# Does Trade reduce Infant Mortality? Evidence from Sub-Saharan Africa[1]

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## Abstract

This study estimates the effects of a large scale trade policy shift on a development indicator like infant mortality, using the recent experience of African Growth and Opportunity Act (AGOA) affecting sub-Saharan Africa. The average difference in probability of death of children born to the same mother before and after AGOA in both AGOA affected and not-AGOA affected countries were estimated, using the retrospective Demographic and Health Surveys (DHS) from 30 sub-Saharan African countries. This helps in exploiting the within-mother variation, which is an improvement over the cross-country studies carried out till date. The identification assumption is that timing of AGOA is exogenous with respect to timing of birth across siblings, and mother fixed effects will difference out time invariant characteristics which may bias results. Findings suggest that infant mortality falls by about 7 to 13 infant deaths per 1000 which is as much as 9% to 16% of the sample mean. This result is robust to controlling for country specific linear trends and country level time varying indicators like GDP per-capita, average female literacy, commodity price index and political regime of the country. It was also found that uneducated women and rural women experience significant decreases in infant deaths. Moreover, the poor experience a large decline compared to non-poor implying trade does not reinforce inequality (in health outcomes). At the macro level, the effect seems to be taking place via increase in GDP per capita and increases in health expenditure per capita. Studying the heterogeneity at country level suggests that the low-income sub-Saharan African countries benefit more out of the policy change. The heterogeneous effects show that trade is helping the more backward sections of the society and low income countries better and hence improving developmental outcomes.

***Keywords:*** Infant Mortality, Child Health, Trade Openness, sub-Saharan Africa

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# 1 Introduction and Background

Over the years, trade has been posited as a key factor in economic development. Economists have argued that trade predicts higher income growth rates (Dollar and Kraay, 2001; Frankel and Romer, 1999). Hence, many developing countries have adopted increasingly open trade policies in the hopes of spurring growth. But, this large literature on trade by far remains inconclusive about its effects on development. In the literature, there are a few country-specific studies analyzing the effect of trade on poverty and inequality as development outcomes (Topalova, 2005; Porto, 2004). There have been even fewer studies analyzing the effect of trade on child health and those exist only in a cross-country cross-sectional setting (Levine and Rothman, 2006)[2]. The problem with cross-country data analysis is that data across countries may not be comparable, may suffer from small sample size and may face difficulty in disentangling the effects of trade policy vis-à-vis simultaneous change in other policies. To alleviate this problem, this study focusses on the impact of a large-scale trade policy shift on an important social development indicator – viz., infant mortality – by building a pseudo-panel micro-dataset across countries and using this dataset for analysis.

Trade can affect the development process of a country via various direct and indirect mechanisms, both at the macro and micro level. Trade affects the overall aggregate or macro state of the economy by affecting economic growth, government health expenditures, urbanization and cultural changes which in turn affects the socio-economic indicators. Trade will improve health conditions in the country if it increases the revenue of the government allowing it to increase health expenditures. Economic growth also results in higher household incomes, which in turn could improve health outcomes via mechanisms like improved nutrition, improved access to sanitation and health care etc. On the other hand, if trade results in increased inequality, then the incomes of the poor may be adversely affected and this in turn may worsen their health conditions.

Trade may also affect the individuals and households directly at the micro-level via household and market effects by changing factor prices, creation/destruction of markets, changing relative prices causing substitution away from goods and creation of employment opportunities. Increased prices of goods due to trade could harm a household that is a net buyer of the good, and benefit that which is a net seller. An increase in inflation decreases the purchasing power of

[2] The development outcomes studied here are infant and under-5 child mortality, child stunting and wasting using data from World Development Indicators, WHO and UNICEF for a cross-section of 100-130 countries.

individuals due to which all the individuals will be willing to spend less on health services, decreasing private health spending and hence harming the health of the population. Increasing opportunities for employment of mothers may contribute towards improving health of the child, due to increasing incomes (income effect) or may even deteriorate health of child as the mother stays away from home (substitution effect). So theoretically, trade may have positive impact, negative impact or no impact at a micro level. An empirical study of this kind intends to analyze the impacts and pathways.

Sub-Saharan Africa is plagued with one of the highest infant and child mortality rates. Infant mortality rate is a socio-economic indicator which points towards well-being and/or health of the population in any country. There have been numerous efforts to tackle the problem of infant mortality in Africa over the years. Recently, sub-Saharan African countries experienced a huge trade agreement - African Growth and Opportunity Act (AGOA) - which conferred on these sub-Saharan African countries largely duty free and quota free access to US markets. This agreement intends to increase export volumes, spurring economic growth in these economies. This deal started in 2000 and has had amendments at regular intervals. There was a phase-wise allocation of AGOA rights to these countries, which permits the usage of the time variation for identification. Frazer and Biesebroeck (2010) found that AGOA had a large and robust impact on exports to US without decreasing the country's export to Europe. Some countries like Kenya experienced almost a 700% increase in exports to US from $36 million in 2000 to $284 million in 2010[3]. Since this trade agreement increased trade volumes and hence incomes for these countries, this study becomes extremely relevant in analyzing if there has been any substantial benefit in terms of improving health conditions in these countries, which is a major developmental concern for the countries in question.

The problem with the studies concerning liberalization in a single country or cross-country at a point in time is that trade liberalization or trade policies are generally endogenous and it is difficult to infer causality in the presence of other confounding socio-economic policies changing at the same time. In this paper, datasets across 30 sub-Saharan African countries from existing household level cross-sectional surveys (Demographic and Health Surveys, DHS) have been collated using the recall data to get a micro-dataset which runs across the sub-Saharan African countries, with the time dimension being the year of child birth given by each mother. By

[3] Onyago and Ikiara (2011) in Reflections on Kenya's Experience under AGOA: Opportunities and Challenges.

observing the children of the same mother before and after the trade policy change, a within-mother variation in survival of children is carried out rather than cross-country or within-country variation; which in turn will help develop a near-causal analysis of effect of trade on health. The paper's findings suggest that infant mortality falls by about 0.7 to 1.3 percentage points which is as much as 9%-16% of the sample mean. This operates via the mechanisms of increasing GDP per capita and increasing health expenditures per capita. The income boost brought about by trade does not only have a transient effect, but also affects development outcomes. Having a micro dataset which runs across countries also helps in identifying the heterogeneous effects based on education, place of residence and wealth.

## 2 African Growth and Opportunity Act (AGOA)

The African Growth and Opportunity Act (AGOA) has been part of the US international cooperation efforts for Africa since 2000. AGOA was initially set to expire in 2008 but was eventually extended to 2015. It entails a series of incentives provided to African countries by the US opening its market for exports originating from these countries. The legislation provides for preferential treatment of exports from Africa in the form of duty-free and largely quota-free access to US markets. AGOA places heavy emphasis on Africa's emerging textile and apparel industry as the primary sector for trade benefits. Currently, 38 sub-Saharan African nations are AGOA eligible of which 27 have eligibility for textile and apparel benefits. With regards to conditions, AGOA preferences are afforded to countries meeting certain economic, political and human rights conditions and are equally withdrawn if countries fail to comply with these conditions. While AGOA removes import duties on eligible African imports, preferential market access is granted only upon compliance with the relevant Rules of Origin. These rules prescribe the percentage value added that must take place locally in an AGOA-beneficiary country, while special provisions relating to apparel outline what processing must take place locally. Overall, total US imports have increased significantly from $5B in 2000 to over $25B in 2005 (Paulos et al., 2010).

Country eligibility for AGOA is determined by the US President (and listed in section 107 of the African Growth and Opportunity Act), and takes into account whether countries meet with a number of requirements. Countries need to "have established, or are making continual progress toward establishing the following: market-based economies; the rule of law and political pluralism; elimination of barriers to U.S. trade and investment; protection of intellectual

property; efforts to combat corruption; policies to reduce poverty, increasing availability of health care and educational opportunities; protection of human rights and worker rights; and elimination of certain child labor practices". The eligibility criteria for the Generalized System of Preferences (GSP) and AGOA substantially overlap, and countries must be GSP eligible in order to be eligible for AGOA.

Paulos et al. (2010) review the progress of a decade of AGOA and find that even though exports may be increasing, it may not be benefitting the countries internally. Thompson (2004) and Mattoo et al. (2006) show that the largest share of US imports from Africa remain to be the oil and energy sectors. Hence, the preference system has not led to an increase in diversification of African economies. Moreover, only a few countries from the whole of Africa actually reap the maximum benefits (Kimenyi (2009)). Hence, it is not clear if AGOA has led to an increase in economic growth of the economies. With the Rules of Origin a bit lax for the developing countries, many Chinese companies have set up facilities in EPZs which produce those textile exports and hence the increase in income is not percolated down to the economy as the raw materials are not coming from within the countries. Moreover, with the ending of Multi-Fibre Agreements (MFA) in 2005, the exports from African countries have decreased in the face of competition from China, Bangladesh, and India. In the light of such studies, it becomes important to look at the effect of AGOA on the people living in these economies.

# 3 Data

The micro level health data for the sub-Saharan African countries comes from the Demographic and Health Surveys (DHS), which is funded by USAID. The DHS questionnaire is standardized, which provides a perfect platform to compare datasets across countries where this survey is carried out. DHS are nationally representative household surveys that provide data for population, health and nutrition. The Standard DHS Surveys have large sample sizes and are typically conducted about every 5 years. Information regarding child health, Anemia, domestic violence, maternal mortality, HIV Prevalence etc. is found in the surveys, along with normal individual characteristics.

DHS collects data using three types of questionnaires – household, women's and men's questionnaires. Household questionnaire is used to collect data on household dwelling units, nutritional status, and anemia; while women's questionnaire is used to collect data from women about the characteristics, reproductive behavior, contraception, children's health etc. Women of

reproductive age (15-49 years) are interviewed about the date of birth and death (if applicable) for up to 20 children they have had. This kind of retrospective survey gives an opportunity to build a panel dataset of mothers, with the time dimension being the year of child birth given by each mother. One problem that can be raised with the recall data is the measurement error problem. To be robust to measurement error and to capture the maximum effect of carrying out the siblings analysis, all children born before 1990 were dropped from the sample. This ensures that the siblings are not very far apart in age and hence are broadly comparable. This also reduces the recall bias.

There are 36 DHS Surveys publically available for the sub-Saharan countries where DHS survey has been carried out at least once till now. Based on the survey time requirements, 30 surveys have been collated to obtain a sample of children along with their mothers[4]. A dummy variable indicating if the child has died before reaching the age of 1 year is constructed. This will be the indicator for *individual-level* infant mortality. Since measurement error is a serious concern for country level data such as infant mortality across countries (Krueger and Lindahl, 2001), the construction of this indicator from household level data overcomes this problem at a broad level. As long as at least one round of survey has been conducted in a particular country, a pseudo-panel dataset of mothers for that country can be built. The effect of trade policy on infant mortality will be gauged by studying the varying exposure between the children born to same mothers but exposed to AGOA or not. The DHS dataset provides an excellent opportunity to carry on the type of micro level analysis for a macroeconomic shock as is intended.

After dropping data for children born within twelve months of the survey or born before 1990, to ensure full exposure for every child in the sample and reduce measurement error, there is a sample of 686,093 children born to 212,738 mothers. The sample average infant mortality rate is 8.15% of live births while the sample neonatal mortality rate is 3.8% of live births. In Table 1(a), we can see that average infant deaths for the whole population, as well as infant mortality based on different characteristics of mother like education, place of residence and wealth levels, significantly (based on t-statistic) decreases after AGOA is implemented. Table 1(b) compares the average number of girl births, number of multiple births and mother's age at birth between AGOA affected and non-affected countries. It is observed that these countries are similar in terms of sex composition and multiple births, but the composition of mother's age at birth is

[4] The list of DHS used and respective sample periods are listed in Table A1 in Appendix.

different across these countries. In the estimation, hence, there is an additional control for mother age at birth to see the effect on the estimated coefficients.

To check if the mothers giving two or more births are different from mothers in the entire sample, Table 1(c) shows the summary characteristics of children born to these different sets of mothers. It is observed that the average infant mortality and neonatal mortality are not systematically different for mothers with two or more births than from the population at large. The sample of mothers with two or more children has the same average educational attainment, wealth and age at birth. There are no systematic differences between the two samples and hence mother fixed effects will not be biasing the results. Since mother fixed effects estimation derives the effect of AGOA on infant mortality using those mothers giving birth both before and after AGOA, Table 1(d) shows the sample mean infant and neonatal mortality rates for mothers giving birth both before and after AGOA and for mothers with more than two births only before or after AGOA. It is seen that sample mean infant and neonatal mortality rates fall for both the groups after AGOA is implemented, though it falls more for the mothers giving birth both before and after AGOA. This hints towards a change in composition of mothers after AGOA has been implemented, leading us to believe the necessity of controlling for mother fixed effects.

## 4 Empirical Strategy

To analyze if trade has reduced infant mortality, the following linear probability model[5] is estimated:

$$IMR_{imct} = \alpha_m + \beta_t + \gamma T_{ct} + X_{imct}\delta + \mu_c.t + \varepsilon_{imct} \quad (1)$$

Here, IMR is a dummy which takes the value 1 if child i born to mother m in country c at time t dies before reaching the age of 1 year, $\alpha_m$ is mother fixed effect, $\beta_t$ is birth-year fixed effect and $\mu_c.t$ captures the country-time specific trend. $T_{ct}$ takes the value 1 if the specific country was under AGOA at time t. $X_{imct}$ is a vector of control characteristics like sex, whether or not they are born in multiple births (i.e. twins, triplets, etc.), dummies for their birth order and birth month. $\gamma$ provides the estimate of the effect of AGOA on infant mortality.

[5] I also check for Logit estimates. They are significant. But due to easier interpretation of LPM estimates, I present those in the results. Using Logit in Mother FE model would limit the possibility of obtaining marginal effect of trade on infant mortality.

For the estimates to be unbiased, the error should not be correlated with any of the covariates and outcomes. Time-invariant heterogeneity regarding geography, history, culture, politics and attitudes etc. are taken care of by the mother fixed effects ($\alpha_m$) since this is implicitly a country fixed effect – mothers of the children belong to a certain country of residence and hence controlling for mother's characteristics implies controlling for the country characteristics. There is a risk in works involving studying of trade policy change that higher ability mothers may self-select into having babies when incomes are higher and times are better (after the trade liberalization). But the formulation of this panel individual-level data rather than country level data helps tackle this endogenous selection issue as this is now taken care by the mother fixed effects. This specification also helps in controlling for events and factors which may affect both trade openness and changes in infant mortality overtime individually but not necessarily having a relationship between the two. The year fixed effects ($\beta_t$) control for an aggregate time variation involving improvement of health technology etc. It also may benefit to control for changing time of mother's age at birth due to improvements in survival of babies overtime in Africa. This is included in another specification, where mother's birth cohort by child's birth year fixed effects is controlled for. The country specific trends ($\mu_c.t$), in fact, also allow country specific improvement in technology i.e. differential states of development of the countries. Standard errors will be clustered at the country level to account for any serial correlation within the countries in the region.

But, there may be time variant heterogeneity which may affect both trade and infant mortality rates. Implementation of AGOA or how well the country does after its implementation may depend on the country's political situation, GDP per capita, average female education of the country etc. Countries with a higher GDP per capita or in a democratic regime may experience a lower IMR too (Kudamatsu, 2012). Hence these may bias the estimates. As a robustness check, at the country level there is a control for additional characteristics ($Z_{ct}$) like GDP per capita, political regime of the country, whether it is a democracy, degree of openness overtime, average level of female education etc. which may help control some of the time variant heterogeneity at the country level. The following equation is estimated to capture these effects:

$$IMR_{imct} = \alpha_m + \beta_t + \gamma T_{ct} + X_{imct}\delta + \mu_c.t + \lambda Z_{ct} + \varepsilon_{imct} \quad (2)$$

To check for heterogeneity based on mother's level of education, place of residence and possession of assets, the mother-FE regression has been run with appropriate interactions to tease out the effects.

# 5 Main Results and Heterogeneity

## *5.1 Main Results*

Figure 1 graphs the mean infant mortality rates for the 27 AGOA affected sub-Saharan African countries in the sample by year of birth of child, 1990 onwards. The data shows a declining trend in infant mortality over time. A sharp fall in infant deaths in some of the countries after the year AGOA is implemented is observed, more prominently than some others. There also seem to be some delayed effects overtime. Table 1(a), 1(b) and 1(c) present the summary statistics of the data, as discussed in the Data Section.

Table 2 provides the main regression results of the effects of treatment on infant mortality. Specification 1 (columns (1)-(3)) controls for linear country time trend and explanatory variables like birth order, sex of child, multiple birth and birth month. Column (1) shows the OLS results. The coefficient is negative and statistically significant. Controlling for country fixed effects in (2) increases the absolute value of coefficient to 1.3 percentage points. Controlling for mother fixed effects in (3) increases the absolute value of the coefficient marginally but the coefficient is still significant. Table 2, specification 2 (columns (4)-(7)) additionally controls for cohort-year fixed effects. By controlling for this, the changing time of mother's age at birth due to improvements in survival of babies over time in Africa is being controlled. It is observed that controlling for these with an interaction of dummies for mother's birth year (cohort) with child's year of birth reduces the magnitude of the coefficient to around 0.7 percentage points, but it still remains significant. Therefore some of the effect that was observed in (1)-(3) may be attributed to changing mother's age at birth over time.

It is also seen that the absolute value of coefficient decreases from 7.6 to 6.95 reductions in infant deaths per 1000 live births, as we move from OLS to Mother FE. This implies that not accounting for quality of mothers in this analysis has created a bias and including fixed effects takes the coefficient to be nearer to zero but is still significantly different from zero. Healthier and more 'intelligent' women seem to be timing the birth of their babies when times are better. This time invariant mother characteristic explains a part of the fall in infant mortality, which

initially was wrongly attributed to exposure to AGOA in the OLS specification. Comparing this with previous literature[6], it is found that the effect is higher in absolute magnitude using mother FE than in the cross-country setting, with trade openness contributing to a reduction by around 7 infant deaths per 1000 births. On carrying out mother fixed effects analysis of AGOA on neonatal mortality in column (7), a significant negative effect is found. Neonatal deaths reduce by 4.4 deaths per 1000, which is about 12% of the sample mean. Hence, majority of the reduction in infant deaths is coming via a decrease in neonatal deaths.

Figure 2 graphs the dynamics of infant mortality from 3 years before AGOA implementation to 4 years after it. It can be seen that infant mortality had been almost constant, not significantly different from zero in the three years before AGOA was implemented, but there is a significant drop in infant mortality as compared to 4 years before implementation of AGOA in year 1, year 3 and year 4 of AGOA being implemented. The effect decreases year 4 onwards most probably because of expiration of Multi-Fiber Agreement which decreased the exports from AGOA countries into the US and hence decreasing the effect of the agreement on the countries.

Table 3 controls for country level variables like log GDP per capita, Democratic regime, Openness, female education etc. in the mother FE specification with cohort-year FE. It can be argued that all the effect that trade brings on infant mortality is due to increasing per capita income. GDP per capita data is obtained from PWT 7.0 and log of GDP per capita is used to run the regression with cohort year fixed effects in Table 3 (1). Infant mortality was observed to decrease with an increase in the GDP per capita (significant at 10% level), but even controlling for GDP per capita did not reduce the magnitude of the AGOA coefficient much nor remove significance. Hence, it can be said that not all the effect that trade brings on infant mortality is via increasing per capita income at the country level.

In the literature, some studies find that democracy and political regime may affect child health (Kudamatsu, 2012). The effect of democracy and political regime has been controlled for by using the democracy-dictator data from Cheibub et al. (2010) which is an updated dataset based on Przeworski et al. (2000). They define democracy as: the executive is directly elected or indirectly elected via the legislature; the legislature is directly elected; there is more than one party; and the executive power alternates between different parties under the same electoral rule.

[6] Levine and Rothman (2006) find that for an average country, a 15-percentage point increase in predicted trade as a share of GDP results in 4 fewer infant deaths per 1000 births.

If a country satisfies these conditions, the democracy indicator takes the value 1. Regime is a categorical variable indicating parliamentary democracy; mixed (semi-presidential) democracy; presidential democracy; civilian dictatorship; military dictatorship; or royal dictatorship. In Table 3- columns (2) and (3), even controlling for both, democracy and political regime of the country, does not change the magnitude of the coefficient much from the results in Table 2. Democracy tends to reduce infant mortality but the coefficient is not significantly different from zero at the conventional level.

It may be argued that a country which already had trade routes open under GSP would have benefitted more from AGOA and hence its coefficient maybe capturing the effects of already increased trade flows. But controlling for openness from PWT 7.0 in Table 3 (4), it is observed that the coefficient is not significantly different from zero and the original coefficient on AGOA does not decrease in absolute value or significance. Data for the average years of schooling of females 15 years or older is collated from Barro and Lee (2010) and there is a control for average years of female education of the country in Table 3 (5). The number of countries for which this data is available falls to 21. It is seen that the coefficient is not significantly different from zero and also the coefficient on treatment to AGOA does not change much and stays statistically significant.

Commodity price fluctuations have contributed to improved incomes and growth in Africa over the last decade (Deaton, 1999). Considering this finding, the commodity price index derived from PWT 8.0 in Table 3 (6) is controlled for but this does not decrease the magnitude of the coefficient on AGOA much. The coefficient on commodity price index is itself significant and tends to increase infant mortality. In Table 3 (7), all the macro variables are controlled for and that also does not reduce the magnitude or significance of the variable in question. It confirms that the coefficient on AGOA is robust to controlling for some of the important country level time variant factors.

## *5.2 Heterogeneity*

AGOA may affect the recipient countries differentially based on their composition of exports at the country level. At the individual level, heterogeneity may exist based on characteristic of the mother and the household. These differences have been explored in the following section.

Table 4 checks for heterogeneity in effects based on mother's place of residence, education and possession of assets. It is observed that AGOA has a significant effect (similar in absolute

magnitude) in decreasing infant deaths of uneducated mothers. Similarly AGOA has a significant effect in reducing infant mortality for mothers living in rural areas but not for those living in urban areas. AGOA seems to be effective in significantly reducing infant deaths for poor, negating the widely held notion that trade increases inequality. AGOA seems to be affecting the more backward sections of the society, where there is a larger scope of reducing infant mortality. This is consistent with the standard economic theory (Hecksher-Ohlin model) stating that gains of trade should flow to abundant factors, and in this developing country setting, unskilled labor (uneducated rural poor mothers) should benefit the most.

AGOA may affect the recipient countries differentially based on their predominant commodity of export. It will be interesting to see if these differences also affect individuals and the health indicators differentially. There is a check for macro level heterogeneity in Table 5. Contrary to expectations, it is seen that countries having the highest volume of exports under AGOA or with petroleum products and apparel products as major exports do not differentially benefit more than other countries. It may well then be that resource rich countries are not really blessed in terms of harnessing the long term gains that trade may bring. The ending of Multi-Fiber Agreement in 2005 does seem to have an impact. With increasing competition in exports from China and other countries after 2005, it is observed that the impact of AGOA on infant mortality is significantly more before 2005. Also, low-income countries in sub-Saharan Africa experience a significant decline in infant mortality due to AGOA vis-à-vis the middle income countries. Even at the macro level, therefore, AGOA helps in levelling the disparities.

### *5.3 Pathways and Robustness Checks*

Table 6 delves into finding the possible pathways through which the effects are taking place at the macro level. Country level macro data from World Development Indicators and Penn World Table has been used and the Country Fixed Effects regression was run controlling for time, to find that increasing GDP per capita and health expenditure per capita seem to be major routes through which these effects are taking place. Apart from income boost, it is bringing about changes in public and private health expenditures which are benefiting the individuals in those countries. The pathway findings are similar to Levine and Rothman (2006)[7]. The country level data doesn't suggest any increase in women labor force participation. It seems that increase in

[7] The authors find that trade predicts higher income, higher immunization rate, and larger public health expenditures.

employment may be coming from the unorganized sector, which is not captured in this country level statistic.

Table 7 shows some more robustness result. Table 7 (a) shows that the result is robust to dropping one country at a time implying that these are not driven by changes in any single outlier country. Table 7 (b) controls additionally for country specific birth order dummy and country specific mother's age quadratic trend. The magnitude and significance of the coefficient derived in Table 2 is unchanged, implying that the result is robust to various specifications.

# 6 Conclusion and Future Work

## *6.1 Conclusion*

Trade policy has been pursued mostly keeping macroeconomic benefits in mind. But, these policies may have intended or unintended effects on microeconomic development indicators as well. Most of the studies till now either have all macroeconomic variables or all microeconomic variables in their analysis. This study bridges the gap and brings synthesis between the two literatures. The results establish a positive relation between AGOA and health indicators, pointing towards a welfare and long term developmental gain to the society by trade and not just a short term income boost. This is a step towards establishing that macroeconomic policies, in fact, may have a positive causal effect on development outcomes like health.

Heterogeneous effects like differential benefits to different sections of the population have also been found. AGOA reduces infant death significantly for the uneducated and rural mothers. This may be happening because uneducated rural mothers provide cheap labor which is employed with the job creation that comes with trade openness. In this sense, trade closes the gap between the groups. At the country level, petroleum and apparel export dominated countries do not significantly do better than others. In fact, it is the other group of countries which benefits more in terms of infant death reductions. Infant deaths are lowered mostly via two mechanisms namely increase in GDP per capita and increase in health expenditures.

It is important that we develop a macro-micro synthesis and study the relationship between health and macroeconomic outcomes as this underdeveloped route will open up new channels of effective policy intervention which would help harness all the benefits that any macroeconomic policy may have on society's welfare. This research is a step towards realizing that potential.

## *6.2 Future Work*

It is expected that AGOA may affect the health seeking behavior of mothers. This may constitute an important pathway through which the changes in infant mortality are taking place at the household level. Since data on various micro pathways like access to toilets, piped water, tetanus toxoid injections etc. are not retrospective, data from the countries which have at least 2 rounds of DHS will be collated to construct a repeated cross section to gauge the effect of AGOA on these routes, controlling for mother characteristics. This will give an insight into what are the mechanisms through which households are successful in averting infant and neonatal deaths. As a further robustness check, block bootstrap on standard errors will also be carried out to check the validity of the inference in presence of severe serial correlation, if it exists.

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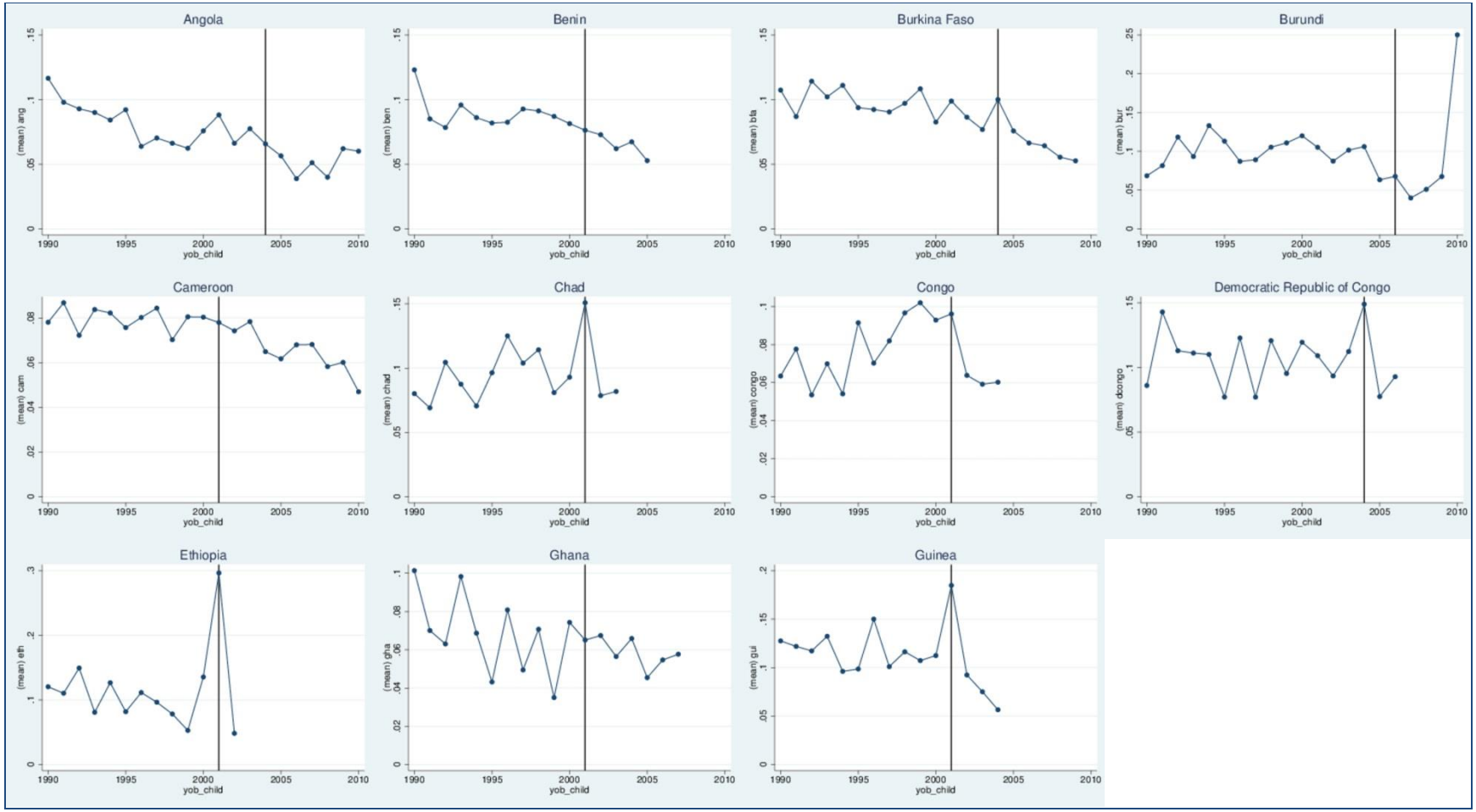



**Figure 1: Sample mean infant mortality rates by country for AGOA affected countries overtime, 1990 onwards**

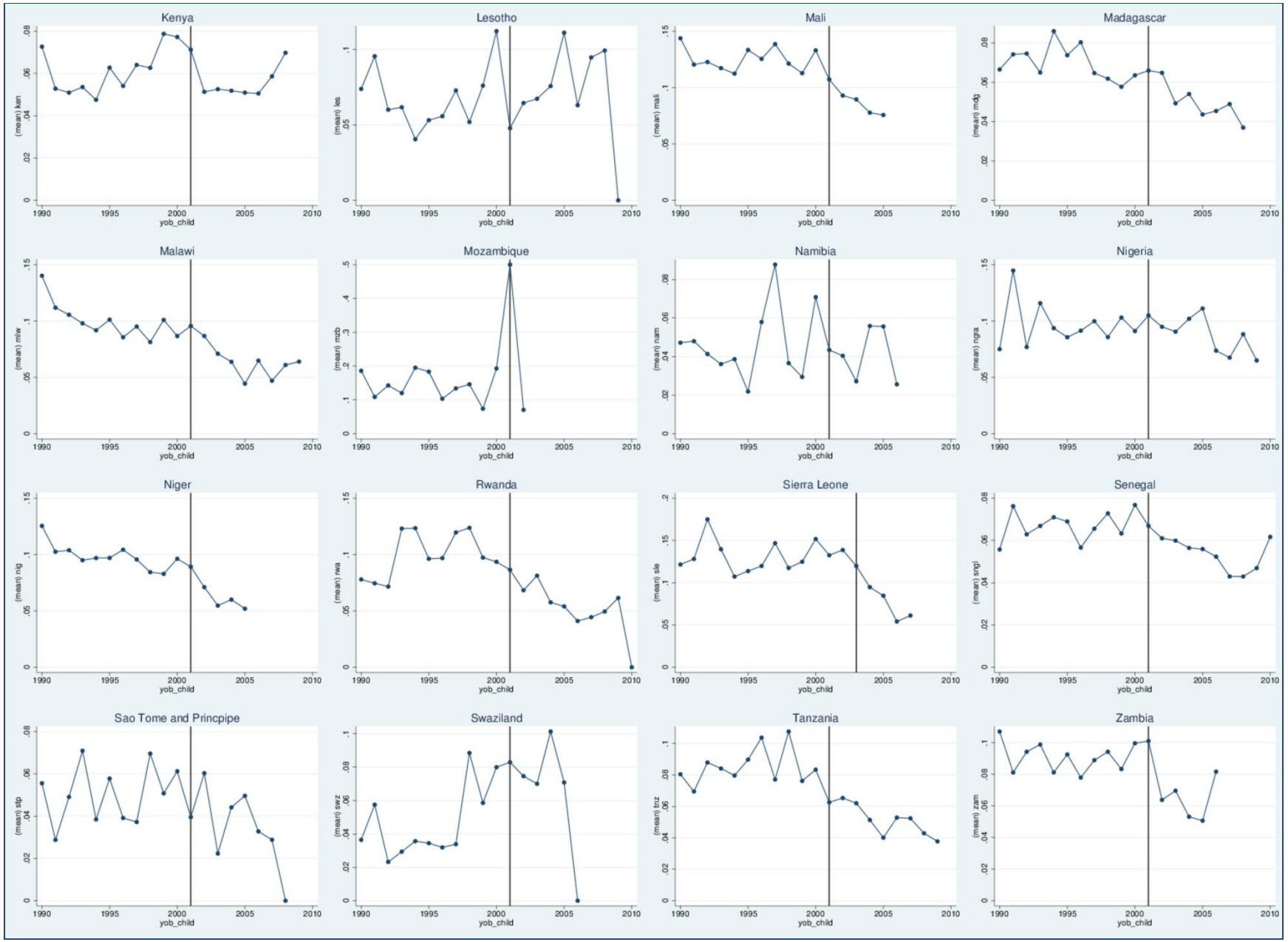
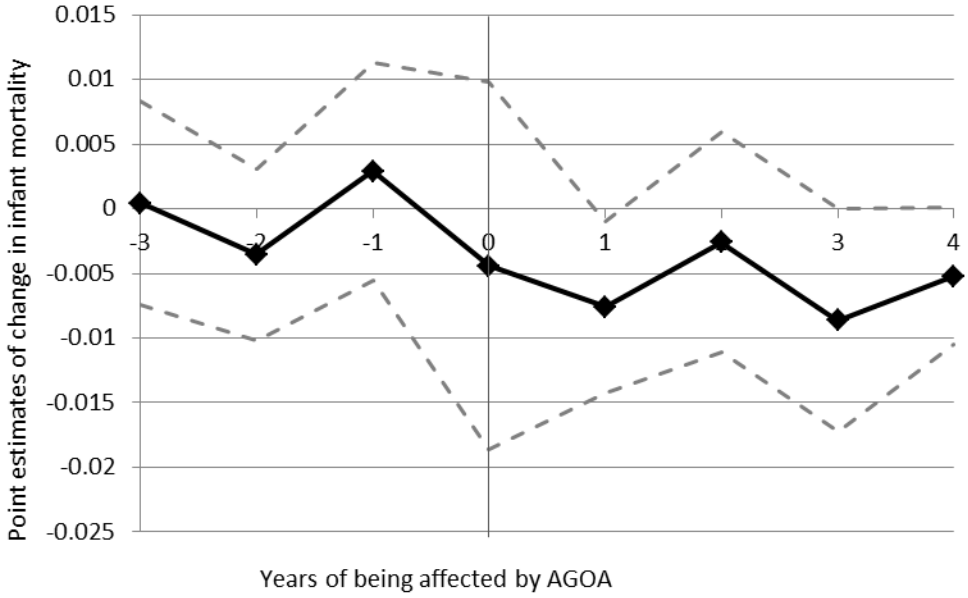



**Figure 1: Sample mean infant mortality rates by country for AGOA affected countries overtime, 1990 onwards**

**Figure 2: Dynamics of infant mortality**




Note: The solid black line depicts the change in infant mortality compared to 4 years before implementation of AGOA controlling for mother fixed effects, cohort-year fixed effects, country specific linear trends, sex of child, whether born in multiple birth, birth order and birth month. Year 0 is the year of implementation of AGOA, such that the countries have been at least partially affected by AGOA in that year. The dotted lines represent the 95% confidence interval with standard errors clustered at the country level. The point estimates for 1, 3 and 4 years after being affected by AGOA are significant at the conventional level.

## Table 1(a): Summary Statistics – Mean Infant Mortality

| | (1) All | (2)Before AGOA | (3)After AGOA | (4)t-test |
|---|---|---|---|---|
| **Infant Mortality** | 0.0815298 | 0.0911973 | 0.0646979 | 38.99 |
| **(All)** | (686093) | (440693) | (220981) | (0.00) |
| **Infant Mortality** | 0.0939331 | 0.1031024 | 0.0719087 | 29.92 |
| **(Uneducated)** | (342382) | (240004) | (95204) | (0.00) |
| **Infant Mortality** | 0.0691751 | 0.0769587 | 0.0592435 | 19.84 |
| **(Educated)** | (343693) | (200679) | (125769) | (0.00) |
| **Infant Mortality** | 0.0902742 | 0.1027345 | 0.0691378 | 31.49 |
| **(Poor)** | (300418) | (190306) | (98470) | (0.00) |
| **Infant Mortality** | 0.0747184 | 0.0824284 | 0.0611292 | 24.26 |
| **(Non-Poor)** | (385675) | (250387) | (122511) | (0.00) |
| **Infant Mortality** | 0.0866415 | 0.0981012 | 0.0671166 | 38.26 |
| **(Rural)** | (501284) | (319048) | (165503) | (0.00) |
| **Infant Mortality** | 0.0676645 | 0.0730897 | 0.0574822 | 12.60 |
| **(Urban)** | (184809) | (121645) | (55478) | (0.00) |

Note: Sample mean infant mortality is reported in the top row and number of observations in the bottom row for columns (1)-(3). Column (1) is for the whole sample with AGOA affected and non-affected countries. Columns (2) and (3) report the sample mean infant mortality before and after the implementation of AGOA in AGOA affected countries. Column (4) reports the t-statistic testing if the means are significantly different between columns (2) and (3). P-value is in the bottom row for column (4).

## Table 1(b): Summary Statistics – Other Variables

| | (1)All | (2)Before AGOA | (3)After AGOA | (4)Non-AGOA | (5)t-test |
|---|---|---|---|---|---|
| **Female** | 0.4922044 | 0.491637 | 0.4932279 | 0.4931815 | 0.311 |
| | (686093) | (440693) | (220981) | (24419) | (0.755) |
| **Multiple Births** | 0.0346644 | 0.0337514 | 0.0367136 | 0.0325976 | -1.84 |
| | (686093) | (440693) | (220981) | (24419) | (0.064) |
| **Mother's age at** | 0.500059 | 0.5071172 | 0.4836117 | 0.5215201 | 6.83 |
| **birth(20-29yrs)** | (686093) | (440693) | (220981) | (24419) | (0.00) |
| **Mother's age at** | 0.2408405 | 0.2338907 | 0.2580855 | 0.2102052 | -11.94 |
| **birth(30-39yrs)** | (686093) | (440693) | (220981) | (24419) | (0.00) |
| **Mother's age at** | 0.0243728 | 0.0142707 | 0.0451442 | 0.0187149 | -6.60 |
| **birth(40-49yrs)** | (686093) | (440693) | (220981) | (24419) | (0.00) |

Note: Sample mean is reported in the top row and number of observations in the bottom row for columns (1)-(4). Column (1) is for the whole sample with AGOA affected and non-affected countries. Columns (2) and (3) report the sample mean before and after the implementation of AGOA in AGOA affected countries. Column (4) reports the sample mean in non-AGOA countries. Column (5) gives the t-statistic testing if the means are significantly different between AGOA and non-AGOA countries. P-value is in the bottom row for column (5).

## Table 1(c): Summary Statistics – Full Sample and 2+ Mothers

| | Full Sample | | 2+ Sample | |
|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| **Infant Mortality** | 0.081529 | 0.2736472 | 0. 0835216 | 0.2766692 |
| | (686093) | | (639128) | |
| **Neonatal Mortality** | 0.0382689 | 0. 191845 | 0.039108 | 0.193852 |
| | (686093) | | (639128) | |
| **Mother's age at birth** | 25.72019 | 6.437027 | 26.02226 | 6.403657 |
| | (686057) | | (639095) | |
| **Mother's schooling** | 0.6613241 | 0.7544092 | 0.6332486 | 0.7375905 |
| | (686057) | | (639095) | |
| **Mother's wealth index** | 2.858324 | 1.401826 | 2.826403 | 1.394373 |
| | (686093) | | (639128) | |

Note: Sample mean is reported in the top row and number of observations in the bottom row. Columns (1) and (2) give the mean and standard deviation for different variables for the whole sample with AGOA affected and non-affected countries. Columns (3) and (4) report the sample mean and standard deviation for mothers with two or more children. All variables are categorical variables except mother's age at birth.

## Table 1(d): Summary Statistics – Infant and Neonatal Mortality for Sample of 2+ Mothers

| | Both before and after AGOA | | Only before or after AGOA | |
|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| **Infant Mortality (Before AGOA)** | 0.0910163 | 0.2876329 | 0.0943533 | 0.2923205 |
| | (254350) | | (169851) | |
| **Infant Mortality (After AGOA)** | 0.0628808 | 0.2427493 | 0.0774712 | 0.2673405 |
| | (146070) | | (47295) | |
| **Neonatal Mortality (Before AGOA)** | 0.0414979 | 0.1994392 | 0.044174 | 0.2054822 |
| | (254350) | | (169851) | |
| **Neonatal Mortality (After AGOA)** | 0.0290614 | 0.1679793 | 0.0426049 | 0.2019669 |
| | (146070) | | (47295) | |

Note: Sample mean is reported in the top row and number of live birth observations for AGOA affected countries in the bottom row. Columns (1) and (2) give the sample mean and standard deviation for infant and neonatal mortality for the sample of mothers giving birth both before and after AGOA. Columns (3) and (4) report the sample mean and standard deviation for mothers with two or more children either only before AGOA or after AGOA.

## Table 2: Effect of AGOA treatment on infant and neonatal mortality

| | Specification 1 | | | Specification 2 | | | |
|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| **Dependent Variable** | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Neonatal Mortality |
| **Treatment** | -0.0116 (0.0011)*** | -0.01362 (0.0020)*** | -0.01363 (0.0021)*** | -0.00776 (0.0019)*** | -0.00732 (0.0029)** | -0.00695 (0.0026)** | -0.004395 (0.0011)*** |
| **Explanatory Variables** | YES | YES | YES | YES | YES | YES | YES |
| **Country time trend** | YES | YES | YES | YES | YES | YES | YES |
| **Country FE** | NO | YES | NO | NO | YES | NO | NO |
| **Mother FE** | NO | NO | YES | NO | NO | YES | YES |
| **Cohort-year FE** | NO | NO | NO | YES | YES | YES | YES |
| **Number of countries** | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| **Number of mothers** | 212738 | 212738 | 212738 | 212738 | 212738 | 212738 | 212738 |
| **Observations** | 686093 | 686093 | 686093 | 686093 | 686093 | 686093 | 686093 |

Note: The explanatory variables included in the specifications are sex of child, whether born in multiple birth, birth order and birth month. Standard errors clustered at the country level are reported in brackets.
*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

## Table 3: Country-level time varying variables

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| **Dependent Variable** | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality |
| **Treatment** | -0.0068 | -0.00723 | -0.00732 | -0.00712 | -0.0077 | -0.0061 | -0.0068 |
| | (0.0024)*** | (0.0026)** | (0.0025)** | (0.0025)*** | (0.0031)** | (0.0024)** | (0.0028)** |
| **Log GDP per capita** | -0.0101 | | | | | | -0.010371 |
| | (0.0053)* | | | | | | (0.0081) |
| **Democracy** | | -0.0035 | | | | | -0.003294 |
| | | (0.0028) | | | | | (0.0030) |
| **Regime** | | | 0.0011 | | | | |
| | | | (0.001) | | | | |
| **Openness** | | | | -0.00002 | | | 0.00009 |
| | | | | (0.00007) | | | (0.0001) |
| **Female Education** | | | | | 0.0018 | | -0.00021 |
| | | | | | (0.0066) | | (0.0058) |
| **Commodity Price Index** | | | | | | 0.02375 | 0.01627 |
| | | | | | | (0.0086)** | (0.0104) |
| **Number of countries** | 30 | 30 | 30 | 30 | 21 | 29 | 20 |
| **Number of mothers** | 212279 | 208604 | 208604 | 212279 | 138272 | 206503 | 129869 |
| **Observations** | 684139 | 667543 | 667543 | 684139 | 430184 | 670719 | 405494 |

Note: The explanatory variables included in the specifications are sex of child, whether born in multiple birth, birth order, birth month, mother fixed effects, country specific linear trends, mother's cohort by child birth year FE. Standard errors clustered at country level are reported in brackets. Data for (1) and (4) taken from PWT 7.0, (2) and (3) taken from Democracy-Dictatorship (DD) Data by Cheibub et al (2010, (5) Barro and Lee (2010), (6) from PWT 8.0. Number of observations and number of mothers varies depending on availability of country level control variable from different data sources.
*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

## Table 4: Heterogeneity across different types of mothers

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Dependent Variable** | **Infant Mortality** | **Infant Mortality** | **Infant Mortality** | **Infant Mortality** |
| Treatment effect on **Educated** | -0.0051773 (0.0031) | | | |
| Treatment effect on **uneducated** | -0.0083362 (0.0028)*** | | | |
| Treatment effect on **Rural** | | -0.0086262 (0.0028)*** | | |
| Treatment effect on **urban** | | -0.0016895 (0.0031) | | |
| Treatment effect on **poor** | | | -0.0104727 (0.0028)*** | |
| Treatment effect on **non-poor** | | | -0.004196 (0.0028) | |
| Treatment effect on **educated in rural areas** | | | | -0.0066317 (0.0036)* |
| Treatment effect on **uneducated in rural areas** | | | | -0.0098936 (0.0031)*** |
| Treatment effect on **educated in urban areas** | | | | -0.0022219 (0.0029) |
| Treatment effect on **uneducated in urban areas** | | | | -0.0004502 (0.0040) |
| Number of Countries | 30 | 30 | 30 | 30 |
| Number of mothers | 212732 | 212738 | 212738 | 212732 |
| Observations | 686075 | 686093 | 686093 | 686075 |

Note: Note: The explanatory variables included in the specifications are sex of child, whether born in multiple birth, birth order, birth month, mother fixed effects, country specific linear trends, mother's cohort by child birth year FE. Standard errors clustered at country level are reported in brackets. The treatment is interacted with the type/characteristic of mothers to get the treatment effect on those types of mothers. Column (1) includes the effect on infant mortality for educated mothers where educated implies having attended any type of school and uneducated mothers, where uneducated is defined as mother did not attend any school. Column (2) assesses this heterogeneity between women living in rural areas and urban areas at the time of interview. Column (3) has effect on infant mortality for mothers having a wealth index as defined as poor or poorer vis-à-vis with mothers who are non-poor based on the wealth index being middle, richer or richest. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities using principal components analysis and is reported in DHS. Column (4) includes effect on mothers with characteristics based on area of residence and whether the mother is educated.
*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

## Table 5: Heterogeneity across different country groupings

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **Dependent Variable** | **Infant Mortality** | **Infant Mortality** | **Infant Mortality** | **Infant Mortality** | **Infant Mortality** | **Infant Mortality** |
| High volume of apparel exports countries | -0.0016569 | | | | | |
| | (0.0046) | | | | | |
| Countries not with high volume of Apparel exports | -0.008095 | | | | | |
| | (0.0028)*** | | | | | |
| Countries having predominantly petroleum exports | | 0.0016571 | | | | |
| | | (0.0039) | | | | |
| Countries not having predominantly petroleum exports | | -0.0086609 | | | | |
| | | (0.0028)*** | | | | |
| Countries having top volume of exports via AGOA | | | 0.00016 | | | |
| | | | (0.0039) | | | |
| Countries not having top volume of exports via AGOA | | | -0.0089734 | | | |
| | | | (0.0028)*** | | | |
| Countries having apparel visa | | | | -0.0068244 | | |
| | | | | (0.0027)** | | |
| Countries not having apparel visa | | | | -0.0072862 | | |
| | | | | (0.0045) | | |
| All AGOA countries after MFA | | | | | -0.0016823 | |
| | | | | | (0.00946) | |
| All AGOA countries before MFA | | | | | -0.0077183 | |
| | | | | | (0.0023)*** | |
| Low income countries | | | | | | -0.009363 |
| | | | | | | (0.0029)** |
| Middle income countries | | | | | | 0.000719 |
| | | | | | | (0.0037) |
| Number of Countries | 30 | 30 | 30 | 30 | 30 | 30 |
| Number of mothers | 212738 | 212738 | 212738 | 212738 | 212738 | 212738 |
| Observations | 686093 | 686093 | 686093 | 686093 | 686093 | 686093 |

Note: The explanatory variables included in the specifications are sex of child, whether born in multiple birth, birth order, birth month, mother fixed effects, country specific linear trends, mother's cohort by child birth year FE. Standard errors clustered at country level are reported in brackets. The treatment is interacted with the different country groupings to get the treatment effect on those groups of countries. Column (1) includes countries with high volume of apparel exports namely Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Swaziland and Tanzania. Column (2) has country groupings based on countries having majorly petroleum exports namely, Angola, Nigeria, Congo, Cameroon, Chad and Ghana. Column (3) includes countries which had highest share of total exports under AGOA – Nigeria, Angola, Chad, Congo, Lesotho, Kenya, Madagascar and Cameroon. Column (4) divides countries based on possession of apparel visa. These countries are Benin, Burkina Faso, Burundi, Cameroon, Chad, Ethiopia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, Swaziland, Tanzania and Zambia. Column (5) assesses heterogeneity in effect after the expiration of Multi Fiber Agreement (MFA) in 2005 vis-à-vis before MFA expired. Column (6) divides the 30 countries based on World Bank's ranking of incomes into low and middle income countries.

*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

## Table 6: Possible Macro Pathways

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **Dependent Variable** | Log GDP Per capita | Female LFPR | Health Expdr. per capita | Health Expdr. per capita | Inequality | Education Expenditure |
| **Treatment** | 0.2623307 | 0.073403 | 13.37613 | 8.803252 | -1.099927 | -0.192887 |
| | (0.1419)* | (1.259) | (5.5235)** | (4.5412)* | (1.7818) | (0.3516) |
| **Log GDP per capita** | | | | 51.26603 | | |
| | | | | (24.333)** | | |
| **Year FE** | YES | YES | YES | YES | YES | YES |
| **Number of countries** | 30 | 29 | 29 | 29 | 29 | 26 |
| **Observations** | 570 | 551 | 427 | 427 | 291 | 360 |

Note: These are country fixed effects regressions controlling for year dummies. Standard errors clustered at country level are reported in brackets. Data for (1) is taken from PWT 7.0, and (2), (3), (4), (5) and (6) are taken from World Bank Indicators. Number of observations and number of countries varies depending on availability of country level data from different data sources.

*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

## Table 7(a): Robustness Check – Dropping one country at a time

| Dependent Variable | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality | Infant Mortality |
|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| **Treatment** | -0.00761 | -0.00737 | -0.00732 | -0.00613 | -0.0077 | -0.00859 | -0.0068 |
| | (0.0029)** | (0.0026)** | (0.0025)** | (0.0032)* | (0.0031)** | (0.0027)*** | (0.0026)** |
| | **(8)** | **(9)** | **(10)** | **(11)** | **(12)** | **(13)** | **(14)** |
| **Treatment** | -0.00849 | -0.00648 | -0.00686 | -0.00703 | -0.00681 | -0.00664 | -0.00677 |
| | (0.0026)*** | (0.0026)** | (0.0026)** | (0.0026)** | (0.0026)** | (0.0026)** | (0.0026)** |
| | **(15)** | **(16)** | **(17)** | **(18)** | **(19)** | **(20)** | **(21)** |
| **Treatment** | -0.00665 | -0.00733 | -0.00713 | -0.00653 | -0.00667 | -0.00682 | -0.00688 |
| | (0.0027)** | (0.0027)** | (0.0028)** | (0.0026)** | (0.0026)** | (0.0026)** | (0.0026)** |
| | **(22)** | **(23)** | **(24)** | **(25)** | **(26)** | **(27)** | **(28)** |
| **Treatment** | -0.00737 | -0.00688 | -0.00698 | -0.00748 | -0.00597 | -0.00715 | -0.00654 |
| | (0.0026)*** | (0.0026)** | (0.0026)** | (0.0026)*** | (0.0025)** | (0.0026)** | (0.0026)** |
| | **(29)** | **(30)** | | | | | |
| **Treatment** | -0.00677 | -0.00616 | | | | | |
| | (0.0026)** | (0.0025)** | | | | | |

Note: The explanatory variables included in the specifications are sex of child, whether born in multiple birth, birth order, birth month, mother fixed effects, country specific linear trends, mother's cohort by child birth year FE. Standard errors clustered at country level are reported in brackets. In each of the separate regressions, one of the countries is dropped at a time in alphabetical order.

## Table 7(b): Robustness Check – Country specific birth order and mother's age quadratic trend

| | (1) | (2) |
|---|---|---|
| **Dependent Variable** | Infant Mortality | Infant Mortality |
| **Treatment** | -0.00684 | -0.00676 |
| | (0.0025)** | (0.0025)** |
| **Explanatory Variables** | YES | YES |
| **Country time trend** | YES | YES |
| **Country Specific Birth Order Dummy** | YES | YES |
| **Country specific mother's age quadratic trend** | NO | YES |
| **Mother FE** | YES | YES |
| **Cohort-year FE** | YES | YES |
| **Number of countries** | 30 | 30 |
| **Number of mothers** | 212738 | 212738 |
| **Observations** | 686093 | 686093 |

*** Significant at 1% level, ** significant at 5% level, * significant at 10% level.

# Appendix

**Figure A1: Map of AGOA eligible and not AGOA-eligible countries**


**Table A1: List of 30 countries in sub-Saharan Africa used in the study, categorized by AGOA Eligibility, year made AGOA eligible, DHS survey used and sample period of births**

| sub-Saharan Africa | AGOA Eligible | Year made AGOA Eligible | DHS used | Sample period |
|---|---|---|---|---|
| Angola | Y | 2003 | 2011 | 1990-2010 |
| Benin | Y | 2000 | 2006 | 1990-2005 |
| Burkina Faso | Y | 2004 | 2010 | 1990-2009 |
| Burundi | Y | 2006 | 2010 | 1990-2010 |
| Cameroon | Y | 2000 | 2011 | 1990-2010 |
| Chad | Y | 2000 | 2004 | 1990-2003 |
| Republic of the Congo | Y | 2000 | 2005 | 1990-2004 |
| Democratic Republic of the Congo | Y | 2003 | 2007 | 1990-2006 |
| Cote d'Ivoire | N | Non-AGOA | 2005 | 1990-2004 |
| Ethiopia | Y | 2000 | 2011 | 1990-2002 |
| Ghana | Y | 2000 | 2008 | 1990-2007 |
| Guinea | | Suspended 2009 | 2005 | 1990-2004 |
| Kenya | Y | 2000 | 2008-09 | 1990-2008 |

| | | | | |
|---|---|---|---|---|
| Lesotho | Y | 2000 | 2009 | 1990-2009 |
| Liberia | Y | 2006 | 2007 | 1990-2006 |
| Madagascar | | Suspended 2009 | 2008-09 | 1990-2008 |
| Malawi | Y | 2000 | 2010 | 1990-2009 |
| Mali | Y | 2000 | 2006 | 1990-2005 |
| Mozambique | Y | 2000 | 2003 | 1990-2002 |
| Namibia | Y | 2000 | 2006-07 | 1990-2006 |
| Niger | | Suspended 2009 | 2006 | 1990-2005 |
| Nigeria | Y | 2000 | 2010 | 1990-2009 |
| Rwanda | Y | 2000 | 2010 | 1990-2009 |
| Sao Tome and Principe | Y | 2000 | 2008-09 | 1990-2008 |
| Senegal | Y | 2000 | 2010-11 | 1990-2010 |
| Sierra Leone | Y | 2002 | 2008 | 1990-2007 |
| Swaziland | Y | 2000 | 2006-07 | 1990-2006 |
| Tanzania | Y | 2000 | 2010 | 1990-2009 |
| Zambia | Y | 2000 | 2007 | 1990-2006 |
| Zimbabwe | N | Non-AGOA | 2010-11 | 1990-2009 |

Note: Since Liberia has sample size till 2006 and AGOA was implemented in 2006 for the country, it effectively in the sample behaves as not being AGOA affected.