are presented in Table A9 in the Appendix.

considered (radio, television, bicycle, motorbike, automobile, landline phone, mobile phone, table and chair, sofa and bedstead) in the estimation of the consumer durables index.

[19]Principal component analysis (PCA) is constructed using the pca2 STATA command in panel data.

Table 4.22: Summary of descriptive statistics for each cohort

Variable	Younger cohort				Older cohort			
	Round-2 (Age 5)		Round-3 (Age 8)		Round-2 (Age 12)		Round-3 (Age 15)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Educational performance of the child								
PPVT raw score	21.21	12.13	79.62	44.31	82.33	25.41	154.9	35.26
Household characteristics								
Female head	0.19	0.39	0.19	0.39	0.29	0.45	0.30	0.46
Household size	6.04	2.06	6.19	1.98	6.09	2.01	6.00	2.13
Wealth index	0.29	0.18	0.33	0.18	0.34	0.18	0.38	0.18
Monthly expenditure on food per adult, in Birr	413.5	297.5	820.0	537.9	413.9	262.3	843.6	488.2
Monthly expenditure on non-food per capita, in Birr	258.7	362.2	475.64	629.34	286.99	422.76	597.13	707.52
Child characteristics and malnutrition indicators								
Female	0.47	0.50	0.47	0.50	0.51	0.50	0.51	0.50
Age - in months	62.37	3.78	97.45	3.69	145.44	3.70	180.74	3.59
Height-for-age z-score (zhfa)	-1.47	1.08	-1.25	1.06	-1.20	1.33	-1.22	1.31
Weight-for-age z-score (zwfa)	1.37	0.90	1.65	0.94	Nd	nd	nd	nd
BMI-for-age z-score (zbfa)	0.63	1.08	1.28	1.01	1.61	1.23	1.56	1.28
Stunted (< -2 SD of zhfa)	0.31	0.46	0.21	0.41	0.24	0.43	0.21	0.41
Severely stunted (< -3 SD of zhfa)	0.08	0.27	0.05	0.22	0.07	0.25	0.03	0.29
Underweight	0.24	0.43	0.35	0.48	Nd	nd	nd	nd
Severely underweight (<-3 of zwfa	0.04	0.19	0.07	0.26	Nd	nd	nd	nd
Thinness (<-2 zbfa)	0.08	0.28	0.21	0.41	0.39	0.49	0.38	0.49
Sever thinness (<-3zbfa)	0.02	0.14	0.04	0.20	0.11	0.32	0.14	0.35
Regional dummy and residence dummy (urban=1)								
Amhara	0.21	0.40	0.21	0.40	0.40	0.49	0.40	0.49
Oromia	0.20	0.40	0.20	0.40	0.06	0.24	0.07	0.25
SNNP	0.25	0.43	0.25	0.43	0.23	0.42	0.21	0.41
Tigray	0.20	0.40	0.20	0.40	Nd	nd	nd	nd
Addis Ababa	0.15	0.35	0.14	0.35	0.31	0.46	0.32	0.47
Urban	0.40	0.49	0.40	0.49	0.57	0.50	0.59	0.49

Note: SNNP = Southern Nations, Nationalities and Peoples. It is one of the national states in Ethiopia. nd = no data reported.

Table 4.4 presents characteristics of the older and younger cohorts by quartiles in Rounds 2 and 3 for the child PPVT score, which acts as a proxy for child's cognitive skills; the household wealth index; and the child nutrition-and-health indicators (the height-for-age z-score and the BMI-for-

age z-score). The results in this table indicate that between the two rounds for both cohorts, children's cognitive skills improved along with both the household wealth index and the child nutrition and health indicators.

Table 4.23: The mean and quartile distribution by cohort for PPVT score, child nutrition-and-health indicators, and wealth index

Round	Variables	Younger cohort				Older cohort			
		Mean	p25	p50	p75	Mean	p25	p50	p75
2	PPVT score	21.2	14.0	19.0	26.0	82.3	61.0	83.0	106.0
	Height-for-age z-score	-1.5	-2.2	-1.5	-0.7	-1.2	-2.0	-1.2	-0.4
	BMI-for-age z-score	0.6	0.0	0.6	1.3	1.6	0.8	1.7	2.5
	Wealth index	0.3	0.1	0.3	0.4	0.3	0.2	0.3	0.5
3	PPVT score	79.6	45.0	66.0	106.5	154.9	132.5	168.0	182.5
	Height-for-age z-score	-1.2	-1.9	-1.2	-0.6	-1.2	-1.9	-1.1	-0.4
	BMI-for-age z-score	1.3	0.7	1.3	1.9	1.6	0.7	1.6	2.5
	Wealth index	0.3	0.2	0.3	0.4	0.4	0.3	0.4	0.5

Source: Author's calculations based on the Young Lives dataset for Ethiopia.

Table 4.5 presents the pairwise correlations of educational performance and other variables. The first column shows the correlation between the standardized PPVT raw scores and various determinants of educational performance. The remaining columns show the correlations among the determinants.

The correlations between the PPVT raw scores and the household wealth index, the height-for-age z-scores, monthly food expenditure, monthly non-food expenditure, time spent studying and time spent at school are all positive. On the other hand, the PPVT-raw-score correlations with children's time spent on domestic tasks and time spent caring for household members are negative. These correlations are consistent with most of the existing studies on cognitive skills or educational performance. Moreover, the joint multicollinearity based on the variance inflation factor (VIF) reported in the last row of Table 4.5 shows that there is no problem of multicollinearity among the explanatory variables included in the regression. VIF is calculated based on the coefficient of determination obtained from the regression of one explanatory variable on the other remaining explanatory variables.

Table 4.24: Pairwise correlations of selected variables with PPVT raw scores and VIF

Variables	1	2	3	4	5	6	7	8	9
1. PPVT raw scores	1								
2. Height-for-age z-score	0.31*	1							
3. Wealth index	0.40*	0.26*	1						
4. Age in month	0.74*	0.09*	0.16*	1					
5. Food expenditure	0.41*	0.16*	0.35*	0.22*	1				
6. Non-food expenditure	0.43*	0.24*	0.64*	0.19*	0.58*	1			
7. Time spent in domestic	-0.11*	-0.07*	-0.29*	0.06*	0.05*	-0.17*	1		
8. Time spent caring HH	-0.07*	-0.10*	-0.19*	0.02	-0.03	-0.12*	0.02	1	
9. Time spent at school	0.54*	0.28*	0.45*	0.42*	0.31*	0.40*	-0.19*	-0.17*	1
10.Time spent studying	0.55*	0.21*	0.30*	0.55*	0.19*	0.29*	-0.16*	-0.12*	0.6*
VIF	-	1.12	1.69	1.62	1.52	1.73	1.06	1.19	1.85

Note: * represents 5 percent level of significance.

Source: Author's calculations based on the Young Lives survey dataset for Ethiopia's STATA results. The data are pooled over both cohorts in the second and third rounds.

4.2 Theoretical framework and econometrics methodology

This section provides an analytical framework for modeling how children's cognitive skills are affected by malnutrition and other socioeconomic indicators at different age levels and how changes in these variables over time are related to each other for the younger and the older cohorts separately. I employed the longitudinal data provided by the Young Lives survey on child anthropometrics, cognitive skills, socioeconomic variables and child time allocations.

The structural equations that I estimated using a parametric framework of an educational production function for early childhood development are similar to those used previously in economics literature (Glewwe, 2005; Glewwe & Miguel, 2007; Todd & Wolpin, 2003, 2007). These equations are estimated for different age groups in each round and when I use longitudinal data I use for each cohort the first differences between rounds in some variables. In this framework, the household is an economic unit that buys commodities for consumption and allocates household resources and time to produce goods and services at work and at home. Child characteristics that have a direct or indirect impact on the child's cognitive skills are included as explanatory variables for PPVT scores as are variables on the child's regional location and whether the child resides in an urban area.

The educational production function developed by Todd and Wolpin (2007) is commonly used in the literature on human capital, child cognitive achievements and education with some minor modifications. For example, the early childhood educational production function has been used in studies linking parents' socioeconomic status, parenting skills, child time allocation and child poverty to cognitive skills (Jenkins & Handa, 2017; Schady et al., 2015; Segretin et al., 2016) in studies looking at the impact of household-income shocks and productive safety net programs on child cognitive achievements in Ethiopia (Debela & Holden, 2014; Favara et al., 2016; Berhane et al., 2015, 2017) and in studies investigating parental investments in children's educational attainments (Attanasio et al., 2017). The model that I use adopts relationships considered by the previous studies with a general production function for child cognitive skills written as:

$$CS_{it} = f_t\left(chh_{it}, cdh_{it}, X_{it}, \mu_i, \varepsilon_{it}\right) \quad (1)$$

where the subscript i denotes a specific child, the subscript t indicates the round of the survey (time), CS_{it} represents the cognitive skills measured by the PPVT score, chh_{it} is a vector of parental/household characteristics, chd_{it} is a vector of various child characteristics, X_{it} is a vector of other observable explanatory variables, μ_{it} are unobserved individual child characteristics relevant in determining mental capacity and ε_{it} is the error term.

The linearized equation to be estimated in two separate single-round cross-sections is:

$$CS_{it} = \beta_o + \beta_1 chh_{it} + \beta_2 cdh_{it} + \beta_3 X_{it} + \varepsilon_{it}\,. \quad (2)$$

with the survey round, *t*, being constant, equal to either 2 or 3 (for Round 2 or 3 respectively). The exclusion of μ_i is a relevant issue which is discussed later. The vector of parental/household characteristics includes age of household head, gender of head, education of head and the household wealth index. The vector of various child characteristics includes an anthropometric indicator of the child's nutrition-and-health status, a dummy variable for the child's gender and variables for the child's time allocations: time spent in paid activity, time spent on domestic tasks, time spent in caring for household members and time spent studying. The various explanatory variables in X_{it}, include regional dummies (with Addis Ababa as the base line), an urban dummy

for whether the child resides in an urban area or not and dummies on the type of school in which the child is enrolled (a private school dummy and an 'other religious school' dummy with public school as the base line). The primary coefficients of interest are those for an anthropometric variable, specifically the height-for-age z-score, and the household wealth index indicator from household characteristics. Separate cross-sectional models were estimated by OLS to assess the potential associations in the younger cohort when the child is 5-years old and when he or she is 8-years old and the potential associations in the older cohort when the child is 12-years old and when he or she is 15-years old.

In line with previous studies (Crookston et al., 2010; Sanchez, 2009) and the reviewed literature in Sudfeld et al. (2015), I present the OLS estimates in Eqn. (2) to provide a deeper insight into how malnutrition, the household's socioeconomic status and other control variables affect a child's cognitive skills in various age categories under given assumptions. However, OLS estimates are biased and inconsistent if at least one of the regressors is correlated with the error term. An endogeneity problem occurs when the error term in Eqn. (2), ε_{it}, contains unobservable variables and explanatory variable with measurement errors are correlated with one of the regressors. For example, a child's immunity to diseases and his or her health could be a result of parental decisions that affect his or her well-being and success (including in education). These decisions impact both the child's performance in school and his or her nutritional status. Therefore, the anthropometric variable, as well as the household wealth index variable may be endogenous (that is, $E\left(\varepsilon_{it} \mid cnh_{it}, hwi_{it}\right) \neq 0$, where cnh_{it} and hwi_{it} are vectors of anthropometric and household wealth index variables respectively), which will bias the cross-sectional estimates. Failure to account for this possible endogeneity will lead to an overestimation of the impact of nutrition and health children's school performance. There are several situations under which some of the core explanatory variables including the household wealth index would be expected to be correlated with the child unobserved individual heterogeneity term μ_i.

To deal with this endogeneity, a standard linear panel model can be used to estimate the relationship between child health and nutrition and school performance more correctly after controlling for other variables. In panel analysis, it is possible to control for the presence of unobserved individual-specific fixed effects even without observing them. It is also possible to test

for the significance of the unobserved heterogeneity based on correlations of residuals with included explanatory variables. Panel data analysis also allows us to study individual behavior in a repetitive environment by considering the unobserved heterogeneity and endogeneity problem (Baltagi, 2008; Cameron & Trivedi, 2009). From the panel estimation techniques, the fixed-effects estimator is an appropriate technique to handle the unobserved heterogeneity and endogeneity problem, leading to coefficients that are consistently estimated as long as the idiosyncratic errors are uncorrelated with the regressors. However, one of the limitations of this estimator is that for time-invariant variables (like the child's gender, religion, region, school type and urban (or not) residence) the observed characteristics cannot be identified as they are dropped through the within transformation.

In general, when a panel has two periods (rounds in our case) re-estimating the same equation with first differences in all the variables and without a constant term, that is, estimating

$$\Delta CS_i = \beta_1 \Delta hhc_i + \beta_2 \Delta cdh_i + \beta_3 \Delta X_i + \Delta \varepsilon_i \qquad (3)$$

where Δ is the first-difference operator (between Rounds 2 and 3), gives identical results to fixed-effect results and both methods handle the problem of unobserved heterogeneity since $\Delta \mu_i = 0$ (at least given that this unobserved heterogeneity is constant over time). However, there is more flexibility with a first-difference model than the standard fixed-effects model, in that time-invariant variables can also be included as explanatory variables.

The basic first-differences model depicted in Eqn. (3) is extended to consider also the effects of time-invariant child characteristics and other time-invariant control variables as:

$$\Delta CS_i = \beta_0 + \beta_1 \Delta hhc_i + \beta_2 \Delta cdh_i + \beta_3 \Delta X_i + \beta_4 hhc_{i2} + \beta_5 cdh_{i2} + \beta_6 X_{i2} + u_i \qquad (4)$$

where in addition to the explanatory variables shown in Eqn. (3), values for *hhc*, *cdh* and the *X* vector in Round 2 (indicated by second subscript '2') are included along with an intercept, allowing us to see how changes in cognitive skills are affected by the initial (Round 2) levels of the variables.

5. Results and findings

I estimated cross-sectional models based on Eqn. (2) using OLS regressions to examine the impact of child nutrition and health, household wealth and other control variables on children's cognitive skills at different ages; the estimates are presented in Table 4.6. The coefficient of the height-for-age z-score variable (the child nutrition and health indicator) has the expected sign and is statistically significant at the 1 percent level in the younger cohort, implying that children's educational performance improved with their nutrition and health levels in early ages (5 and 8 years). A 1 unit increase in the height-for-age z-score led to an improvement in the PPVT scores by 1.08 units for 5-year-olds and by about 5.17 units for 8-year-olds, all else constant. In contrast, the height-for-age z-score had an insignificant but a positive effect on PPVT scores for 12-year-olds and 15-year-olds. The coefficient estimate for the age of the child is positive and statistically significant at the 1 percent level for all of the four age levels considered (note: there is some variation in age in months within each age level).

My results also show that children from richer households performed better in educational outcomes than children from poorer households in all age categories across both rounds, all else equal. Moreover, food and non-food expenditure of the household (per adult) had positive and significant impacts on children's cognitive skills in the younger cohort. Both food and non-food expenditure are a good proxy of the living standard of the household. This result is consistent with the coefficient estimates for the child nutrition indicator and the household wealth index, that is, food and non–food expenditure is vital for developing cognitive skills in the early years of a child's life.

All the coefficient estimates for the urban-residence dummy across all four age groups are positively significant, implying that children who live in urban areas have better cognitive skills than children in rural areas. Likewise, in comparison with the base-line region, Addis Ababa, all other regions have children in the lower three age groups performing significantly lower in cognitive skills. This is a well-known phenomenon which is usually attributed to the capital having the best private schools and better access to education materials, along with it being able to attract the best teachers from other regions.

Table 4.25: Cross-section OLS regression results of each cohort in each round and age

Independent Variables	Dependent variable: Cognitive skills (PPVT z-score)							
	Younger cohort				Older cohort			
	Age-5 Round-2		Age-8 Round-3		Age-12 Round-2		Age-15 Round-3	
	(1)		(2)		(3)		(4)	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Height-for-age z-score	1.08**	(0.50)	5.17***	(1.50)	1.36	(1.18)	1.6	(1.78)
(Height-for-age z-score)^2	0.11	(0.14)	0.73*	(0.42)	0.13	(0.28)	-0.21	(0.42)
Wealth index	0.80***	(0.29)	5.77***	(0.97)	1.74*	(1.04)	6.64***	(1.33)
Child's age in month	0.61***	(0.07)	2.52***	(0.22)	0.95***	(0.25)	0.72**	(0.35)
Monthly food expenditure	0.002*	(0.00)	0.005**	(0.00)	0.008*	(0.00)	0.0003	(0.00)
Monthly non-food expenditure	0.005***	(0.00)	0.007***	(0.00)	0.005*	(0.00)	-0.001	(0.00)
Household size	-0.31**	(0.13)	-1.23***	(0.47)	-0.88*	(0.48)	-1.10*	(0.66)
Mother's education	0.056*	(0.03)	0.078	(0.09)	0.12	(0.10)	0.061	(0.13)
Region dummies, Addis Ababa as base line								
Amhara	-10.8***	(1.05)	-28.9***	(3.64)	-12.8***	(3.29)	-5.21	(4.69)
Oromia	-7.15***	(1.00)	-39.2***	(3.51)	-11.5***	(4.25)	-1.41	(5.80)
SNNP	-4.84***	(1.02)	-15.1***	(3.57)	-5.99*	(3.31)	2.08	(4.67)
Tigray	-8.44***	(1.04)	-22.5***	(3.58)	nd	nd	Nd	nd
School dummies, public school as base line								
Private school	1.6**	(3.18)	12.4***	(4.56)	9.14**	(3.95)	13.124**	(6.87)
Other religious school	4.86	(3.81)	6.51	(4.98)	5.14	(4.86)	3.79	(4.88)
Urban	1.99**	(0.79)	7.87***	(2.58)	15.5***	(3.09)	19.5***	(4.10)
Female	-0.85*	(0.50)	-0.86	(1.80)	-4.06**	(1.94)	-12.9***	(3.06)
Religion dummies, Muslim as base line								
Orthodox	3.75***	(0.86)	7.61***	(2.79)	2.3	(3.03)	11.9***	(4.17)
Others	3.08***	(0.97)	4.77	(3.16)	4.39	(4.14)	14.0**	(5.76)
Time spent in paid activity	0.53	(1.50)	-3.01	(3.66)	-1.17	(1.26)	-1.77**	(0.88)
Time spent on domestic tasks	-0.13	(0.22)	-1.51***	(0.45)	-1.54***	(0.58)	-2.63***	(0.85)
Time spent in caring HH	-0.11	(0.26)	-1.50**	(0.71)	0.084	(1.06)	-2.96*	(1.61)
Time spent studying	3.21***	(0.73)	6.44***	(1.01)	0.74	(1.02)	1.04	(1.12)
Constant	-12.9***	(4.36)	-151***	(25.60)	-39.8	(39.90)	41.3	(66.00)
Number of observations	1646		1593		443		443	
R^2	0.29		0.45		0.51		0.5	
Adjusted R^2	0.29		0.45		0.49		0.48	

Note: ***, **, and * represent a 1 percent, 5 percent and 10 percent level of significance respectively. Standard errors are shown in parentheses. nd means that there was no data available.

Table 4.6 also shows that being a female is negatively associated with cognitive skills at the late ages of 12 and 15 years. An explanation for this is that females face the double burden of performing household chores (for example, cleaning, cooking, childcare and collecting water and firewood) and performing agricultural activities such as sowing, harvesting and livestock maintenance, which negatively affect their educational performance. Similarly, when children in the 15-years age group increase the hours that they work in paid labor, their achievement scores significantly decrease at the 1 percent level. All else equal, an additional hour spent on domestic tasks (farming and farm business) lowers the PPVT scores by about 1.51 units when the child's age is 8 years and by about 1.54 and 2.63 units when the child's age is 12 and 15 years.

I also tried to take advantage of the panel nature of the Young Lives dataset. As noted in the previous section, re-estimating the same equations with first differences in all the variables and without a constant term gives results identical to fixed-effects results and both methods handle the problem of unobserved heterogeneity.[20] However, there is more flexibility with a first-difference model than the standard fixed-effects model in that time-invariant variables can also be included as explanatory variables. In the first-difference regressions presented in Table 4.7, based on Eqn. (4), changes in a child's cognitive skills are regressed not only on changes of the time-varying variables but also on the initial (Round 2) values for the height-for-age z-score, the wealth index, child's age and household size, and on time-invariant variables like urban (or not) residence of the child, gender of the child and regional dummies. The results are reported in Table 4.7 for the young and older cohorts separately.

Like the results in Table 4.6, the results in Table 4.7 show that in the younger cohort all the nutritional indicators -- Δ height-for-age z-score, height-for-age z-score in Round 2 and Δ (height-for-age z-score)^2 have coefficient estimates that are positive and significant, but the analogous coefficient estimates are statistically insignificant in the older cohort. The implication for the younger cohort is that for every one standard-deviation increase in the change in height-for-age between Rounds 2 and 3 increasingly improves PPVT scores and a one standard-deviation increase

[20] The estimation results from pooled ordinary least squares, random-effects and fixed-effects regressions for the determinants of child educational performance in Ethiopia are given in Columns 1-3 of Table A4 in the Appendix. The Breusch and Pagan Lagrangian multiplier (with p-value of 0.000) and the robust Hausman tests (with p-value of 0.000) reject the pooled ordinary least squares and the random-effects and favour the fixed-effects model.

in the initial (Round 2) height-for-age also improves PPVT scores between the rounds for any given change in the height-for-age between the rounds. These results are consistent with most of the previous studies in the area (Dercon & Sanchez, 2008; Berhane et al., 2015, 2017; Shekar et al., 2016). A possible explanation for the insignificant effect of child nutrition on educational outcomes for the older cohort could be that anthropometric measures are better indicators of child nutrition and health at younger ages than at older ages.

As shown in Table 4.7 a change in household wealth and the initial household wealth index level shows significant and positive relationships with the change in a child's cognitive skills (between-round changes in the PPVT scores) in both the younger and older cohorts. This is similar to the cross-sectional results. These results are in line with other studies such as that by Deng et al. (2014) who used data from the China Household Income Project in 2002 and Chowa et al. (2013), who found that there was a significant positive association between parents' asset holdings and a children's educational outcomes in Ghanaian youth.

As the results given in Table 4.7 show, all the regional dummies except those for SNNP have significantly negative coefficient estimates for the younger cohort. This implies that all else equal, the change in cognitive skills in the lower-aged cohort (5 to 8 years of age between the rounds) was lower in Amhara, Oromia and Tigray as compared to Addis Ababa. Similarly, improvements in cognitive skills in urban areas were higher than in rural areas in the younger cohort. In the older cohort, females' cognitive skills changed slowly as compared to their male counterparts.

Furthermore, the results in Table 4.7 also show that children enrolled in private schools as compared to public schools had significantly faster improvements in their cognitive skills between rounds, all else equal. Likewise, a greater change in a child's age (in months) between Rounds 2 and 3 had a positive and significant impact on his or her educational performance in both the younger and the older cohorts. For the younger cohort the age of the child in Round 2 also had a positive and significant impact on the change in his/her educational performance. Furthermore, the estimated magnitudes of the coefficients for the type-of-school and child-age variables varied substantially across the two cohorts but their signs are consistent with the cross-sectional regression results in Table 4.6 for each round in the younger and older cohorts.

Among the other control variables, a faster increase in household monthly expenditure on non-food items had a positive effect on how quickly a child's cognitive skills improved in the younger cohort, suggesting that greater household income has a positive effect on a child's school performance. Similarly, a faster increase in household size had a negative impact, statistically significant at the 10 percent level, on how quickly a child's cognitive skills improved in the younger cohort. One possible explanation for this is that, all else equal, as a household increases in size it is less likely to be able to provide adequate food and necessary educational material to its children due to the costs of having more family members.

Table 4.26: Regression results using between-round variable changes in variables for each cohort

Independent variables	Dependent variable: Change in cognitive skills			
	Younger cohort		Older cohort	
	Coef.	SE	Coef.	SE
Δ Height-for-age z-score	7.61***	(2.19)	-0.69	(2.15)
Height-for-age z-score	3.95***	(1.24)	0.49	(1.17)
Δ (Height-for-age z-score)^2	2.03***	(0.66)	-0.2	(0.39)
Δ Wealth index♠	4.36***	(1.48)	3.15*	(1.64)
Wealth index	5.17***	(1.22)	3.92***	(1.46)
Δ Child's age in months	2.90***	(1.07)	3.79***	(1.21)
Child's age in months	2.09***	(0.28)	0.019	(0.36)
Δ Monthly expenditure on food	0.003	(0.00)	0.0026	(0.00)
Δ Monthly expenditure on non-food items	0.005**	(0.00)	-0.003	(0.00)
Δ Household size	-1.54*	(0.84)	-0.29	(0.85)
Household size	-0.94	(0.61)	-0.67	(0.76)
Female household head	2.68	(2.72)	5.24*	(3.01)
School dummies, public school as base line				
Private school	12.3***	(3.89)	13.5*	(7.14)
Other religious school	4.23	(4.33)	8.47	(5.36)
Region dummies, Addis Ababa as base line				
Amhara	-18.7***	(4.25)	8.47*	(4.80)
Oromia	-33.0***	(4.07)	7.94	(5.80)
SNNP	-1.83	(4.21)	3.26	(4.77)
Tigray	-13.5***	(4.21)	Nd	nd
Urban	11.3***	(3.08)	4.33	(4.32)
Female	0.7	(2.10)	-9.31***	(2.88)
Religion dummies, Muslim as base line				
Orthodox	-0.41	(3.82)	4.38	(4.40)
Others	-2.29	(5.11)	7.32	(5.87)
Time spent in paid activity			-2.14**	(0.91)
Time spent on domestic tasks			-0.95	(0.89)
Time spent in caring HH			0.28	(1.70)
Time spent studying			0.18	(1.16)
Constant	-160.2***	(46.00)	-75.7	(73.30)
Number of observations	1202		440	
R^2	0.28		0.19	
Adjusted R^2	0.27		0.14	

Note: ***, **, and * represent a 1 percent, 5 percent and 10 percent level of significance. Standard errors are shown in parentheses. Δ shows the difference between the two rounds and explanatory variables without a Δ use information from Round 2. ♠ indicates that the wealth index is from PCA. nd refers to no data.

In addition to the aggregated wealth index, I also analyzed how alternative household wealth indices (indices for housing quality, access to services and consumer durables) are associated with child cognition, which has rarely been done in previous studies. Table 4.8 presents the results for selected coefficient estimates with the full regression results given in Table A5 in the Appendix for both the cohorts.

The results in Table 4.8 show that the alternative wealth indices had different effects on children's cognitive skills. In the younger cohort, the coefficient estimates for the household consumer-durables variables (the initial Round 2 index level and the changes between Rounds 2 and 3) are both significantly positive and these coefficient estimates are stronger in magnitude than the analogous coefficient estimates if the housing-quality variables or access-to-services variables are used instead. The household consumer durables index includes household expenditure on tools and equipment, on radio and television, on landlines and mobile phones and on transportation (from bicycles to automobiles). Such expenditure clearly has both direct and indirect impacts on children's school achievements. Ownership of consumer durables indicates the richness of a household in developing countries like Ethiopia, and children from richer families arguably should have access to better education than their poorer counterparts, leading to large positive effects on child educational performance and future earnings. Also, ownership of more consumer durables is arguably associated with a higher level of education for the parents and well-educated parents have higher awareness about the quality of life that indirectly raises their children's cognitive abilities.

Furthermore, families that have access to information through radio and television, telecommunication and transport have more knowledge about the importance of nutrition for children. In particular, when a mother knows about the importance of nutrition and applies that knowledge, it has both direct and indirect impacts on her child's cognitive skills by affecting that child's nutrition and health. In the older cohort, however, the coefficient estimates for the housing-quality variables (the initial Round 2 index level and the changes between Rounds 2 and 3) are both significantly positive and these coefficient estimates are stronger in magnitude than the analogous coefficient estimates if access-to-services or consumer-durables variables are used instead.

Table 4.27: Regression results using between-round variable changes and alternative wealth indices

Independent variables	Dependent variable: Change in cognitive skills of the child							
	Younger Cohort							
	1		2		3		4	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Δ Height-for-age z-score	7.01***	(2.19)	8.70***	(2.19)	8.52***	(2.19)	7.85***	(2.17)
Height-for-age	3.73***	(1.24)	4.44***	(1.24)	4.20***	(1.23)	3.47***	(1.23)
Δ (Height-for-age z-score)^2	1.88***	(0.66)	2.18***	(0.66)	2.26***	(0.66)	2.11***	(0.65)
Δ Wealth index	34.7***	(11.50)						
Wealth index	39.2***	(9.65)						
Δ Housing quality			11	(8.47)				
Housing quality			10.4	(7.24)				
Δ Access to services					12.0**	(6.08)		
Access to services					16.0**	(6.58)		
Δ Consumer durables							29.7***	(9.46)
Consumer durables							43.6***	(8.26)
Δ Child's age in months	3.07***	(1.07)	2.99***	(1.08)	2.97***	(1.08)	3.61***	(1.07)
Child's age in months	2.04***	(0.28)	2.12***	(0.29)	2.12***	(0.29)	2.11***	(0.28)
Number of observations	1202		1207		1204		1209	
R^2	0.29		0.27		0.28		0.29	
Adjusted R^2	0.28		0.26		0.26		0.28	
	Older Cohort							
Δ Height-for-age z-score	-0.71	(2.15)	-0.93	(2.14)	-0.43	(2.17)	-0.45	(2.17)
Height-for-age	0.6	(1.16)	0.8	(1.14)	0.79	(1.17)	0.96	(1.17)
Δ (Height-for-age z-score)^2	-0.19	(0.39)	-0.26	(0.39)	-0.14	(0.39)	-0.14	(0.39)
Δ Wealth index	26.2**	(12.70)						
Wealth index	34.4***	(11.50)						
Δ Housing quality			20.3**	(9.48)				
Housing quality			37.5***	(9.09)				
Δ Access to services					11	(7.07)		
Access to services					14.4*	(7.76)		
Δ Consumer durables							15.8	(11.20)
Consumer durables							9.3	(10.50)
Δ Child's age in months	3.71***	(1.21)	3.88***	(1.19)	3.77***	(1.21)	3.65***	(1.22)
Child's age in months	0.042	(0.36)	-0.042	(0.36)	0.038	(0.36)	-0.0049	(0.36)
Number of observations	440		440		441		441	
R^2	0.18		0.2		0.17		0.17	
Adjusted R^2	0.14		0.15		0.13		0.12	

Note: ***, **, and * represent a 1 percent, 5 percent and 10 percent level of significance. These results are extracted from the full regression results presented in Table A5 in the Appendix. Δ shows the difference between the two rounds and explanatory variables without a Δ use information from Round 2.

6. Conclusions and policy recommendations

Over the past decades, governments and international organizations around the world have started recognizing the importance of child malnutrition and health for labor productivity and a country's economic prosperity. Malnutrition is one of the biggest risk factors for illnesses and the burdens of diseases, particularly in developing countries. Moreover, it has a negative impact on a child's brain, physical development and educational performance. Since its consequences are multidimensional, the Government of Ethiopia has demonstrated policy commitment in streamlining nutritional efforts by incorporating nutrition indicators in its five-year Growth and Transformation Plan II and in the second National Nutrition Program (NNP II), focusing on the first 1,000 days of life to eradicate chronic malnutrition by 2030. Furthermore, Ethiopia's Productive Safety Net Program (PSNP), which is a large-scale social-protection program has been focusing to reduce the level of malnutrition in the poor households, and the health extension have been working to reduce malnutrition levels in the country.

This paper has examined the impact of malnutrition and household wealth on children's educational performance using the Young Lives dataset from Round 2 (held in 2006) and Round 3 (held in 2009). Although the determinants of children's educational performance have been the focus of a number of recent studies on Ethiopia, empirical evidence that links household wealth, malnutrition and educational performance at the age-cohort level is scarce. This paper contributes to literature by comparing the effects a child nutrition-and-health indicator and household wealth indices on children's cognitive skills in four different age categories. Unlike most previous research that was based on cross-sectional data for a single year, this paper uses both cross-sectional data for each age cohort in each of two survey rounds and data using changes in variables across the two survey rounds which helps reduce selection bias and endogeneity. Moreover, this paper has also looked at various explanatory variables of child cognitive skills including monthly food and non-food expenditure and household size.

The findings from the cross-sectional regressions and from the regressions using changes in variables between the two rounds show that malnutrition and poor health often lead to lower levels of cognitive abilities in children in the younger cohort, but such an effect is insignificant in the older cohort. One of the main lessons of this paper is that child nutrition and health have different effects on child cognitive skills in different age brackets. The results reinforce research findings

that support the compelling claim that early childhood development has important long-term implications for the productivity and prosperity of the economy.

The results also indicate that greater household wealth has a positive and significant impact on children's educational performance in both the age cohorts. Notably, among the components of the aggregate wealth index (indices for housing quality, access to services and consumer durables), the household consumer durables index had the strongest positive association with children's cognitive skills in the younger cohort, but housing quality had the strongest positive association with children's cognitive skills in the older cohort.

My results also suggest that the more hours that children in Ethiopia spend on paid activities or domestic tasks, indicative of child labor, the poorer their test scores, most notably among older children. This result is consistent with other studies suggesting that child labor will lead to a poor school performance (Gunnarsson et al., 2006; He, 2016; Heady, 2003; Psacharopoulos, 1997; Rosati & Rossi, 2003). Moreover, my study also sheds light on the gender gap in educational performance in the older cohort where girls' performance is poorer than that of boys.

The results of this study suggest that policies aimed at increasing household wealth, reducing child labor and improving children's health and nutrition will likely improve their educational outcomes. Therefore, the Government of Ethiopia should recognize the importance of nutrition for children's cognitive and educational development and should try to ensure that nutrition is integrated as a key component in the early years' programs for children, including in early childhood care and development programs. It is also important for the Ethiopian government to design and integrate policies that improve child nutrition and child health in its five-year plans to improve children's cognitive skills, which should lead to a more productive generation that can transform the country to higher levels of prosperity. Moreover, all domestic and international non-governmental organizations involved in development work should consider providing more funding for improving the children's nutritional status in the early ages to improve long-term human capital development in developing countries, particularly in Ethiopia. Investing in a package of proven nutrition interventions, along with policy changes to address underlying causes of malnutrition will help millions of children develop into healthy and productive members of society. It is obvious that making these changes is the right thing to do.

Appendix

Table A1: Descriptive statistics of the variables across regions and cohorts

Variable	Addis Ababa		Amhara		Oromia		SNNP		Tigray
	Younger cohort	Older cohort	Younger cohort	Older cohort	Younger cohort	Older cohort	Younger cohort	Older cohort	Younger cohort
PPVT raw score	78.6	138.5	42.3	102.9	41.9	129.3	49.6	116.0	48.2
Age of head	44.1	48.6	42.8	47.2	41.6	45.1	42.4	45.2	43.3
Sex of head (Female=1 and male=0)	1.3	1.4	1.2	1.3	1.2	1.2	1.1	1.2	1.3
Education of head	10.3	10.0	12.2	10.7	9.9	10.8	7.4	10.0	8.7
Household size	5.6	6.0	5.8	5.8	6.1	5.5	6.5	6.6	6.4
Wealth index	0.5	0.5	0.2	0.3	0.3	0.5	0.3	0.3	0.3
Monthly expenditure on food per adult, in Birr	164.0	146.2	123.1	114.7	145.8	205.1	103.0	101.7	128.3
Monthly expenditure on non-food items per capita,	129.6	115.9	57.4	50.3	90.2	170.3	75.6	93.1	45.9
Total monthly expenditure per adult, in Birr	293.6	262.1	180.6	165.0	236.1	375.5	178.6	194.9	174.1
Child's sex (female=1 and male =0)	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5	1.4
Child's age - in months	80.4	163.8	80.1	163.1	80.0	164.5	79.4	161.7	79.7
Child’s weight (kg)	18.9	39.0	17.4	32.5	18.4	40.0	18.2	39.8	17.7
Child’s height (cm)	114.6	151.7	111.8	145.3	112.0	152.1	111.6	152.4	112.2
Calculated bmi=weight / squared(height)(bmi)	14.3	16.8	13.9	15.2	14.6	17.1	14.5	16.9	14.0
Weight-for-age z-score(zwfa)	-0.9	-0.9	-1.4	-1.8	-1.4	-0.8	-1.4	-0.7	-1.3
Height-for-age z-score(zhfa)	-0.9	-1.3	-1.3	-2.2	-0.7	-1.0	-0.8	-1.1	-1.2
Bmi-for-age z-score (zbfa)	0.2	0.1	0.3	0.4	0.3	0.1	0.3	0.1	0.2
Stunted (< -2 SD of zhfa)	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0
Severely stunted ((< -3 SD of zhfa))	0.2	0.3	0.2	0.6	0.1	0.1	0.1	0.2	0.2
Thinness (<-2 zbfa)	0.0	0.1	0.0	0.2	0.0	0.1	0.0	0.0	0.0
Sever thinness(<-3zbfa)	19.9	19.2	25.2	20.2	31.2	19.9	36.4	24.5	23.6

Table A2: Summary statistics of selected variables by region, cohort and survey round

Region of residence	Indicators	Older Cohort		Younger Cohort	
		Round 2	Round 3	Round 2	Round 3
Addis Ababa	PPVT score	101.86	173.85	31.76	125.75
	Height-for-age z-score	-0.92	-0.91	-1.09	-0.78
	Wealth index	0.47	0.49	0.46	0.49
	Total monthly expenditure per adult	185.35	195.59	211.60	218.96
Amhara	PPVT score	67.24	138.49	16.37	68.27
	Height-for-age z-score	-1.84	-1.71	-1.54	-1.31
	Wealth index	0.24	0.29	0.22	0.27
	Total monthly expenditure per adult	99.81	133.17	114.52	142.41
Oromia	PPVT score	85.52	170.14	20.82	62.81
	Height-for-age z-score	-0.77	-0.91	-1.65	-1.16
	Wealth index	0.45	0.50	0.31	0.37
	Total monthly expenditure per adult	233.76	280.46	167.24	169.00
SNNP	PPVT score	81.55	152.65	21.38	77.96
	Height-for-age z-score	-0.59	-0.84	-1.46	-1.37
	Wealth index	0.29	0.35	0.26	0.30
	Total monthly expenditure per adult	124.29	148.90	133.76	121.21
Tigray	PPVT score	Nd	nd	18.71	77.64
	Height-for-age z-score	Nd	nd	-1.41	-1.22
	Wealth index	Nd	nd	0.24	0.28
	Total monthly expenditure per adult	Nd	nd	124.51	121.02

Note: SNNP is the Southern Nations, Nationalities and Peoples, one of the national states in Ethiopia. nd represents no data for the older cohort in Tigray.

Table A3: OLS regression results across age categories (by region)

Dependent variable PPVTs and independent variable is height-for-age

Regions	Variable	Child age in years							
		Age-5		Age-8		Age-12		Age-15	
Addis Ababa	Height-for-age z-score	0.053**	(0.02)	0.093**	(0.05)	0.011	(0.03)	-0.015	(0.03)
	Constant	-0.55***	(0.03)	1.27***	(0.06)	0.74***	(0.04)	2.09***	(0.04)
Amhara	Height-for-age z-score	0.01	(0.01)	0.090**	(0.04)	0.026	(0.03)	0.11***	(0.04)
	Constant	-0.90***	(0.01)	0.21***	(0.06)	0.11*	(0.06)	1.62***	(0.08)
Oromia	Height-for-age z-score	0.029***	(0.01)	0.086**	(0.03)	-0.081	(0.10)	-0.071	(0.07)
	Constant	-0.78***	(0.02)	0.088*	(0.05)	0.37***	(0.12)	1.98***	(0.10)
SNNP	Height-for-age z-score	0.054***	(0.01)	0.27***	(0.03)	0.078**	(0.03)	0.12	(0.07)
	Constant	-0.74***	(0.02)	0.63***	(0.06)	0.39***	(0.05)	1.80***	(0.10)
Tigray	Height-for-age z-score	-0.0025	(0.01)	0.17***	(0.04)	nd	nd	nd	nd
	Constant	-0.87***	(0.01)	0.48***	(0.07)	nd	nd	nd	nd

Note: ***, **, and * represent a 1 percent, 5 percent and 10 percent level of significance. nd means that there is no data in the older cohort for Tigray region.

Table A4: Regression results of pooled, random effects and fixed effects models

	Pooled	RE	FE
Height-for-age z-score	3.2487***	3.2551***	4.0214***
	(0.61)	(0.63)	(1.17)
Wealth index	68.9959***	66.6252***	83.9747***
	(5.95)	(6.10)	(13.04)
Age of household head	0.1008	0.1168	0.8770***
	(0.09)	(0.09)	(0.26)
Sex of household head	8.6688***	9.0706***	14.5250**
	(2.04)	(2.10)	(4.88)
Monthly expenditure on food	0.0262***	0.0299***	0.0429***
	(0.00)	(0.00)	(0.00)
Monthly expenditure on non-food items	0.0044	0.0049	0.0120*
	(0.00)	(0.00)	(0.01)
Household size	-3.4088***	-3.6335***	-3.2845***
	(0.39)	(0.40)	(0.93)
Caregiver's level of education	0.0964	0.0928	0.5177*
	(0.07)	(0.08)	(0.24)
Caregiver's age	1.1923***	1.2458***	2.1324***
	(0.11)	(0.13)	(0.35)
	1.4958**	1.9375***	4.9349***
Caregiver's ladder - subjective well-being	(0.46)	(0.47)	(0.66)
Constants	-15.7565***	-20.9683***	-1.2e+02***
	(4.63)	(4.83)	(15.47)
Number of observations	4400	4400	4400
R^2	0.2896	-	0.4607
Adjusted R^2	0.288	-	0.4595
Sigma_e		37.6577	37.6577
ρ		0.1539	0.5609
Lagrangian multiplier test, chibar2(1)		28.92***	
Hausman test $\chi^2(9)$		151.03***	

Table A528. Full results of between-round variable changes using alternative wealth indices

Independent variables	Dependent variable: Change in cognitive skills of the child							
	Younger cohort							
	1		2		2		4	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Δ Height-for-age z-score	7.01***	(2.19)	8.70***	(2.19)	8.52***	(2.19)	7.85***	(2.17)
Δ (Height-for-age z-score)^2	1.88***	(0.66)	2.18***	(0.66)	2.26***	(0.66)	2.11***	(0.65)
Δ Wealth index	34.7***	(11.50)						
Wealth index	39.2***	(9.65)						
Δ Housing quality			11	(8.47)				
Housing quality			10.4	(7.24)				
Δ Housing quality					12.0**	(6.08)		
Housing quality					16.0**	(6.58)		
Δ Housing quality							29.7***	(9.46)
Housing quality							43.6***	(8.26)
Δ Child's age in months	3.07***	(1.07)	2.99***	(1.08)	2.97***	(1.08)	3.61***	(1.07)
Δ Monthly expenditure on food	0.003	(0.00)	0.0042*	(0.00)	0.0039*	(0.00)	0.0023	(0.00)
Δ Monthly expenditure on non-food items	0.0043**	(0.00)	0.0057***	(0.00)	0.0056***	(0.00)	0.0044**	(0.00)
Δ Household size	-1.46*	(0.84)	-1.56*	(0.85)	-1.58*	(0.84)	-1.66**	(0.84)
Height-for-age	3.73***	(1.24)	4.44***	(1.24)	4.20***	(1.23)	3.47***	(1.23)
Child's age in months in Round 2	2.04***	(0.28)	2.12***	(0.29)	2.12***	(0.29)	2.11***	(0.28)
Household size	-0.76	(0.61)	-0.76	(0.62)	-0.91	(0.62)	-0.97	(0.61)
Household sex (Female=1)	3.42	(2.72)	1.49	(2.72)	1.89	(2.72)	4.01	(2.72)
Public school as base line								
Private school	9.07**	(4.03)	16.0***	(3.78)	14.9***	(3.81)	9.59**	(3.91)
Other religious schools	-0.53	(4.60)	6.83	(4.34)	5.29	(4.35)	1.09	(4.39)
Addis Ababa as base line								
Amhara	-18.4***	(4.17)	-7.91***	(3.04)	-10.4***	(2.97)	-9.89***	(2.92)
Oromia	-32.4***	(3.99)	-21.2***	(3.07)	-24.3***	(3.13)	-26.0***	(3.06)
SNNP	-1.52	(4.15)	6.35*	(3.82)	3.69	(3.76)	2.57	(3.73)
Tigray	-12.8***	(4.12)	15.7***	(4.39)	-11.6***	(4.19)	-6.53	(4.24)
Residence (Urban=1)	8.34**	(3.26)	18.3***	(2.59)	15.6***	(2.95)	10.3***	(2.94)
Sex of the child (Female=1)	0.62	(2.10)	0.36	(2.12)	0.32	(2.11)	1.18	(2.10)
Muslim as the base line								
Orthodox	3.01	(3.95)	0.5	(3.86)	1.09	(3.83)	0.44	(3.79)
Other religion	0.71	(5.17)	-0.95	(5.17)	0.063	(5.10)	-1.54	(5.06)
Constant	-170.1***	(45.8)	-174.1***	(46.2)	-173.1***	(46.2)	-196***	(45.70)
Number of observations	1202		1207		1204		1209	
R^2	0.29		0.27		0.28		0.29	
Adjusted R^2	0.28		0.26		0.26		0.28	

Continue to the next page

Continued Table A5

Independent variables	Older cohort							
	1		2		2		4	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Δ Height-for-age z-score	-0.71	(2.15)	-0.93	(2.14)	-0.43	(2.17)	-0.45	(2.17)
Δ (Height-for-age z-score)^2	-0.19	(0.39)	-0.26	(0.39)	-0.14	(0.39)	-0.14	(0.39)
Δ Wealth index	26.2**	(12.70)						
Wealth index	34.4***	(11.50)						
Δ Housing quality			20.3**	(9.48)				
Housing quality			37.5***	(9.09)				
Δ Housing quality					11	(7.07)		
Housing quality					14.4*	(7.76)		
Δ Housing quality							15.8	(11.20)
Housing quality							9.3	(10.50)
Δ Child's age in months	3.71***	(1.21)	3.88***	(1.19)	3.77***	(1.21)	3.65***	(1.22)
Δ Monthly expenditure on food	0.0023	(0.00)	0.003	(0.00)	0.0029	(0.00)	0.0026	(0.00)
Δ Monthly expenditure on non-food items	-0.0025	(0.00)	-0.0022	(0.00)	-0.0018	(0.00)	-0.002	(0.00)
Δ Household size	-0.29	(0.84)	-0.12	(0.84)	-0.27	(0.84)	-0.38	(0.85)
Height-for-age	0.6	(1.16)	0.8	(1.14)	0.79	(1.17)	0.96	(1.17)
Child's age	0.042	(0.36)	-0.042	(0.36)	0.038	(0.36)	-0.0049	(0.36)
Household size	-0.87	(0.75)	-0.48	(0.74)	-0.88	(0.75)	-0.9	(0.75)
Household sex (Female=1)	4.93	(3.00)	4.27	(2.97)	4.34	(3.00)	5.03*	(3.04)
Public school as base line	.	.	.	.	.	.	.	.
Private school	13.8*	(7.12)	12.3*	(7.05)	13.4*	(7.09)	14.6**	(7.19)
Other religious schools	8.38	(5.30)	7.28	(5.22)	7.24	(5.21)	8.4	(5.36)
Addis Ababa as base line								
Amhara	8.34*	(4.60)	7.76*	(4.48)	5.82	(4.52)	7.46	(4.85)
Oromia	6.93	(5.67)	7.96	(5.61)	6.7	(5.74)	7.33	(5.72)
SNNP	4.06	(4.62)	4.86	(4.61)	2.93	(4.59)	2.89	(4.63)
Residence (Urban=1)	5.11	(4.25)	6.83*	(3.89)	7.01	(4.32)	9.23**	(4.07)
Sex of the child (Female=1)	-7.4***	(2.57)	-7.62***	(2.54)	-7.17***	(2.58)	-7.01***	(2.59)
Muslim as the base line								
Orthodox	5.28	(4.36)	5.41	(4.24)	6.97	(4.30)	7.44*	(4.37)
Other religion	8.1	(5.81)	7.83	(5.74)	9.98*	(5.79)	9.6	(5.87)
Constant	-89.1	(73.40)	-84.6	(72.70)	-84.6	(73.70)	-74.2	(74.30)
Number of observations	440		440		441		441	
R^2	0.18		0.2		0.17		0.17	
Adjusted R^2	0.14		0.15		0.13		0.12	

Note: ***, **, and * represent a 1 percent, 5 percent and 10 percent level of significance. Standard errors in parentheses. Δ shows the difference between the two rounds, and explanatory variables without Δ use information from Round 2.

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