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Commodity price volatility and infant mortality rates

A panel data analysis of 52 African countries

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Abstract

This thesis explores the relationship between infant mortality rates and commodity price volatility in Africa. The commodity terms of trade (CTOT) – a weighted index for the commodity export prices of a country – is used to proxy the windfall gains and losses from commodity trade. Subsequently, a fixed effects panel OLS regression is used to investigate the relationship between infant mortality rates and CTOT volatility with data on 52 African countries with 5-year non-overlapping observations spanning 1980-2020. The results consistently show a significant, positive relationship between CTOT volatility and infant mortality rates. These findings are, however, not robust when a different calculation for the CTOT is employed or when the data is transformed into 3-year averages, instead of 5-year averages. This thesis furthermore explores how this relationship varies across countries with different levels of institutional quality, agricultural sector size and export dependency. This thesis finds that the impact of CTOT volatility increases in countries with large agricultural sector size and decreases in countries with large export sectors. The relationship between infant mortality rates and commodity price volatility certainly requires future research, due to limitations in this study like limited data availability. Nonetheless, the positive, significant relationship found in this research highlights the role commodity price volatility plays in the resource curse.

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I Introduction

Projections by UNICEF have shown that Africa has made significant progress in lowering its infant mortality rates from 183 deaths per thousand children in 1955 to 47 in 2020 (UN-IGME, 2024). Nevertheless, infant mortality rates remain notoriously high in Africa in comparison to other regions. This issue falls within the general trend of lagging economic development in Africa. A paradox that has grasped the attention of development economists, is that the African continent is simultaneously endowed with vast natural resources. The IMF (2022), for example, estimated that up to 30% of the minerals needed for the climate change transition – cobalt, nickel, lithium, etc – are found in sub-Saharan Africa. This phenomenon has been labeled the resource curse, where a country is experiencing economic and developmental stagnation despite being endowed with vast natural resources that can generate significant export revenues.

The resource curse has been studied extensively, but the theoretical mechanisms remain contentious. There are various economists that have looked at the price level of commodities to explain the resource curse. Most famously the Prebisch-Singer hypothesis (PSH), for example, attributes the resource curse to falling commodity prices in comparison to manufacturing prices. Recently, economists have also turned to look at the role volatile commodity prices play in the resource curse. Cavalcanti et al. (2014), for example, argue that commodity price volatility, instead of the price level, is a key factor in determining whether commodity dependence positively or negatively impacts an economy. This thesis strives to gain greater insight into the possible role volatile commodity prices play in the resource curse by exploring the relationship between volatile commodity prices and infant mortality rates, an indicator of economic development.

The possibility of a relationship between commodity price volatility and infant mortality rates has been explored, albeit very limited. These papers have mainly been focused on specific case studies (Miller & Urdinola, 2010; Asian Development Bank, 2010). There is one study that explored this relationship using cross-sectional data on 69 low-income countries from 1970-2010 (Makhlouf et al., 2017). The results of these papers have suggested that volatile commodity prices, on average, lead to greater infant mortality rates. This thesis will also use panel data to contribute to this area of research, focusing on Africa, with the following research question: how has the volatility of the commodity terms of trade impacted infant mortality rates in Africa during the period 1980-2020?

The contribution of this thesis firstly lies in using a centralized database on CTOT rates from the IMF. This database was published in 2019, which means that the research on CTOT rates prior to 2019 was based on manually calculated indices. Calculating the CTOT by hand is problematic because each researcher uses its own methodology, making it difficult to build on each other's work. Manually calculated CTOT rates have furthermore ignored changes in trade volumes, a factor the IMF successfully includes in their calculation. Therefore, while Makhlouf et al. (2017) investigated the relationship between CTOT volatility and infant mortality rates, they did not use the newly calculated CTOT rates, which arguably reflect windfall gains and losses from commodity trade more accurately. Using a centralized database in this study furthermore facilitates future research to build on the same dataset.

Secondly, this thesis uses more recent data than previous studies on the relationship between commodity price volatility and economic development. This thesis analyses cross-sectional data on 52 African countries ranging 1980-2020. The case studies that looked at the relationship between infant mortality rates and commodity price volatility use data from before the 2000s (Miller & Urdinola, 2010; Asian Development Bank, 2010). Makhlouf et al. (2017), moreover, used a dataset that covered 1970-2010. Using a more recent dataset allows this thesis to produce more relevant results and provides greater insights into the current trends in economic development.

Thirdly, this thesis builds on the previous results of Makhlouf et al. (2017), by also examining the heterogeneity of the relationship between commodity price volatility and infant mortality rates. While the authors did look at how the aforementioned relationship varies across countries with different institutional levels, the heterogeneity has not been researched any further. This thesis will look at how the results vary between countries of different institutional quality, agricultural sector size and export dependency. The goal is to shed light on how these three factors may influence a country's resilience to commodity price shocks.

Fourth, this thesis solely focuses on a single continent as opposed to the majority of research in this literature doing a global analysis. The focus on a single continent will steer the analysis to a region where countries, on average, are commodity dependent and lag economic growth (African Development Bank, 2007). In doing so, the analysis could produce insights into the resource curse that are relevant to Africa and as such aid in forming more specific policy implications than a global analysis would do.

Lastly, this thesis will contribute to the literature on the resource curse by focusing on economic development as opposed to economic growth. While economists have looked closely at the impact of commodity dependence on economic growth, there has been a lacking interest in its consequences for economic development. One may, however, argue that the average citizen is more impacted by economic development indices, like infant mortality rates, than by abstract measures like GDP growth. This thesis will take a closer look at the mechanisms of the resource curse and the extent to which it impacts an important indicator of economic development, namely infant mortality rates.

This thesis will explore the relationship between the CTOT volatility and infant mortality rates using a fixed effects OLS regression on panel data from 52 African countries covering 1980-2020. Following Makhlouf et al. (2017) and Cavalcanti et al. (2014), the data has been divided into five-year non-overlapping intervals to smooth out short-term fluctuations in commodity prices and infant mortality rates. The results indicate a positive and significant relationship between infant mortality rates and CTOT volatility, albeit of a small magnitude. The robustness checks highlight the small magnitude, as the relationship becomes insignificant when using three-year intervals – instead of five-year intervals – and when a different calculation of the CTOT is employed. This thesis also explores the heterogeneity of the baseline results across countries with different levels of institutional quality, agricultural sector size and export dependency. It is shown that the positive relationship becomes greater in economies with a larger agricultural sector and the opposite occurs for countries with larger export sectors. The relationship does not change significantly for countries with lower institutional quality. In sum, the results of this thesis suggests that commodity price volatility plays a significant role in the resource curse.

After this introduction the *Theoretical Framework* follows. Next, sections three and four will respectively discuss the panel data and the fixed effects OLS model used in this thesis. Section five will discuss the results from the OLS regressions and cover the limitations of the statistical analysis. Lastly, the conclusion will follow in section six.

II Theoretical framework

2.1 The resource curse

The goal of this thesis is to gain a better understanding of the potential role volatile commodity prices play in the resource curse – the phenomenon that the economies endowed with the vast natural resources tend to be lagging most in economic growth and development (Badeeb et al., 2017). There is a great body of research into the resource curse with, for example, Sachs & Warner (1995), most notably using cross-sectional data from 97 developing countries ranging from 1970-1989 to show a negative relationship between natural resource endowment and economic growth. This result is considered counter intuitive within the framework of classical economics, as Adam Smith and Ricardo have for example argued that international trade tend to benefit those countries that are most resource abundant (Badeeb et al., 2017). Economists have strived to gain a better understanding of this paradox, and some have even contested its existence with Brunnschweiler (2008), for example, arguing for a positive relationship between resource abundance and economic growth when controlling for institutional quality. This thesis strives to gain greater insights into the resource curse by focusing on Africa – a continent that is, on average, lagging in economic development and endowed with vast natural resources.

Economists frequently highlight the central role commodity prices play in the resource curse. Most famously, the Prebisch-Singer hypothesis (PSH) stated that the resource curse is driven by increasing prices for manufactured goods and decreasing prices for commodities. In the late 1900s, this view was supported by other economists, with for example Sachs & Warner's (1995) empirical study supporting this hypothesis. More recently, Harvey et al. (2010) examined the price movement of 25 commodities and in accordance with the PSH found a long-term downward trend. Nonetheless, this hypothesis has also been critiqued by other researchers for oversimplifying the complex dynamics of international trade and economic development. Hadass & Williamson (2003), for example, note that the decline in price varies significantly across different commodities. As such, the extent and magnitude of the impact of the long-term decline in commodities may not be as impactful as stated by the PSH. Moreover, Harvey et al. (2010) argue that it is the structural changes in the world economy that decrease commodity prices, like advancements in technology, that drives the disparity in development between periphery and non-periphery countries.

More recently, economists have turned to look at the volatility of commodity prices – instead of their level – to find an explanation for the resource curse. Cavalcanti et al. (2014), for example, used a GMM model to show that CTOT volatility decreases the accumulation of human and physical capital, which in turn lowers GDP per capita. Most notably, these researchers found a stronger relationship between the volatility of commodity prices and economic growth than with the level of commodity prices. Lee (2023) builds on Cavalcanti's results using sector-specific data on 49 commodity exporting economies to show that commodity price volatility impedes economic growth due to lower factor productivity. The sector-specific data allowed Lee (2023) to highlight the increased impact of commodity price volatility in sectors with greater credit constraints. Combes & Guillaumont (2003), furthermore, highlight the non-linear relationship between GDP per capita growth and poverty reduction, arguing that volatile commodity prices have a more profound impact on poverty in developing economies than on economic growth. The research on commodity price volatility is, in comparison to the commodity price level, more recent and not many researchers have focused on economic development – as opposed to growth – yet. This thesis strives to address this underexplored area by focusing specifically on commodity price volatility and an indicator of economic development, namely infant mortality rates.

2.2 Commodity prices and volatility

This thesis will use the CTOT index to proxy price commodity volatility. Similarly, to the IMF, this thesis defines the CTOT as the weighted index of world prices for the commodities a country exports, based on each commodity's share in export revenues (Spatafora & Tytell, 2009). Resultingly, the CTOT is typically used to approximate an economy's windfall gains or losses from commodity exports.

This particular index was chosen because it specifically focuses on world commodity prices, as opposed to other indices, like the terms of trade (TOT). The TOT is a weighted ratio of a country's export prices to its import prices, proxying an economy's purchasing power relative to its trading partners. The TOT is generally regarded as the predecessor to the CTOT (Cavalcanti et al., 2014). An improvement in the TOT suggests that a country can import more products without having to increase exports and vice versa for a TOT deterioration (Mendoza, 1995). While this metric also includes import prices, as opposed to the CTOT, the main issue with the TOT pertains to endogeneity issues because this metric uses domestic export and import prices. As stated by Gruss & Kebhaj (2019), researchers have shifted to using other metrics than the TOT, because the TOT is not only influenced by external factors in the international economy, but also by domestic market conditions. The CTOT, in contrast, uses the world prices of commodities that are mainly driven by external factors in the international economy. Consequently, the CTOT can measure developments in the international market economy more directly than the TOT. As such, this thesis follows the trend of using the CTOT to proxy commodity price volatility to research its impact on infant mortality rates.

2.2 Infant mortality rates and CTOT volatility

The main hypothesis of this thesis is that greater CTOT volatility will lead to increased infant mortality rates in African countries. This section will discuss three channels through which volatile commodity prices impact infant mortality rates: (1) complicated fiscal planning, (2) stagnated economic growth and (3) decreased household incomes. Additionally, these three channels lead to the expectation that CTOT volatility will have a more pronounced impact on infant mortality rates on countries with respectively worse institutional quality, greater export dependency and agricultural sector size.

Firstly, CTOT volatility can lead to increased infant mortality rates in Africa through complicated fiscal planning. Specifically, volatile commodity prices can lead to uncertain government revenue streams which in turn hinders the government support needed to reduce infant mortality rates.

Volatile commodity prices are expected lead to uncertain government streams in African countries due to their commodity dependency. The UNCTAD for example found 83% of African countries having commodity export revenues make up more than 60% of merchandise exports. Moreover, a report by the African Futures & Innovations Programme has shown that the commodity dependency of African countries has only increased in the past decades (Cilliers, 2024). A number of case studies specifically look into the relationship between commodity exports and government revenue in Africa. Ebimobowei (2022), for example, found oil revenue to be a strong predictor for government funds available in Nigeria; Haabazoka (2023) found the same relationship in Zambia with government revenue and copper revenues; and Abafita et al. (2022) found the same relationship in Ethiopia for government revenue and coffee beans.

Volatile government revenue income – caused by volatile commodity prices – is subsequently expected to be problematic for reducing infant mortality rates in Africa. Primarily because economic development projects require long-term fiscal planning, which is hindered by uncertain government revenue streams. Gavin & Hausmann (1998) have for example shown that sub-Saharan African governments invest less in development projects when macroeconomic uncertainty increases, suggesting that volatility erodes government investments in development. Little et al. (1994) specifically argue that negative shocks in trade revenues, on average, reduce the liquidity of governments, resulting in less investments in human development projects. Additionally, Cuddington (1989) found that sudden increases in commodity prices can also negatively impact commodity-exporting economies, due to governments overspending the windfall gains from exports. Apparently, both positive and negative shocks in government revenue can therefore impede long-term fiscal planning. Makhlouf et al. (2017) discuss this route too and underline the important role institutional quality therefore plays in the relationship between CTOT volatility and infant mortality rates. Governments with greater institutional quality are, namely, expected to be better equiped to handle long-term fiscal uncertainty. CTOT volatility is thus also expected to impact infant mortality rates more significanty in countries with lower institutional quality.

Secondly, volatile CTOT rates can also lead to greater infant mortality rates through its negative macroeconomic impact. As mentioned briefly under 2.1, economists have argued that commodity price volatility stagnates economic growth in commodity dependent countries. Moser & Ichida (2001) have subsequently shown that there is a relationship between economic growth and infant mortality rates, using cross-sectional data on 47 sub-Saharan countries. Moreover, Hegerty (2016) looked at the impact of volatile commodity prices on other macroeconomic indicators, like inflation and exchange rates. Analyzing monthly data on nine developing economies covering 1980-2014, Hegerty (2016) showed that commodity shocks can spark inflation and depreciations in the exchange rates, due to decreased consumer confidence. Both inflation and exchange rate depreciation, generally, cause prices to increase, which in turn decreases purchasing power for households, making quality child care more expensive and perhaps even inaccessible. Akinlo & Odusanya (2016), for example, found that increased food prices can spark infant mortality rates in sub-Saharan Africa. In sum, volatile CTOT rates can increase infant mortality rates due to worsened macroeconomic conditions, like hampered economic growth, increased inflation and depreciations in the local currency. The impact of volatile CTOT rates are therefore expected to be more pronounced in economies with larger export sectors as the windfall gains and losses are proportionally more impactful.

Lastly, volatile CTOT rates can also impact infant mortality rates through its negative impact on disposable household incomes. Volatile CTOT rates can firstly lead to lower household incomes due to its impact on unemployment. Cavalcanti et al. (2014), for example, showed that CTOT volatility has a significant negative impact on employment as capital owners are less prone to hire labour during uncertain times. Sengupta et al. (2017) further explore this, by comparing commodity price volatility and unemployment levels in central and eastern European countries. Comparatively to Cavalcanti et al. (2014), Sengupta et al. (2017) also found decreased unemployment during commodity price volatility. Secondly, volatile CTOT rates can decrease the disposable income of the average household, as it has been shown that volatile commodity prices can exacerbate inequality in commodity dependent countries due to a discrepancy in the return to labour and capital. Mohtadi & Castells-Quintana (2021) have shown that commodity price shocks, in general, have a negative impact on income inequality. Windfall gains of commodities seemed to be mainly appropriated by capital owners while windfall losses are absorbed through lower wages and greater unemployment. These researchers found that the impact of commodity price volatility on inequality was particularly significant for sectors that are labor intensive, like agriculture. The impact of commodity price volatility on household incomes was furthermore empirically investigated by Lederman & Porto (2015), who found that African (and Latin-American) drops in household incomes and expenditures are historically highly correlated with commodity price shocks. In sum, there is evidence that commodity price volatility can negatively impact household incomes in African countries. Following this reasoning , the expectation is that the relationship between CTOT volatility and infant mortality rates becomes more pronounced in countries with large labour intensive sectors, like agriculture.

To briefly summarize the three channels above: volatile CTOT rates are firstly expected to complicate long-term fiscal planning for governments, which in turn hampers the necessary government support to lower infant mortality rates. Secondly, commodity price volatility can lead to worsened macroeconomic conditions, which in turn can lead to higher infant mortality rates. Thirdly, fluctuations in CTOT rates can directly affect household incomes in commodity dependent countries, which in turn reduces spending on quality childcare. The relationship between CTOT volatility and infant mortality rates are therefore expected to be more pronounced in countries with lower institutional quality, greater export dependency, and larger agricultural sector sizes.

This title will lastly comment on the studies that look directly at the relationship between commodity price volatility and infant mortality rates. Most notably, Miller and Urdinola (2010) looked at three distinct coffee price shocks in in Columbia and its consequences on infant mortality rates. With a series of probit regression models, these researchers have shown that infant mortality rates and child morbidity had increased during the coffee price shocks in 1975, 1985 and 1989-1990. Moreover, a study by Carrasco & Romero (2022) analyzed a natural experiment in Peru where the price of cocao beans dropped substantially in the mid 1990s. A least-squares estimation shows that the drop in cocao bean prices was followed by a substantial increase in child mortality rates.

Besides case studies, there is but one study that conducted a cross-sectional analysis between countries to investigate the aforementioned relationship. Makhlouf et al. (2017) analyzed panel data on 69 low-income countries and found a positive, significant relationship between infant mortality rates and CTOT volatility. The researchers found this relationship through a fixed effects panel OLS regression. In addition, this paper found that this relationship becomes is more pronounced in autocratic countries as opposed to democratic countries. These researchers also found that the CTOT level, itself, had no significant impact on infant mortality rates. As mentioned under the introduction, this thesis distinguishes itself with respect to Makhlouf et al.'s (2017) study by: using the CTOT calculated with rolling weights, employing more recent data, exploring the heterogeneity of the relaitonship and focusing the analysis on a single continent.

III Data

3.1 Sample choice and specification

This thesis uses an unbalanced panel data set from 52 African countries covering 1980-2020 (full country list under appendix A). As opposed to previous studies on the relationship between economic development and CTOT volatility, like Makhlouf et al. (2017), this thesis solely focuses on one continent as opposed to the whole globe. Focusing on African countries focuses the analysis to a region where commodity exports play a central role in domestic economies (Barka et al., 2023), meaning that CTOT volatility could have a significant impact on economic development. In addition, the greater level of homogeneity within a single continent in terms of geographical characteristics and economic development could lead to a more controlled analysis.

3.1 Variable Specification

a) infant mortality rate

Data on the infant mortality rate is taken from the UNICEF database. This database is compiled by the United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME) that uses household surveys, civil registration and population censuses to estimate national mortality rates across the world. This statistic is presented as the number of children below the age of five dying per 1000 children. This data source was chosen due to its data availability and the quality guarantee due to, for example, yearly peer reviews by other UN organs.

b) CTOT volatility

Data on the CTOT index are found in the IMF database, created in 2019. As mentioned above, the CTOT is a weighted index of a country's export prices based on each commodity's contribution the national export revenue. The baseline year of the index is 2012, meaning that each country's CTOT in 2012 was 100. The logged difference of the weighted export prices is then used to calculate the CTOT in all other years (full equation is found under appendix B). The IMF used 45 commodities to calculate the CTOT (Gruss & Kebhaj, 2019).

There are two main variants of the CTOT: one calculated with rolling weights and another calculated with fixed weights. The CTOT calculated with rolling weights changes the weight allocated to each commodity for each annual observation to take changes in trade patterns into account. The fixed weight CTOT, in contrast, allocates the same weight to each commodity in every observation, based on its overall contribution to a country's export revenues in the period 1980-2020. This thesis will focus on the CTOT calculated with the rolling weights to bring changes in exports into account. This choice is firstly motivated by the fact that Makhlouf et al. (2017) used the fixed weights, meaning that an analysis with rolling weights will produce new insights to this area of literature. Secondly, the CTOT with rolling weights is expected to be a more accurate proxy for the windfall gains and losses from commodity exports. The rolling weight would namely take the fact into account that the main exports of countries change over time. The fixed weight will be used, though, to check the robustness of the main results.

The standard deviation of the CTOT is used to measure its volatility, as is standard in the CTOT literature (Calvacanti et al., 2014; Makhlouf et al., 2017; Shaxson, 2005).

c) control variables

The following control variables are added to the baseline regression: GDP per capita, inflation rate, domestic credit to private sector as a percentage of GDP, primary enrolment rate, change in CTOT and percentage of population aged between 0-5. Data on the former four control variables are collected from the World Bank "World Development Indicator" database. This database had the greatest data availability, and the World Bank was deemed a reputable source for high quality data. Data on the number of children aged 0-5 is collected from the World Health

Organisation Child Growth Standard database. The change in CTOT is calculated using data from the aforementioned IMF database from 2019.

These control variables are included in the regression as these variables are expected to influence the infant mortality rate. A study by Arik & Arik (2007) showed that infant mortality rates tend to decrease with economic growth and increase with greater inflation. Moreover, while Makhlouf et al. (2017) argue that the CTOT rate itself has an insignificant impact on infant mortality rates, it was still deemed necessary to properly isolate the impact of CTOT volatility by controlling for changes in CTOT. Furthermore, the baseline regression will also control for financial development – through the variable domestic credit to private sector as a percentage of GDP – as this impacts a country's resilience to external shocks, like fluctuating export prices (Lee, 2023).

The variable for the percentage of the population aged 0-5 will control for the age of the population. As a population gets older, on average, the expectation is that infant mortality rates will fall. Makhlouf et al. (2017) also used this variable in combination with the share of the population aged 65. Due to limited data availability this thesis was unable to also include the latter variable in the baseline regression. Lastly, the primary enrolment rate was included due to the general trend of improved education reducing infant mortality rates (Dutta et al., 2020).

These control variables could introduce biased estimates if CTOT volatility affects infant mortality rates through any of them, thereby reducing the statistical power of the independent variable. However, based on the correlation matrix in section 4.4, it seems unlikely that CTOT volatility is strongly correlated with any of the control variables, mitigating this potential scenario.

d) Institutional quality, agricultural sector size and export dependency

Lastly, this thesis will investigate the heterogeneity of the baseline results across countries with different levels of institutional quality, agricultural sector size and export dependency. These three variables will be proxied by respectively the corruption perception index (CPI), agricultural sector size as a percentage of GDP and exports as a percentage of GDP. Data on the CPI was collected from a database from *Transparency International,* the organization that created this measure of institutional quality. The latter two proxies were collected from the World Bank. The selection of proxies was based on data availability, as these three proxies had the least gaps in the data from the highest quality source.

A common issue across all three proxies is the limited availability of data. While the data on the three proxies is fairly complete from 2005-2020, data on previous years is significantly limited. The decision is therefore made to use the available data to rank the countries in order of, on average, lowest institutional quality, agricultural sector size and export dependency. Subsequently a dummy variable be created that is equal to one when a country belongs to the upper quartile of the aforementioned rankings. As a sensitivity check, a similar dummy variable will be created that will indicate whether a country belongs to the upper half in each ranking. While this transformation does limit the depth of the analysis, it was necessary to facilitate an investigation into the heterogeneity of the baseline results.

3.3 Summary statistics

The table below summarizes the unbalanced panel dataset for 52 African countries covering 1980-2020. As will be described under title 4, the analysis will transform the annual data into non-overlapping five-year averages, such that there will be a maximum of eight observations per country. The CTOT volatility is thus its standard deviation during each five-year period. As such, the table below presents the descriptive statistics for the five-year non-overlapping intervals.

Table 1: summary statistics for the main variables

Variable	N	Mean	Std. Dev.	Min	Median	Max
Infant mortality rate (deaths per 1000 children)	415	116.635	65.181	12.358	105.656	338.764
CTOT volatility (standard deviation)	390	1.438	1.516	.112	0.879	12.222
CTOT	392	99.175	11.779	44.576	101.633	121.15
GDP per capita (in current dollars)	398	1627.113	2404.017	121.017	736.279	17354.175
Inflation (% change)	349	36.559	354.387	-5.531	6.647	6424.988
Domestic credit to private sector (% of GDP)	358	19.536	20.292	.005	13.385	130.153
Primary enrolment	388	89.16	27.463	20.262	94.121	150.109
Child population	416	2609.279	4003.701	7	1360.1	32744.8

The data is consistently skewed to the right across all the variables, as the mean of all the variables is greater than its median. The extent to this skewness varies, as the difference between the median and mean is especially large for the GDP per capita, inflation rate and child population. These variables also exhibit the greatest variability, as shown by the standard deviation. These observations highlight the need to consider outliers in the analysis. Section 4 will further explain how the methodology will accommodate for the potential issue of outliers.

IV Methodology

This thesis employs a panel ordinary least squares (OLS) regression with fixed time and entity effects. Firstly, a baseline regression will be estimated for the relationship between the CTOT volatility and infant mortality rates. Afterwards, three robustness checks will be conducted on the baseline results. Lastly, the heterogeneity of the results will be explored by introducing three different interaction variables, investigating how institutional quality, agricultural sector size and trade dependency influences the relationship between infant mortality rates and volatility CTOT.

4.1 OLS with fixed effects and fixed time effects

An OLS regression estimates a linear relationship between two or more variables by fitting a line that minimizes the sum of the squared differences between the predicted and observed values (Moore, 2011). When OLS regressions are used to analyse panel data, an important choice must be made regarding the entity specific effects. As opposed to cross-sectional data, panel data namely involves multiple observations for the same entity over time. The OLS regression can either assume a random entity specific effect, a fixed effect or ignore the entity specific effect altogether (Moore, 2011). These approaches are respectively known as the random effects, fixed effects, and pooled OLS models.

The fixed effects model was chosen for this thesis because, firstly, it is expected that infant mortality rates differ significantly across the different entities, i.e., African countries. The determinants of infant mortality rates – GDP per capita, inflation, primary enrolment rates, etc. – are namely expected to be highly country-specific. A pooled OLS would therefore incorrectly ignore the significant role the country specific effect could have on infant mortality rates, potentially biasing the results. Furthermore, the fixed effects model is preferred over the random effects model due to the correlation between entity-specific effects and the independent variables used in this thesis. The independent variables– e.g., GDP per capita, inflation, and primary enrollment rate – are expected to be systematically higher or lower in some African countries than in others. The fixed effects model accounts for this correlation by allowing each entity to have its own intercept, thereby controlling for time-invariant characteristics (Moore, 2011). In contrast, the random effects model assumes no such correlation and captures the entity-specific effects in the error term. In addition, a Hausman test will be conducted to test whether this methodological choice is an accurate reflection of the data used in this thesis (see appendix C).

Lastly, the baseline regression will include a fixed time effect to account for the global trend of decreasing infant mortality rates (UN-IGME, 2024). As such, it is expected that this methodological choice will control for the temporal variation that impacts all African countries in the sample. This methodological choice corresponds to other studies on infant mortality rates (Panda, 2020; Mahklouf et al., 2019; Avendano, 2012).

4.2 Baseline model specification (and interaction variable)

The following equation shows the general fixed effects OLS regression that is used in the literature to analyse the relationship between infant mortality rates and an economic variable:

$$(1)\ IMR_{it} = \beta_0 + \beta_1 CTOTv_{it} + \beta_2 X_{it} + \delta_t + \varepsilon_{it}$$

Where *IMR* refers to the infant mortality rate, i refers to the country and t refers to a particular year. *CTOTv* stands for the volatility of the CTOT and X for the control variables included in this study. δ and ε are respectively the fixed time effect and the error term.

The first mutation to equation one is using non-overlapping intervals of five years, instead of annual data. As is common in development economic research, the transformation to five-year intervals allows the regression to capture medium to long-term trends more efficiently (Cavalcanti et al., 2014; Blattman et al., 2004). This particular interval is common research practice as five-year averages smooth out short run business cycles (Cavalcanti et al. (2014). As mentioned before, the CTOT volatility is also defined by its standard deviation over a period of five years.

Secondly, the infant mortality rates and control variables are transformed into logged differences. Taking the logged differences firstly negates the impact of any outliers (Moore, 2011). Secondly, this transformation was deemed necessary to negate any stationarity issues with the data on infant mortality rates. Studies have shown that infant mortality rates are non-stationary and decreasing linearly in the previous century (Bishai et al., 2006; Caporale & Gil-Alana, 2014). An Augmented Dickey-Fuller test furthermore shows that the null hypothesis for non-stationarity cannot be rejected at the 5% level for infant mortality rates, but can be overthrown when the logged difference is taken (appendix D) .

Lastly, this thesis investigates how the baseline results vary amongst countries with various levels of institutional quality, agricultural sector size and export dependency. These variables will be respectively measured by the corruption perception index, agricultural sector size as percentage of GDP and exports as percentage of GDP. The analysis will be conducted by introducing an interaction dummy variable that will indicate whether a country belongs in the upper quartile or upper half of countries that are most corrupt, have the largest agricultural sectors, or are most export dependent. The rankings are based on the average value of the respective proxy in the period 1980-2020. This approach accommodates for the limited data availability of the proxies. Resultingly, the main limitation of this approach is that the interpretation will be limited to the interaction variable, as the time dummies are time-invariant and will not be included by itself in the regression.

$$(2)\ \Delta imr_{it} = \beta_0 + \beta_1 CTOTv_{it} + \beta_2 CTOTv_{it} \times ID_{it} + \beta_4 \Delta x_{it} + \delta_t + \varepsilon_{it}$$

Where Δimr_{it} is the logged difference of the infant mortality rate, $CTOTv$ the CTOT volatility, ID the dummy interaction variable and Δx the logged difference of the control variables. i refers to the country and t to one of the eight five-year periods.

4.3 Robustness checks

Three main robustness checks will be conducted on the baseline regression. Firstly, a CTOT calculated with fixed weights, instead of rolling weights, will be used. This change will investigate whether the results remain robust when using a measure of CTOT that does not capture changes in trade volumes. Secondly, a dataset will be used where three-year intervals are used instead of five-year intervals. While the five-year averages are common practice in economic development literature, the shorter time periods will increase the number of observations to a maximum of 13 observations per country, which may increase the statistical power of the regressions. The shorter time periods will, however, also increase noise and lead to larger standard errors which could decrease the statistical power of the regressions. Lastly, a subsample is created with the quartile of countries with most volatile CTOT rates. The expectation is that this subsample will amplify any existing relationship between the CTOT volatility and infant mortality rates. While focusing the analysis on a single quartile will significantly lower the observations available, this robustness check will highlight the magnitude of the CTOT volatility effect in regions where it is the most significant.

Additionally control variables will be added and omitted to the baseline regression to investigate the impact of the control variables on the main results. Specifically, four regressions will be made. Initially the regression will only include the independent and dependent variable, to isolate the relationship between the infant mortality rates and CTOT volatility. Then, the CTOT level will be added to the regression which still isolates the relationship to the CTOT and infant mortality rate. Thirdly, the GDP per capita, inflation rate and financial development variables will be added to investigate how the macroeconomy influences the aforementioned relationship. Lastly, the primary enrolment rate and child population will be added to investigate the relationship with all control variables.

4.4 Assumptions and limitations

An essential assumption of the fixed effects OLS model is that the explanatory variables are exogeneous to the dependent variable and, therefore, not correlated with the error term. Essentially this means that the independent variables should influence the dependent variable, infant mortality rates, without being influenced by unobserved factors captured by the error term. The model firstly addresses such potential endogeneity issues by including control variables, to limit any omitted variable bias. The aforementioned control variables capture the most significant variables that may impact mortality rates, but of course one must be mindful that there are unquantifiable control variables – culture, household dynamics, etc. – that can cause omitted variable bias. Furthermore, endogeneity issues due to reverse causality is highly unlikely as CTOT rates are primarily impacted by commodity prices and not by domestic development indicators like infant mortality rates. Lastly, panel data analyses can encounter endogeneity issues arising from unobserved time and entity-specific effects. The model above mitigates this issue by including time and entity specific effects.

Another important assumption in the fixed effects OLS model is that the variance of the error terms is homoscedastic, meaning that the variance is constant across all levels of the independent variables. To investigate whether this assumption holds in the baseline results, a Wald test will be conducted on each regression. Furthermore, it is important that the data is not serially correlated. In other words, the residuals should not be correlated across time periods. A Woolridge test will be used to check whether this assumption is adhered to in the baseline regressions. Lastly, the OLS model assumes that the independent variables are not collinear. This means that the explanatory variables should not be closely correlated. Looking at the correlation matrix, it appears that the variables included in the regression are indeed not closely correlated as the highest correlation coefficient is 0.218.

Table 2: correlation matrix of the baseline regression variables

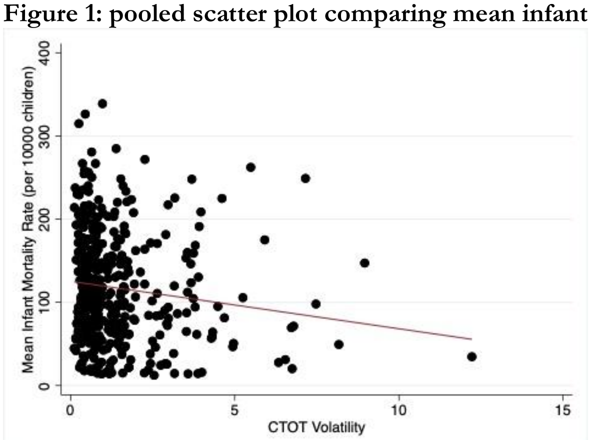
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Δln(infant mortality rate)	1.000							
(2) CTOT volatility	0.020	1.000						
(3) Change in CTOT	0.107	-0.118	1.000					
(4) Δln(inflation)	-0.054	-0.064	0.047	1.000				
(5) Δln(GDP per capita)	-0.086	0.027	0.157	-0.124	1.000			
(6) Δln(domestic credit to private sector in % of GDP)	-0.066	0.097	-0.019	-0.218	0.096	1.000		
(7) Δln(child population)	-0.038	-0.122	0.100	-0.024	0.068	-0.047	1.000	
(8) Δln(child population)	-0.064	-0.109	0.063	0.046	-0.107	0.027	0.155	1.000

V Results

5.1 Preliminary evidence

The graph below shows a pooled scatter plot of all the available observations, comparing the mean infant mortality rate with the CTOT volatility in each period. As shown by the trendline, there is a slight negative relationship between CTOT volatility and the mean infant mortality rate. It is important to note, however, that this data has not been pooled or transformed to logged differences. The negative trend can, therefore, be largely explained by firstly the general trend of infant mortality rates decreasing over time (see appendix E). Simultaneously, one of the largest spikes in CTOT volatility occurred in 2008 during the financial crisis (appendix E). Resultingly, the slightly negative trend is likely a product of the greatest volatile CTOT rates occurring in 2008, where infant mortality rates had already decreased significantly since the 1980s. A pooled scatter plot per African country can provide greater insights, notwithstanding the limited number of observations per country. While most countries display a positive relationship between the CTOT volatility and infant mortality rates – as hypothesized – no concrete conclusions can follow from a visual inspection (See appendix F).

Figure 1: pooled scatter plot comparing mean infant mortality rates to CTOT volatility



5.2 Baseline regression

As mentioned under section 4, four different regressions have been created with different control variables. In regressions 1, 2 and 4 the coefficient for the CTOT volatility is positive and significant at the 5% level. In regression 3 this coefficient is only significant at the 10% level. The magnitude of this coefficient is the highest in regression 1 and 2, followed by regression 4 and is significantly lower in regression 3. Overall, the R-squared values is quite low in each regression. It is, however, noticeable that the R-squared value is significantly higher in model four which also has the least observations.

Table 3: investigating the impact of CTOT volatility on infant mortality rates with fixed time and entity effects.

	(1) Δln(infant mortality rate)	(2) Δln(infant mortality rate)	(3) Δln(infant mortality rate)	(4) Δln(infant mortality rate)
CTOT volatility	.054**	.055**	.027*	.041**
	(.023)	(.021)	(.016)	(.02)
Change in CTOT		.003	.004	.01***
		(.003)	(.003)	(.003)
Δln(inflation)			-.028	-.236
			(.081)	(.187)
Δln(GDP per capita)			-.063	-.117**
			(.042)	(.048)
Δln(domestic credit to private sector in % of GDP)			.009	-.018
			(.049)	(.054)
Δln(child population)				-.046
				(.06)
Δln(primary enrolment)				-.01
				(.055)
Observations	389	388	288	216
R-squared	.049	.052	.053	.118

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

The remaining explanatory variables generally lack statistical significance. The signs of their coefficients, however, do somewhat align with the theoretical expectations. Inflation, for example, shows a negative but insignificant effect in regressions 3 and 4. While Hegerty (2016) showed that infant mortality rates increase with worsened macroeconomic conditions – which typically means higher inflation – the negative sign could be explained if many countries faced deflation, which could also be a sign of poor economic conditions. The coefficient for GDP per capita is furthermore negative and significant at the 5% level in regression 4, corresponding to the expectation that economic growth leads to lower infant mortality rates (Moser & Ichida, 2001). The coefficient for primary enrolment rates is negative but statistically insignificant. The sign of this coefficient coincides with the theoretical expectation that decreased infant mortality rates goes paired with increased primary enrolment rates (Sagan & Fifi, 1978; Dutta et al., 2020). Lastly, regression 4 shows a positive and significant relationship between a change in CTOT and infant mortality rates at the 5% level. Makhlouf et al. (2017), in contrast, found a statistically insignificant relationship between these two variables. Nonetheless, the magnitude of this effect is smaller than the CTOT volatility which coincides with the results of Cavalcanti et al. (2014).

Appendix G shows the diagnostic tests conducted on each regression to control for heteroskedasticity and serial correlation. The Wald test was firstly used to test for heteroskedasticity, where the null hypothesis is that the variance of the error term is correlated with the explanatory variable, CTOT volatility. As shown, the null hypothesis can be rejected at the 5% level for regression 1, 2 and 4. In regression 3, the null hypothesis can only be rejected at the 10% level. The Woolridge test was furthermore used to test for autocorrelation. The null hypothesis that there is autocorrelation can be rejected at the 5% level in regression 1 and 2. There is a 90% confidence interval that there is no autocorrelation in regression 3, but the null hypothesis cannot be rejected in regression 4. In sum, regressions 1 and 2 are likely to have no issues with heteroskedasticity and autocorrelation. The same can be concluded about regression 3, but only at the 90% level. Only heteroskedasticity can be ruled out in regression 4, while issues pertaining to autocorrelation cannot be ruled out in this regression.

5.2 Robustness checks

To check the robustness of the baseline results, the data was firstly transformed into non-overlapping intervals of three years, instead of five years. This transformation significantly increases the number of observations available to around a 150-200 extra observations per regression. This could explain the increased explanatory power of each regression, as the R-squared value increased from 0.075 to around 0.178 on average.

Table 4: investigating the impact of CTOT volatility on infant mortality rates with fixed time and entity effects, using non-overlapping 3-year intervals

	(1) Δln(infant mortality rate)	(2) Δln(infant mortality rate)	(3) Δln(infant mortality rate)	(4) Δln(infant mortality rate)
CTOT volatility	-.001	0	.001	-.004
	(.003)	(.003)	(.004)	(.005)
Change in CTOT		.001***	.001***	.001
		(0)	(0)	(0)
Δln(inflation)			-.002	-.01
			(.013)	(.016)
Δln(GDP per capita)			-.03	-.036***
			(.018)	(.013)
Δln(domestic credit to private sector in % of GDP)			-.008	-.007
			(.009)	(.011)
Δln(child population)				-.039
				(.027)
Δln(primary enrolment)				-.099
				(.183)
Observations	633	633	481	371
R-squared	.177	.187	.166	.184

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

The coefficient of the CTOT volatility lost significance, becoming extremely close to zero and statistically insignificant. This change is likely caused by the increased noise from using three-year intervals, which may capture short-term fluctuations that are not captured by the five-year intervals. After calculating the variance of CTOT volatility for the five-year and three-year periods (2.292 and 8.208, respectively), it is evident that shorter time periods do indeed introduce greater noise which could have obscured the relationship between CTOT volatility and infant mortality rates. Furthermore, the coefficients of the change in CTOT and GDP per capita are statistically significant and of the same sign as in the baseline results. It is notable that both coefficients decreased in magnitude, suggesting that the impact of economic growth and CTOT fluctuations on infant mortality rates requires time to accumulate.

The second robustness check uses a CTOT index calculated with fixed weights instead of rolling weights. The fixed weights eliminate any influence from changes in trade volumes. Each commodity's weight is based on its average contribution to the country's export revenue over the entire period, isolating any changes in the CTOT to changes in world prices.

Table 5: investigating the impact of CTOT volatility on infant mortality rates with fixed time and entity effects, using the fixed weights CTOT index

	(1) Δln(infant mortality rate)	(2) Δln(infant mortality rate)	(3) Δln(infant mortality rate)	(4) Δln(infant mortality rate)
CTOT volatility	.038	.04	.022	0.00
	(.03)	(.03)	(.039)	(.054)
Change in CTOT		.002	.005	.009**
		(.003)	(.004)	(.004)
Δln(inflation)			-.023	-.224
			(.081)	(.19)
Δln(GDP per capita)			-.057	-.1**
			(.041)	(.048)
Δln(domestic credit to private sector in % of GDP)			.01	-.014
			(.049)	(.055)
Δln(child population)				-.007
				(.056)
Δln(primary enrolment)				-.035
				(.064)
Observations	391	390	288	216
R-squared	.017	.018	.045	.09

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

As shown in the table above, the volatility of the fixed weight CTOT rates has a statistically insignificant relationship with infant mortality rates in each regression. The coefficients in each regression are, however, positive and zero in regression 4. This result contradicts the findings of Makhlouf et al. (2017), as they used a CTOT index with fixed weights to find a significant positive relationship between the CTOT volatility and infant mortality rates. This discrepancy could be the result of using different datasets; Makhlouf et al. (2017) used a data set from 1970-2010, whereas this thesis covers 1980-2020. In the fourth regression, the change in CTOT and GDP per capita are statistically significant and carry the same sign as the baseline results.

Lastly, the table below shows the regressions on a subsample of the quartile of countries that, on average, had the most volatile CTOT rates between 1980-2020. As expected, the magnitude of the coefficient of the CTOT volatility increased in all four regressions. However, the standard errors increased substantially too, decreasing the significance of these coefficients. In regression 3 the coefficient is only significant at the 10% level and statistically insignificant in regression 4. The decreased significance is likely a result of the substantial decrease in observations available. Despite the lower number of observations, it is notable that the R-squared value increased substantially with respect to the baseline regressions. Furthermore, the change in

CTOT and GDP per capita are significant at the 5% level in the fourth regression. The signs of these coefficients are the same as in the baseline regression, too.

Table 6: investigating the impact of CTOT volatility on infant mortality rates with fixed time and entity effects, using a subsample of the quartile of countries with most volatile CTOT rates

	(1) Δln(infant mortality rate)	(2) Δln(infant mortality rate)	(3) Δln(infant mortality rate)	(4) Δln(infant mortality rate)
CTOT volatility	.086***	.089***	.078*	.111
	(.027)	(.026)	(.043)	(.066)
Change in CTOT		-.003	0	.011**
		(.003)	(.007)	(.004)
Δln(inflation)			.013	.12
			(.26)	(.326)
Δln(GDP per capita)			-.154*	-.218**
			(.083)	(.098)
Δln(domestic credit to private sector in % of GDP)			-.069	-.038
			(.093)	(.11)
Δln(child population)				.041
				(.076)
Δln(primary enrolment)				-.189
				(.16)
Observations	103	103	78	61
R-squared	.174	.177	.237	.29

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

5.3 Institutional quality, agricultural sector and export dependency

The following section will discuss the regressions that examine the heterogeneity of the baseline results. As mentioned under 2.2, the expectation is that CTOT volatility has a more pronounced impact on infant mortality rates in countries with lower institutional quality, greater export dependency and larger agricultural sector size. This hypothesis was tested by introducing interaction dummy variables into the baseline regressions to explore how the results vary across countries with different levels of institutional quality, agricultural sector size and export dependency. The regression below displays the three regressions created with a dummy variables indicating whether a country falls into the upper quartile for the lowest institutional quality (regression 1), largest agricultural sector size (regression 2), and highest export dependency (regression 3). This regression also includes all control variables. Additionally, three other regressions have been created: one with all control variables and a dummy for the upper half of countries, and two without control variables, each with a dummy for the upper quartile or half of countries for each characteristic. These additional regressions are shown under appendix H.

Table 7: introducing an interaction effect for the upper quartile of countries with lowest institutional quality, largest agricultural sector and export dependency (including all control variables)

	(1) Δln(infant mortality rate) Agri-sector size	(2) Δln(infant mortality rate) Institutional quality	(3) Δln(infant mortality rate) Export dependency
CTOT volatility	.04*	.033*	.091***
	(.02)	(.018)	(.026)
Dummy upper quartile x CTOT volatility	.016	.071	-.087***
	(.074)	(.072)	(.028)
Change in CTOT	.01***	.01***	.008**
	(.003)	(.003)	(.003)
Δln(inflation)	-.01	-.223	-.266
	(.055)	(.182)	(.18)
Δln(GDP per capita)	-.238	-.112**	-.122**
	(.186)	(.047)	(.049)
Δln(domestic credit to private sector in % of GDP)	-.117**	-.025	-.024
	(.048)	(.052)	(.053)
Δln(child population)	-.019	-.044	-.055
	(.058)	(.06)	(.062)
Δln(primary enrolment)	-.046	-.015	-.01
	(.06)	(.052)	(.054)
Observations	216	216	216
R-squared	.118	.125	.143

Robust standard errors are in parentheses
**** $p<.01$, ** $p<.05$, * $p<.1$*

The dummy variables for agricultural sector size are consistently positive but differ in significance. The regression shown in table 5 shows no significantly different relationship in the quartile of countries with greatest agricultural sector size. This interaction effect is only statistically significant at the 10% level when the control variables are omitted from the regression (Appendix H, table H2). The interaction effect does become significant when the dummy variable for the upper half of countries with largest agricultural sector size is used (appendix H, tables H1 & H3). Overall, this interaction effect could signify that having a large labour-intensive exporting sector, like the agricultural sector, can amplify the impact of a volatile CTOT on infant mortality rates.

The dummy variables for institutional quality are less conclusive, as the interaction effect is insignificant in all four regressions. The interaction effect is consistently positive, though, which does suggest that the impact of CTOT volatility is at least not more pronounced in countries with greater institutional quality. As mentioned under title 2.2, the expectation was that countries with lower institutional quality would be more vulnerable to CTOT volatility due to complicated fiscal planning. Although the magnitude of the interaction effect in Table 7 is substantial, its significance is diminished by the large standard error.

Lastly, the interaction variables for export dependency are consistently negative and significant in all regressions, which contradicts the expectation set out under title 2.2 that countries with greater export sectors are more vulnerable to shocks in export prices. The negative coefficient namely indicates that CTOT volatility has a smaller impact on infant mortality rates in countries with large export sectors. In table 7, it is also noticeable that the magnitude of the coefficient for the CTOT volatility increased substantially in comparison to the baseline regression in table 3. This observation could suggest that CTOT volatility has a more amplified impact on infant mortality rates in countries with smaller export sectors.

5.4 Discussion

The most significant limitation of this study is the number of observations in each regression. Transforming the data into non-overlapping periods of 5 year limited the number of observations per country to a maximum of eight. There were also significant gaps in the data available for the control variables – most notably for the inflation rate and financial development proxy– which lowered the observations available in the analysis. It is notable, that reducing the length of the period to three years in the second robustness check, to increase the number of observations, did not lead to any fruitful results, due to substantially higher noise and variability.

Secondly, it is important to recognize the attrition bias caused by the bulk of missing observations to come from older time periods. Most observations missing are namely from the periods 1980-2000. Seeing that infant mortality rates were, on average, higher in the past (see time plots in appendix E) there is a possibility that this also led to a bias in the coefficients of the independent variables. Furthermore, this attrition bias also reduces the statistical power of the analysis.

Third, there is a possibility of omitted variable bias in the baseline regressions due to the selection of control variables. The selection was heavily influenced by data availability, leading to the omission of factors impacting infant mortality rates for which no data was available. As mentioned before, the proportion of the population aged 65 and up – used by Makhlouf et al. (2017) to control for the age of the population, was omitted for this reason. Additionally, Arik & Arik (2009) have shown that female education is also a strong indicator for infant mortality rates. This variable was also omitted due to limited data availability.

Lastly, this thesis focused on the medium to long term effect of commodity price volatility on infant mortality rates. There are, however, also numerous studies that approached volatility studies with a SVAR analysis that zoomed in to the immediate effect of a commodity price shock. Cavalcanti et al. (2014), for example, produced a series of impulse response functions that showed the immediate effect of a shock in the CTOT on macroeconomic variables like growth and capital accumulation. The methodological approach in this study was made under the assumption that infant mortality rates are only impacted by CTOT volatility on the medium to long term. If infant mortality rates were however impacted on the short term, the SVAR method could have also produced useful insights.

IV Conclusion

The goal of this thesis was to explore the relationship between infant mortality rates and CTOT volatility in African countries. The main hypothesis was that greater volatility in the CTOT lead to greater infant mortality rates. This thesis considered three distinct theoretical channels through which this relationship occurred: complicated fiscal planning, an unfavorable macroeconomic environment and lowered household incomes. These three theoretical channels brought about the hypothesis that this positive relationship becomes more pronounced in countries with lower institutional quality, greater agricultural sector size and increased export dependency. These hypotheses were tested through a series of fixed effects OLS regressions on a panel data set on 52 African countries covering 1980-2020.

Like Makhlouf et al. (2017), this thesis found a positive relationship between CTOT volatility and infant mortality rates. The significance of this relationship varied between the regressions in this study. This relationship was significant at the 5% level for all baseline regressions, besides the regression that only controlled for macroeconomic conditions. The significance decreased substantially in the robustness checks, where no significant relationship was revealed in the regressions using three-year periods and the fixed weights CTOT. The robustness check that looked at the subsample of countries with most volatile CTOT rates, only yielded significant results when all control variables, besides the change in CTOT, were omitted. Notwithstanding, the relationship the CTOT volatility and infant mortality rates were positive across all regressions. This relationship can therefore be considered significant, albeit of a low magnitude.

This thesis furthermore explored how the impact of CTOT volatility varied across countries with different levels of institutional quality, agricultural sector size and export dependency. The results showed that the effect did not vary significantly between countries with different levels of institutional quality. The effect of CTOT volatility became more pronounced in countries with greater agricultural sector size and less pronounced in countries with greater exports. The insignificant impact of institutional quality is unexpected, considering the vast body of literature that highlights the importance of institutional quality in country's ability to withstand external shocks, like export price fluctuations (Cavalcanti et al., 2014). The negative interaction effect of export dependency was also unexpected, as the expectation was that export dependent countries are, on average, more vulnerable to commodity price shocks. Further research into these interaction effects could therefore be warranted by the results of this thesis.

Another notable finding was the positive relationship between the CTOT rate and infant mortality rate. Across all regressions the coefficient for the change in CTOT was either positive or equal to zero. For a substantial number of regressions, this coefficient was statistically significant at the 5% level, too. These results hint at a positive relationship between the CTOT level and infant mortality rates, while the expectation was to find an insignificant relationship between these two variables, following the findings of Makhlouf et al. (2017).

The policy implications of this study are rather limited, as the results have only revealed a weak relationship between infant mortality rates and CTOT volatility. This thesis does, however, suggest that volatile commodity prices play a significant role in the resource curse as hypothesized by, for example, Cavalcanti et al. (2014). The relationship between infant mortality rates and CTOT volatility does namely indicate that commodity price volatility has a negative impact on development through for example infant mortality rates. It follows that this thesis supports the argument for developing countries to reduce commodity dependency and diversify their exports to become less exposed to volatile commodity world prices.

As noted in the previous section, this study faced several limitations that must be kept in mind when interpreting its results. Most notably, the limited data availability – in particular for the control variables – could have obstructed the production of more significant results. It would therefore be a meaningful extension of this study to reevaluate the relationship between CTOT volatility and infant mortality rates when more data is available. Moreover, this study solely focused on export prices to evaluate the impact of commodity trading on developing countries. It would be interesting to also look at import prices to gain a more wholistic view between the relationship of development and commodity prices.

References

African Development Bank. (2007). *African Development Report 2007*. Oxford University Press.

Arik, H., & Arik, M. (2009). Is It Economic Growth or Socioeconomic Development? A Crosssectional Analysis of the Determinants of Infant Mortality. *The Journal of Developing Areas*, *42*(2), 31–55. http://www.jstor.org/stable/40376209

Asian Development Bank. (2010). Social impact of commodity price volatility in Papua New Guinea. *Poverty and Sustainable Development in Asia*.

Avendano, M. (2012). Correlation or causation? Income inequality and infant mortality in fixed effects models in the period 1960–2008 in 34 OECD countries. *Social Science & Medicine*, *75*(4), 754–760. https://doi.org/10.1016/j.socscimed.2012.04.017

Badeeb, R. A., Lean, H. H., & Clark, J. (2017). The evolution of the natural resource curse thesis: A critical literature survey. *Resources Policy*, *51*, 123–134. https://doi.org/10.1016/j.resourpol.2016.10.015

Barka, H. B., Awiti, C., Slany, A., Tepe, S., & Yedan, A. (2023). Economic Development in Africa Report 2023. In *UNCTAD*.

Bishai, D., Opuni, M., & Poon, A. (2006). Does the level of infant mortality affect the rate of decline?: Time Series data from 21 countries. *Economics & Human Biology*, *5*(1), 74–81.

Blattman, C., Hwang, J., & Williamson, J. (2004). *The Impact of the terms of trade on Economic development in the periphery, 1870-1939: Volatility and secular change*. https://doi.org/10.3386/w10600

Brunnschweiler, C. N. (2008). Cursing the blessings? natural resource abundance, institutions, and economic growth. *World Development*, *36*(3), 399–419. https://doi.org/10.1016/j.worlddev.2007.03.004

Caporale, G. M., & Gil-Alana, L. A. (2014). Infant mortality rates: time trends and fractional integration. *Journal of Applied Statistics*, *42*(3), 589–602. https://doi.org/10.1080/02664763.2014.980785

Carrasco, J. M., & Romero, J. (2022). Commodity price shocks and child mortality: evidence from Anti-Coca policies in Peru. *International Food Policy Research Institute*.

Cilliers, J. (2024). Africa's growing dependence on commodities. In African Futures. ISS African Futures.

Combes, J., & Guillaumont, P. (2002). Commodity price volatility, vulnerability and development. *Development Policy Review*, *20*(1), 25–39. https://doi.org/10.1111/1467-7679.00155

De V Cavalcanti, T. V., Mohaddes, K., & Raissi, M. (2014). Commodity Price Volatility and the Sources of Growth. *Journal of Applied Econometrics*, *30*(6), 857–873. https://doi.org/10.1002/jae.2407

Dutta, U. P., Gupta, H., Sarkar, A. K., & Sengupta, P. P. (2020). Some Determinants of Infant Mortality Rate in SAARC Countries: an Empirical Assessment through Panel Data Analysis. *Child Indicators Research*, *13*(6), 2093–2116. https://doi.org/10.1007/s12187-020-09734-8

Gavin, M., & Hausmann, R. (1998). Macroeconomic volatility and economic development. In *Palgrave Macmillan UK eBooks* (pp. 97–116). https://doi.org/10.1007/978-1-349-26284-7_5

Gruss, B., & Kebhaj, S. (2019). Commodity Terms of Trade: A new database. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3333745

Hadass, Y. S., & Williamson, J. G. (2003). Terms-of-Trade Shocks and Economic Performance, 1870–1940: Prebisch and singer revisited. *Economic Development and Cultural Change/Economic Development and Cultural Change (University of Chicago. Online)*, *51*(3), 629–656. https://doi.org/10.1086/375259

Harvey, D. I., Kellard, N. M., Madsen, J. B., & Wohar, M. E. (2010). The Prebisch-Singer Hypothesis: Four centuries of evidence. *the Review of Economics and Statistics*, *92*(2), 367–377. https://doi.org/10.1162/rest.2010.12184

Hegerty, S. W. (2016). Commodity-price volatility and macroeconomic spillovers: Evidence from nine emerging markets. *the North American Journal of Economics and Finance*, *35*, 23–37. https://doi.org/10.1016/j.najef.2015.10.014

Lee, D. (2023). Commodity terms of trade volatility and industry growth. *European Economic Review*, *156*, 104479. https://doi.org/10.1016/j.euroecorev.2023.104479

Little, I. M. D., Cooper, R. N., Corden, W. M., & Rajapatirana, S. (1994). Trade policies: tightening and liberalization. In *Boom, Crisis, and Adjustment: The Macroeconomic Experience of Developing Countries (A World Bank Book)* (Vol. 32, Issue 01, pp. 264–289). Oxford University Press.

Makhlouf, Y., Kellard, N. M., & Vinogradov, D. (2017). Child mortality, commodity price volatility and the resource curse. *Social Science & Medicine*, *178*, 144–156. https://doi.org/10.1016/j.socscimed.2017.01.063

Mendoza, E. G. (1995). The terms of trade, the real exchange rate, and economic fluctuations. International Economic Review, 36(1), 101. https://doi.org/10.2307/2527429

Miller, G., & Urdinola, B. P. (2010). Cyclicality, mortality, and the value of time: the case of coffee price fluctuations and child survival in Colombia. *Journal of Political Economy*, *118*(1), 113–155. https://doi.org/10.1086/651673

Mohtadi, S., & Castells-Quintana, D. (2021). The distributional dimension of the resource curse: Commodity price shocks and income inequality. *Structural Change and Economic Dynamics*, *59*, 63–78. https://doi.org/10.1016/j.strueco.2021.08.002

Moser, G. G., & Ichida, T. (2001). Economic growth and poverty reduction in Sub-Saharan Africa. *IMF Working Paper*, *01*(112), 1. https://doi.org/10.5089/9781451853605.001

Moore, D. S. (2011). CHAPTER 12 Inference for regression. In *The practice of statistics for business and economics*. W H Freeman & Company.

Panda, P. (2020). Does trade reduce infant mortality? Evidence from sub-Saharan Africa. *World Development*, *128*, 104851. https://doi.org/10.1016/j.worlddev.2019.104851

Sagan, L., & Afifi, A. (1978). Health and Economic Development I: Infant Mortality. *IIASA*. http://pure.iiasa.ac.at/id/eprint/956/

Sengupta, J., Nag, R. N., & Goswami, B. (2017). Commodity price fluctuations and unemployment in a dependent economy. *Contemporary Economics*, *11*(3), 315–325. https://doi.org/10.5709/ce.1897-9254.245

Shaxson, N. (2005). New approaches to volatility: dealing with the 'resource curse' in sub-Saharan Africa. *International Affairs*, *81*(2), 311–324. https://doi.org/10.1111/j.1468-2346.2005.00452.x

Spatafora, N., & Tytell, I. (2009). Commodity Terms of Trade: The History of booms and busts. *Social Science Research Network*. https://doi.org/10.2139/ssrn.1486523

UN-IGME. (2024). Levels and trends in child mortality. In *UNICEF Data*.

Ziesemer, T. H. (1994). Economic Development and Endogenous Terms-of-Trade Determination: Review and Reinterpretation of the Prebisch-Singer Thesis. *MPRA Paper*. https://ideas.repec.org/p/pra/mprapa/54864.html

Appendix

Appendix A: Country list

Table A: list of African countries in alphabetical order

Algeria	Equatorial Guinea	Mauritania	Tunisia
Angola	Eritrea	Mauritius	Uganda
Benin	Eswatini, Kingdom of	Morocco	Zambia
Botswana	Ethiopia	Mozambique	Zimbabwe
Burkina Faso	Gabon	Namibia	
Burundi	Gambia, The	Niger	
Cabo Verde	Ghana	Nigeria	
Cameroon	Guinea	Rwanda	
Central African Republic	Guinea-Bissau	São Tomé and Príncipe	
Chad	Kenya	Senegal	
Comoros	Lesotho	Seychelles	
Congo, Democratic Republic of	Liberia	Sierra Leone	
Congo, Republic of	Libya	South Africa	
Côte d'Ivoire	Madagascar	Sudan	
Djibouti	Malawi	Tanzania	
Egypt	Mali	Togo	

Appendix B: CTOT equation

$$\Delta \ln\left(CTOT_{i,t}\right) = \sum_{J=1}^{J} \Delta P_{J,t} \tau_{i,j,t}$$

Where P is the price of a commodity, τ the weight of the commodity in a country's export revenue, j refers to the commodity, t the time and i the country (Mati et al., 2021).

Appendix C: Hausman test

Table C: Hausmann test comparing a fixed effects and random effects model

	Coef.
Chi-square test value	44.566
P-value	.038

Appendix D: Augmented dickey fuller testing stationarity:

Table D1: ADF test for stationarity on infant mortality rates

	Statistic	p-value
Inverse chi-squared(104)	P=316.6791	0.0000
Inverse normal	Z=0.9190	0.8209
Inverse logit t(259)	L=4.3941	0.0000
Modified inv. chi-squared	Pm=14.7466	0.0000

Table D2: ADF test for stationarity on infant mortality rates

	Statistic	p-value
Inverse chi-squared(104)	P=575.884	0.0000
Inverse normal	Z=-10.488	0.0000
Inverse logit t(259)	L=-19.842	0.0000
Modified inv. chi-squared	Pm=32.719	0.0000

Appendix E: Time plots infant mortality rates and CTOT volatility:

Table E1: Plotting average CTOT volatility over time

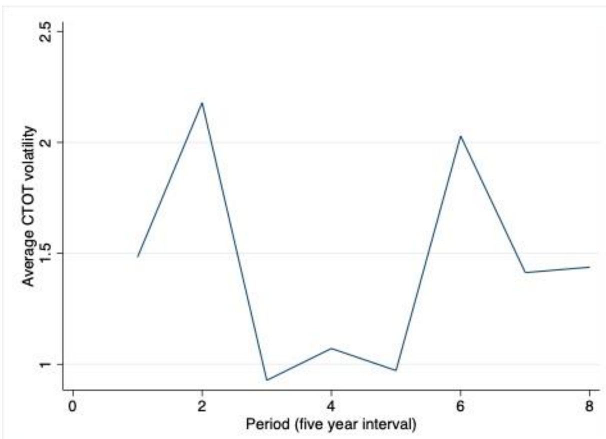
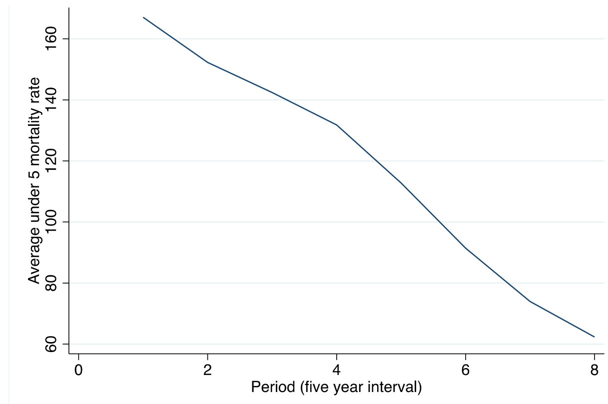
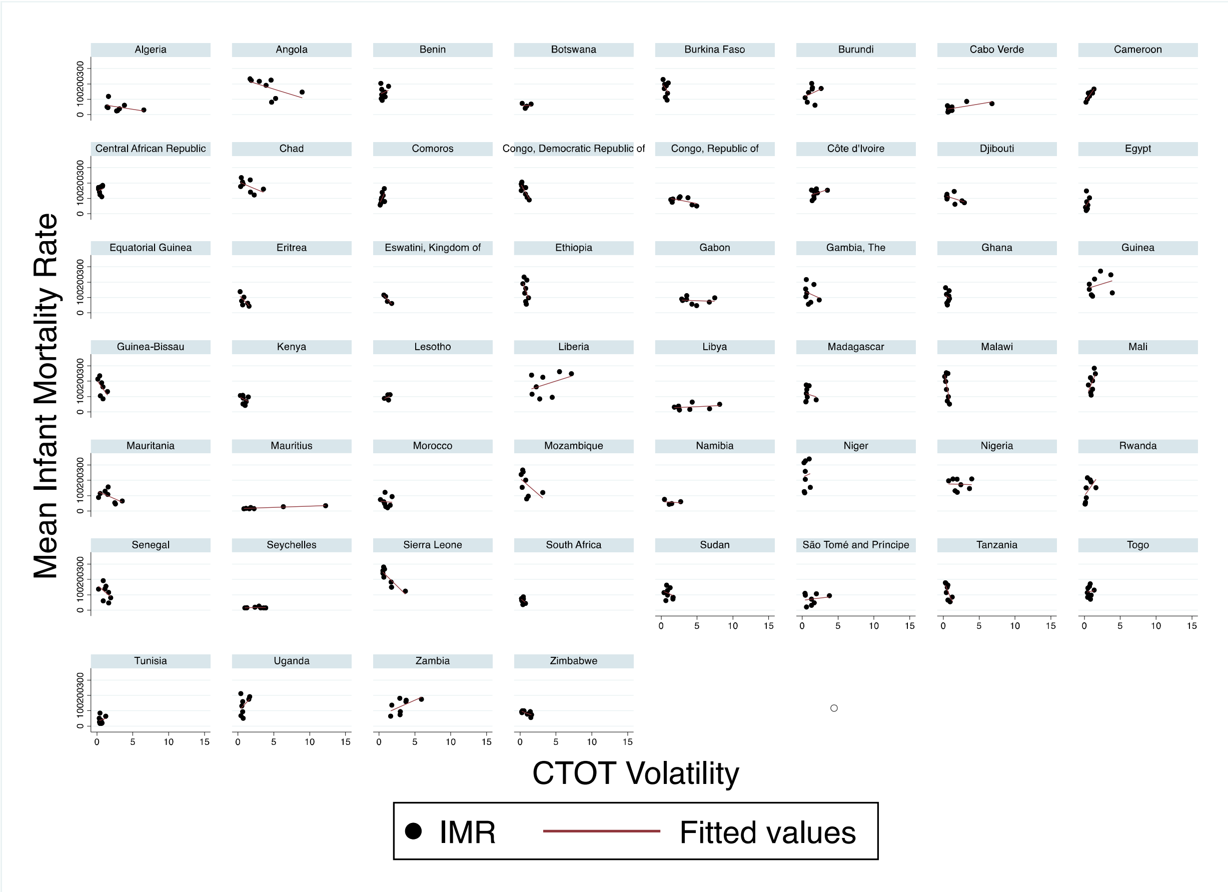


Table E2: Plotting average infant mortality rates over time



Appendix F: Pooled scatter plots comparing infant mortality rates and CTOT volatility



Appendix G: Diagnostic tests on baseline regressions:

Table G1: P-values for a Wald test for heteroskedasticity

Regression #	P-value
1	0.022
2	0.011
3	0.089
4	0.0475

Table G2: P-values for a Woolridge test for autocorrelation

Regression #	P-value
1	0.022
2	0.028
3	0.055
4	0.107

Appendix H: Heterogeneity regressions

Table H1: introducing an interaction effect for the upper half of countries with lowest institutional quality, largest agricultural sector and export dependency (including all control variables)

	(1) Δln(infant mortality rate) Agri-sector size	(3) Δln(infant mortality rate) Institutional quality	(3) Δln(infant mortality rate) Export dependency
CTOT volatility	.028*	.028	.121***
	(.016)	(.02)	(.044)
Dummy upper half x CTOT volatility	.119**	.054	-.091*
	(.047)	(.045)	(.048)
Change in CTOT	.01***	.009***	.01***
	(.003)	(.003)	(.003)
Δln(inflation)	-.003	-.237	-.277
	(.054)	(.18)	(.183)
Δln(GDP per capita)	-.243	-.116**	-.115**
	(.171)	(.047)	(.048)
Δln(domestic credit to private sector in % of GDP)	-.115**	-.017	-.029
	(.048)	(.053)	(.054)
Δln(child population)	-.025	-.04	-.041
	(.054)	(.06)	(.061)
Δln(primary enrolment)	-.044	-.004	-.005
	(.061)	(.055)	(.054)
Observations	216	216	216
R-squared	.144	.126	. 134

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

Table H2: introducing an interaction effect for the upper quartile of countries with lowest institutional quality, largest agricultural sector and export dependency (omitting all control variables)

	(1) Δln(infant mortality rate) Agri-sector size	(3) Δln(infant mortality rate) Institutional quality	(3) Δln(infant mortality rate) Export dependency
CTOT volatility	.047*	.061*	.116***
	(.024)	(.03)	(.026)
Dummy upper quartile	.063*	-.028	-.103***
	(.034)	(.037)	(.031)
Observations	389	389	389
R-squared	.055	.052	.087

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

Table H3: introducing an interaction effect for the upper half of countries with lowest institutional quality, largest agricultural sector and export dependency (omitting all control variables)

	(1)	(3)	(3)
	Δln(infant mortality rate)	Δln(infant mortality rate)	Δln(infant mortality rate)
	Agri-sector size	Institutional quality	Export dependency
CTOT volatility	.041*	.058	.14***
	(.023)	(.035)	(.034)
Dummy upper half	.084***	-.01	-.106***
	(.03)	(.038)	(.039)
Observations	389	389	216
R-squared	.064	.05	.077

Robust standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*