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Education and Fertility: Panel Time-Series Evidence from Southern Africa*

Manoel Bittencourt[†]

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Abstract

In this paper I investigate whether secondary school enrolment has played any role on total fertility rates in all fifteen countries of the Southern African Development Community (SADC) between 1980 and 2009. The evidence, based on panel time-series analysis (I make use of the Pooled OLS, Fixed Effects, Common Correlated Effects and Fixed Effects with Instrumental Variables estimators), robustly suggest that education has reduced fertility rates in the community, or that the community is already trading-off quantity for quality of children. The results are important because lower fertility, caused by education, implies more capital per worker, higher productivity and therefore higher growth rates, and also because—in accordance to the unified growth theory—they suggest that southern Africa is experiencing its own transition from the Malthusian regime into sustained modern growth.

Keywords: Education, fertility, Africa.

JEL Classification: I20, J13, O55.

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"For the study of the economic growth of nations, it is imperative that we become familiar with findings in those related social disciplines that can help us understand population growth patterns, the nature and forces in technological change, the factors that determine the characteristics and trends in political institutions, and generally the patterns of behavior of human beings—partly as a biological species, partly as social animals."

Simon Kuznets

1 Introduction

The African continent has been known for its recent political independence from European rule, for a number of political regime changes—particularly during the cold war—for civil and military conflict, and for a rather poor macroeconomic performance, ie in terms of economic activity the late 1980s and early 1990s saw even negative growth rates taking place in some countries. More recently though, the continent has seen some economic structural changes and reforms being implemented, which combined with a certain degree of political stability, have generally been matched by better economic performance, Bates, Coatsworth and Williamson (2007).

Bearing the above background in mind, I investigate the role of secondary school enrolment in determining total fertility rates in the Southern African Development Community (SADC), a community of countries which includes a diverse set of nations, eg with Angola and Mozambique presenting positive growth rates since the 1990s and with some double figures from 2004 onwards, with Botswana and Mauritius presenting positive growth for the whole period investigated, with South Africa presenting positive growth, although modest, since the end of the Apartheid regime in 1994, and with a country like Zimbabwe which has presented negative growth rates since 1999. More specifically, I use data from all fifteen SADC countries between 1980 and 2009, and panel time-series analysis (I use the Pooled OLS, Fixed Effects, Common Correlated Effects and Fixed Effects with Instrumental Variables estimators in order to deal with heterogeneity, cross-section dependence and endogeneity, and democracy and globalisation provide education with external variation) to study whether education played any role on fertility in the community.

Interestingly enough, although these SADC countries differ in terms of economic and institutional development, eg with Botswana, Mauritius and South Africa being more economically and politically developed than most of the other countries in the region, they also share common factors. For instance, most of them went through those above-mentioned economic and political changes from the 1960s onwards. In addition, other fundamental structural changes are taking place in the southern part of the continent, eg fertility rates as well as the share of the agricultural sector to GDP have been decreasing over time, and education enrolment and urbanisation rates have been on the rise. Therefore, I pay special attention to these fifteen countries which are part of a community that advocates the importance of regional integration, democracy and prosperity as tools to eradicate poverty in the region.

Given the above-mentioned regional characteristics, we rely on unified growth theory models (Galor and Weil 1999, Galor and Weil 2000, and Galor and Moav 2002), which divide the process of development into three distinct regimes, to better understand and contextualise the contemporaneous development of the southern African region. The underlining theory suggests that initially there is the Malthusian regime in which increases in income—usually coming from external shocks, eg the Black Death in 14th-century Europe—will have the effect of increasing fertility rates. After some time though, given the usual "preventive checks" (disease, famine and malnutrition), this natural economy converges back to its original equilibrium, ie shocks have no long-run effects on income per capita, only on population density, Ashraf and Galor (2013). Secondly, there is the Post-Malthusian regime in which income increases and some industrialisation and technological progress take place, without too much human capital though. In addition, during this transitional period, life expectancy as well as fertility tend to increase. Finally, during the sustained growth regime, technological progress and industrialisation take off, human capital formation increases and in fact takes a central role in production, fertility rates see a reduction and eventually the demographic transition takes place.

The evidence I report suggests that, firstly, secondary education enrolment has been a robust determinant of total fertility rates in the community. More specifically, because of higher demand for human capital coming from the modern sectors of those economies, eg services and manufacturing, ed-

ucation is associated with lower fertility in a region that has not yet gone through its own demographic transition, Murphy (2010). Secondly, because of uncertainty about survival of offspring, the rise in life expectancy that the region has been experiencing for some time is still not accompanied by lower fertility rates, Galor (2012)¹. Thirdly, the agricultural sector of those economies, because of non-complementarities between unskilled-agricultural goods and lower fertility, is associated with higher fertility rates, Becker, Cinnirella and Woessmann (2010). Lastly, there is some evidence suggesting that income increases, because of a rise in opportunity costs of having children, lower fertility in the SADC, Becker (1960). All in all, the evidence, particularly the role of education and income on fertility, indicates that southern Africa has already escaped the Malthusian regime, however the region has not yet entered the sustained growth regime of development, eg at this stage there is no evidence that fixed capital formation, or industrialisation, is directly associated, because of skill complementarities between industrialised and services goods and higher relative wages for women in particular sectors of the economy, with lower fertility rates, Galor and Moav (2006) and Galor and Weil (1996).

The importance of acquiring a better understanding of the role of education on fertility rates in southern Africa is because lower fertility implies more capital per worker, higher productivity and therefore higher growth rates, and also because the take off into the sustained growth regime, usually caused by a shock, requires a critical level of human capital so that the virtuous circle between human capital and technological progress can take place, Galor and Moav (2002). Given the evidence, and always bearing in mind the numerous factors that might have delayed Africa's own demographic transition, eg colonialism, it is fair to say that southern Africa is going through its very own Post-Malthusian regime, or transitioning from the Malthusian regime into sustained growth.

In addition to the contributions mentioned above, Hansen and Prescott (2002) propose an unified growth model in which income and population are positively related to each other, however the model is silent about the decline in population growth taking place after the industrial revolution

¹It is also important to mention that although the community has seen a decline in life expectancy in the 1990s (because of the AIDS epidemic), life expectancy has already picked up its positive trend.

in England. In a slightly different vein, Soares (2005) proposes a model in which exogenous increases in life expectancy will be followed—because of an increase in human capital investment horizon, but with a lag—by reductions in fertility rates and increases in human capital. This model also predicts that the interaction above might lead to sustained economic growth. In similar vein, Cervellati and Sunde (2005) devise a model in which higher life expectancy leads to higher investment in human capital which is accompanied by technological progress and economic growth. Furthermore, Doepke (2004) suggests that free education combined with effective child labour laws can reduce fertility rates in developing countries (he compares Brazil with South Korea), and Doepke (2005) indicates that lower child mortality is associated with lower fertility rates. On the other hand, Galor (2012) presents some evidence which suggests that in 18th- and 19th-centuries England, increases in life expectancy were associated with increases in fertility because of the precautionary demand for children during that transitional period².

The empirical literature on the role of education on fertility has mostly studied the European trade-off between quantity and quality of children taking place in the 19th century. Firstly, Dribe (2008) uses Swedish data from 1880 to 1930, at county and national level, to report that the number of teachers per 100 children (aged between 7 and 14) reduces fertility rates. Secondly, Murphy (2010) uses twenty years of French departmental-level data between 1876 and 1896 to report that female literacy reduced fertility in France. Moreover, Becker, Cinnirella and Woessmann (2010 and 2012) use data from Prussian counties in the 19th century, 1849 and 1816 respectively, to report that school enrolment reduced the child-woman ratio at the time. In similar vein, Becker, Cinnirella and Woessmann (2013) report estimates which suggest that female education reduces fertility rates in 19th-century Prussia³.

In essence, this non-exhaustive literature review suggests firstly that higher life expectancy plays an important role on decisions regarding investment on human capital and fertility, and it also highlights the impor-

²See also Galor (2005 and 2011) for extensive surveys of the literature on unified growth models.

³Alternatively, Voigtländer and Voth (2013) suggest that the Black Death, combined with the Catholic doctrine of mutual consent and land abundance, played an important role in reducing fertility rates in Europe by better employment opportunities for women and higher relative wages, already in the 14th century.

tance of education and lower fertility on technological progress and sustained growth. Needless to say that all these variables are going through changes in southern Africa as we speak, and are therefore of significant importance for Africa’s development. Secondly, the empirical evidence, mostly covering European countries in a time period which they had not yet experienced their own demographic transition, just like Africa now, suggests that school enrolment was already playing an important role in lowering total fertility rates and consequently on growth.

Hence, it is fair to say that this paper is a natural development of the previous literature on the subject. I conduct a case study of an important community of African developing countries—which share particular characteristics and common goals, but which also present their own idiosyncrasies—that attempts to pinpoint in more detail the effects of secondary school enrolment on total fertility rates in contemporaneous Africa. I do that by taking advantage of unified growth theory models and panel time-series analysis, which allow me to put the evidence into context and also to deal with particular econometric issues in thin panels, ie heterogeneity, cross-section dependence and endogeneity, which enables me to provide—to the best of my knowledge, for the first time—informative and contextual estimates so that our knowledge of an idiosyncratic, and also diverse within, southern Africa is deepened.

2 Empirical Analysis

2.1 The Data

The dataset I use covers the period between 1980 and 2009, and fifteen sub-Saharan African countries which are all members of the SADC, namely Angola, Botswana, the Democratic Republic of the Congo, Lesotho, Madagascar, Mozambique, Mauritius, Malawi, Namibia, South Africa, Swaziland, Seychelles, Tanzania, Zambia and Zimbabwe. To illustrate the importance of these countries in the African context, these fifteen countries accounted for approximately 52% of the total GDP in sub-Saharan Africa in 2009.

The variable proxying for total fertility, *FERTIL*, is defined as the number of children per woman—which is the number of children that would be born to each woman with age-specific fertility rates—and the data are provided by the United Nations. For education I use secondary school en-

rollment as percentage of the corresponding age group, *EDUC*, and the data are provided by the World Bank. Firstly, although primary education is, no doubt, important, it can be argued that secondary education in 21st-century Africa plays a similar role that primary education had in 19th-century Europe, ie the provision of basic technical skills for use in services and manufacturing. Secondly, from the brief literature review above it is plausible to expect that education leads to more investment in the quality than in the quantity of offspring, or that higher secondary enrolment reduces total fertility rates even before a region's demographic transition, eg Becker, Cinnirella and Woessmann (2012).

In addition, following the underlining theory, I use standard control variables for the analysis. First, I use a variable accounting for life expectancy, *EXPECT*, which is defined by life expectancy in terms of number of years at birth. The data come from the United Nations Population Division and it is expected that an increase in life expectancy might lead to an increase in fertility, particularly in developing countries where uncertainty about survival of offspring rates is still high, Galor (2012). Moreover, I make use of the importance, in percentage terms, of the agricultural sector on the respective GDPs of those countries, *AGRIC*, and the data are from the World Development Indicators provided by the World Bank. In this case it is reasonable to expect that more agrarian societies tend to favour quantity (or brawn) instead of quality of children and therefore it is predicted that the higher the importance of agriculture, the higher the fertility rates, Becker, Cinnirella and Woessmann (2010).

Furthermore, I use the gross fixed capital formation to GDP, *INV*, as a proxy for industrialisation and the data are provided by the World Bank. In this instance it is predicted that fixed capital formation is associated with lower total fertility rates because of skill complementarities in services and manufacturing and higher relative wages for women, Galor and Moav (2006) and Galor and Weil (1996). Lastly, I control for income per capita, *GDP*, and the data come from the World Development Indicators. In this case it is expected that higher income, bearing in mind the different developmental stages of the countries in the sample, might lead to a decline in fertility because of higher opportunity costs of having children which takes place when countries reach a particular developmental threshold, Becker (1960).

To give a flavour of the main variables of interest, Figure One shows

the averaged-data on fertility and education in all fifteen countries in the sample, and the eye-ball evidence shows that during the whole period investigated fertility rates in southern Africa have been decreasing over time, ie from roughly six children per woman in 1980 to approximately four in 2009. Moreover, secondary education has been on the rise throughout the whole period, from less than 30% of the corresponding population age group in 1980 to more than 50% in 2009.

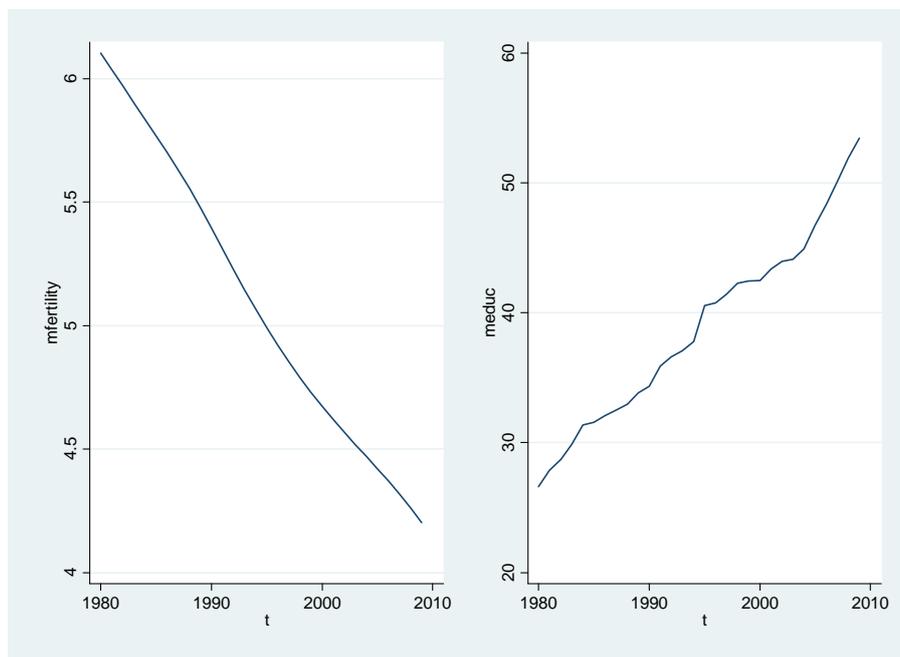


Figure 1: Fertility rates and secondary education, SADC, 1980-2009. Sources: United Nations and World Development Indicators.

Table One presents the correlation matrix of the variables, in logs, used for the analysis. Initially, the two main variables of interest, fertility rates and secondary education, present a negative and statistically significant correlation with each other. In addition, life expectancy presents a negative and significant correlation to fertility, which suggests that an increase in life expectancy might reduce uncertainty about survival of offspring, increase the horizon of investment in human capital and consequently play a role in reducing total fertility in the community, Soares (2005) and Doepke (2005).

Furthermore, the importance of the agricultural sector presents a positive

correlation with fertility, which indicates that rural areas tend to have higher fertility rates because of non-complementarities between non-industrial and unskilled goods, and lower fertility rates. On the other hand, fixed capital formation presents the expected negative correlation with fertility, which suggests that capital formation leads to reduced fertility because of complementarities between industrialised and skilled goods and lower fertility rates. Finally, income per capita displays a negative correlation with fertility, which indicates that higher income, because of higher opportunity costs of having children, might reduce fertility in the community.

Table 1: The Correlation Matrix: SADC, 1980-2009.

	FERTIL	EDUC	EXPECT	AGRIC	INV	GDP
FERTIL	1					
EDUC	-0.741*	1				
EXPECT	-0.663*	0.590*	1			
AGRIC	0.709*	-0.736*	-0.491*	1		
INV	-0.282*	0.136*	0.388*	-0.311*	1	
GDP	-0.234*	-0.000	0.158*	-0.231*	0.265*	1

Sources: United Nations and World Development Indicators. * represents significance at the 5% level.

Figure Two shows the OLS regression line between secondary education enrolment and total fertility rates in all those fifteen SADC countries. The relationship is negative and statistically significant, which indicates that there is an economic relationship between education and fertility in the panel or that, because of higher demand for reasonably educated people who can work in services and manufacturing, the community is already trading-off quantity for quality of children.

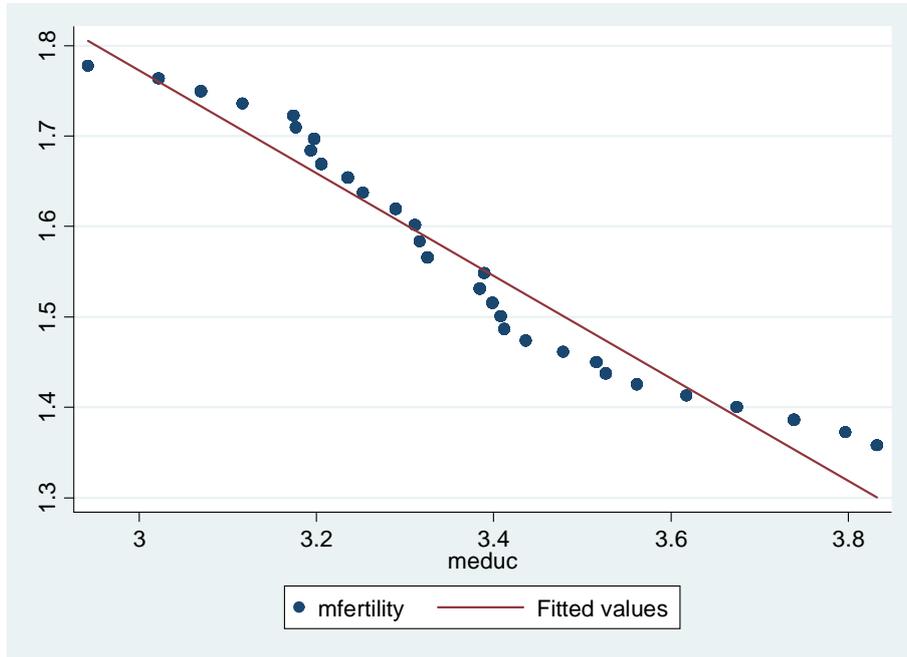


Figure 2: OLS Regression Line, fertility rates and secondary education, SADC, 1980-2009. Sources: United Nations and World Development Indicators.

2.2 The Empirical Strategy

Since I have a $T > N$ dataset, with $T = 30$ and $N = 15$ observations, the empirical strategy is based on panel time-series analysis. Panel time-series allows me to deal with important econometric issues in relatively thin panels—heterogeneity, cross-section dependence and endogeneity biases—in an attempt to obtain informative and reliable estimates. In essence, panel time-series allows a more specific analysis of the SADC, with all its idiosyncrasies and differences within, without treating it either as an outlier or as a dummy, and therefore a clearer picture of the community and less unwarranted generalisations can be achieved.

Firstly, although some of the variables are either ratios or indices, and therefore bounded within closed intervals, I also evoke Phillips and Moon (1999) result which suggests that the issue of spurious regressions is much less of a problem in panels because of the averaging taking place in panel estimators which reduces the prospective noise coming from such regressions.

Secondly, the issues of statistical endogeneity—which arises because the unobserved individual effects that are nested in the error term might be correlated to the regressors—and heterogeneity of intercepts, are dealt with by the one-way Fixed Effects (FE) with robust standard errors estimator, and this estimator provides consistent estimates when $T \rightarrow \infty$, Smith and Fuentes (2010), and Achen (2001).

Essentially, although these countries shared some political and economic transitions in their recent history, which makes the homogeneity of slopes a plausible assumption, the FE estimator also accounts for important econometric issues in $T > N$ panels, statistical endogeneity and heterogeneity biases, or for the fact that some of these countries do indeed present different characteristics in terms of economic and political development, eg Botswana, Mauritius and South Africa are known to be relatively richer and more politically stable than most other countries in the community, and these country differences are picked up by the heterogeneous intercepts of the FE estimator.

Thirdly, one can argue that, given the nature of the countries in the sample, cross-section dependence can be present. Thus, I make use of the Common Correlated Effects (CCE) estimator proposed by Pesaran (2006) which introduces in the regressions individual cross-section averages of all variables as additional regressors and these averages are proxies for unobserved common factors.

Fourthly, some would argue that economic endogeneity is present, or that higher fertility might lead to lower education, Becker, Cinnirella and Woessmann (2010). I therefore use the Fixed Effects with Instrumental Variables (FE-IV) two-stage Least Squares estimator, which provides estimates that are asymptotically consistent and efficient as $T \rightarrow \infty$, and this estimator retains the time series consistency even if the instrument set is only predetermined, Arellano (2003).

In terms of instruments used, with the assumption ($E(educ_{it-1}v_{it}) = 0$) in mind, firstly I make use of the lag of education as a baseline identifying instrument for contemporaneous education. Then I use the rather popular and normalised, so that it ranges from zero to one, polity2 variable (POL) from the Polity IV files to account for the external democratic shock coming with the end of the cold war in the 1990s that the region saw taking place back then and which continues to the day, Bates, Block, Fayad and Hoeffler

(2013). In addition, I use a variable for economic globalisation, *GLOBAL*, provided by Dreher (2006) and which takes into account trade to GDP, and also, eg foreign direct and portfolio investment and import barriers, to account for the latest external wave of globalisation taking place in the world, which includes southern Africa. Since I use these instruments separately the estimated systems are just identified.

Figure Three shows the transition to more democratic institutions taking place in 1990, which coincides with the end of the ideological conflict between the West and the former USSR, and the second panel shows the latest wave of globalisation affecting this community of countries, which also increases sharply after the 1990s.

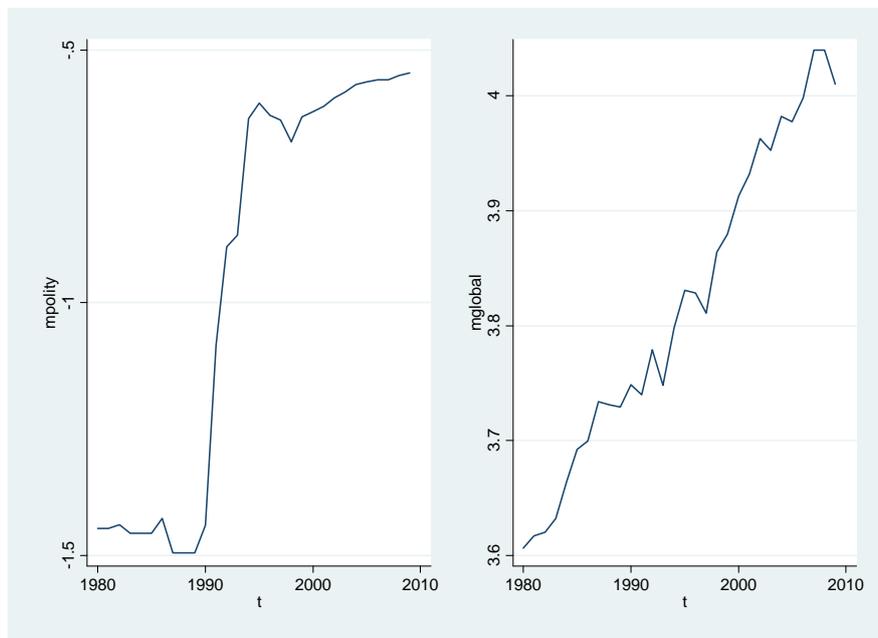


Figure 3: Democracy and globalisation, SADC, 1980-2009. Sources: Polity IV and Dreher (2006).

Essentially, what is expected of these instruments is that, firstly, education is rather persistent over time, therefore a positive effect of lagged education on contemporaneous secondary enrolment is expected. Secondly, democracy should play a positive role on education, eg by better governance and more efficient allocation of resources towards education, Tavares and Wacziarg (2001) and Stasavage (2005). Lastly, it is expected that glob-

alisation might play a positive role on total factor productivity, which includes human capital, Andersen and Dalgaard (2011), through the flows of people, knowledge and technologies⁴. Figure 4 shows the OLS regression lines between the external instrumental variables and education, and both panels display positive relationships amongst democracy, globalisation and education.

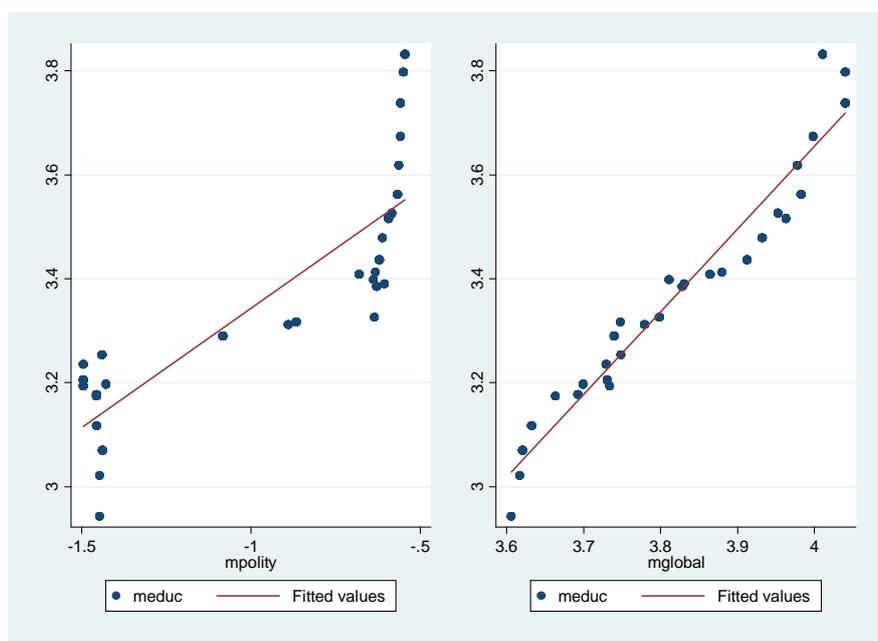


Figure 4: OLS Regression Lines between Democracy, globalisation and secondary education, SADC, 1980-2009. Sources: Polity IV, Dreher (2006) and World Development Indicators.

I therefore estimate equations with different pooled estimators (the baseline Pooled OLS (POLS), which assumes homogeneity of intercepts and slopes, the FE, the CCE and FE-IV estimators), so that different econometric issues are dealt with and reliable estimates provided. The one-way FE estimated equation is as follows,

$$FERTIL_{it} = \alpha_i + \beta EDUC_{it-1} + \beta EXPECT_{it} + \gamma AGRIC_{it} + \delta INV_{it} + \epsilon GDP_{it} + v_{it} \quad (1)$$

⁴Alternatively, Galor and Mountford (2008) suggest that, at least in non-industrialised developing countries trading with developed countries, globalisation might negatively affect education because developing countries will specialise in non-skilled agricultural goods.

where *FERTIL* are the number of children per woman, *EDUC* is secondary enrolment, *EXPECT* is life expectancy at birth, *AGRIC* is the share of the agricultural sector to GDP, *INV* is the share of gross fixed capital formation to GDP and *GDP* is income per capita. All variables are in logs.

2.3 Results and Discussion

In Table Two I report the baseline POLS (first panel) and then the robust FE estimates (bottom panel). All POLS as well as most FE education estimates are negative and statistically significant against fertility rates. More specifically, the FE estimate in column four suggests that for each percentage point increase in secondary enrolment, there will be a .23 percentage point reduction in fertility in the region, a result (in terms of sign and size) which is in accordance to the previous literature, Becker, Cinnirella and Woessmann (2012).

About the control variables, the agricultural sector is associated with significantly higher fertility rates, which emphasizes the importance of non-complementarities between unskilled-agricultural goods and lower fertility in the region, Becker, Cinnirella and Woessmann (2010). In addition, but bearing in mind all developmental differences within the community, income per capita has the ability of reducing fertility rates in the community—because of higher opportunity costs of having children—which indicates that the substitution effect is already dominating the income effect in southern Africa, Becker (1960).

Furthermore, the variable for life expectancy, when using the preferred FE estimator, presents positive and significant estimates on fertility, which suggests that an increase in life expectancy combined with precautionary demand for children in an uncertain environment, increases fertility in those developing countries, Galor (2012). Finally, fixed capital formation is not presenting clear-cut estimates, which somehow confirms that the industrial sector in most of those countries is rather small and therefore still not having the expected effect of reducing fertility in the region.

Table 2: Pooled OLS and Fixed Effects Estimates of Education on Fertility, 1980-2009.

FERTIL	POLS (1)	POLS (2)	POLS (3)	POLS (4)	POLS (5)
EDUC	-.343 (-23.25)	-.248 (-15.18)	-.173 (-7.85)	-.180 (-7.95)	-.211 (-9.14)
EXPECT		-.834 (-9.92)	-.709 (-8.64)	-.664 (-7.51)	-.609 (-6.99)
AGRIC			.137 (7.57)	.130 (6.95)	.103 (5.38)
INV				-.030 (-1.36)	-.016 (-0.75)
GDP					-.008 (-4.76)
F test	540.76	380.36	301.74	227.22	194.66
R ²	0.55	0.63	0.68	0.68	0.70
FERTIL	FE (1)	FE (2)	FE (3)	FE (4)	FE (5)
EDUC	-.335 (-4.33)	-.304 (-5.52)	-.230 (-4.22)	-.229 (-4.20)	-.092 (-1.50)
EXPECT		.685 (2.98)	.605 (2.61)	.613 (3.07)	.607 (4.25)
AGRIC			.177 (3.46)	.176 (3.52)	.042 (0.94)
INV				-.004 (-0.17)	.007 (0.31)
GDP					-.249 (-3.58)
F test	18.79	24.52	33.97	26.39	35.08
R ²	0.55	0.30	0.46	0.46	0.06

T-ratios in parentheses. Number of observations: $NT = 450$. *FERTIL* is child per woman, *EDUC* is secondary school enrolment, *EXPECT* is life expectancy at birth, *AGRIC* is agriculture ratio to GDP, *INV* is the gross fixed capital formation ratio to GDP and *GDP* is income per capita. POLS is the Pooled OLS and FE the Fixed Effects estimators.

In Table Three I report the CCE and FE-IV estimates and in this case I instrument education with its own lag, $EDUC_{-2}$. Initially, all *EDUC* estimates are negative and statistically significant against total fertility rates. For example, using column four, second panel, the *EDUC* estimate suggests that for each percentage point increase in secondary enrolment, there will be a reduction in .25 percentage point in total fertility.

In addition, in the second panel life expectancy confirms its positive and significant role on fertility, ie higher life expectancy in southern Africa combined with uncertainty about survival of offspring increases total fertility. In similar vein, the share of the agricultural sector to GDP presents positive and significant estimates against fertility, which confirms the role of non-complementarities in the rural sector between non-industrialised and unskilled goods and lower fertility. On the other hand, income presents neg-

ative and significant effects on fertility, which points to the importance of the substitution effect taking place in the community. Fixed capital formation does not present entirely clear-cut estimates though.

Moreover, in the first-stage regressions our identifying instrument displays the expected sign against secondary enrolment, ie lagged education is persistent on itself. Furthermore, the t -stats of the identifying instruments are all significantly different from zero as well as the F-tests for overall significance, which minimise the issue of weak instruments in the regressions (the complete first-stage regressions are available on request). Lastly, the CCE averages of fertility (available on request) are significant, which suggests that there are common factors, or spillovers, in the community.

Table 3: CCE and FE-IV Estimates of Education on Fertility.

FERTIL	CCE (1)	CCE (2)	CCE (3)	CCE (4)	CCE (5)
EDUC	-.055 (-1.00)	-.098 (-2.46)	-.094 (-2.92)	-.094 (-3.26)	-.091 (-2.91)
EXPECT		.328 (0.45)	-.019 (-0.06)	.306 (0.53)	.031 (0.06)
AGRIC			.018 (0.97)	.026 (1.36)	.027 (1.45)
INV				.005 (0.70)	.019 (2.53)
GDP					-.033 (-0.98)
Wad test	1.01	6.56	20.32	18.94	16.90
FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)
EDUC	-.366 (-18.12)	-.319 (-18.25)	-.255 (-13.47)	-.255 (-13.40)	-.112 (-5.31)
EXPECT		.702 (11.53)	.624 (11.42)	.642 (10.85)	.632 (12.56)
AGRIC			.157 (9.59)	.156 (9.48)	.037 (2.16)
INV				-.009 (-0.79)	.001 (0.18)
GDP					-.233 (-11.03)
F* test	131.46	146.32	162.28	160.93	218.83
R ²	0.55	0.30	0.46	0.46	0.06
IV	EDUC ₋₂				
	.962 (67.81)	.979 (69.22)	.946 (59.29)	.945 (59.18)	.904 (46.24)
F test	4598	2457	1613	1210	1026

T-ratios in parentheses. Number of observations: $NT = 450$. *FERTIL* is child per woman, *EDUC* is secondary school enrolment, *EXPECT* is life expectancy at birth, *AGRIC* is agriculture ratio to GDP, *INV* is the gross fixed capital formation ratio to GDP and *GDP* is income per capita. *EDUC₋₂* is the lag of secondary school enrolment. CCE is the Common Correlated Effects and FE-IV is the Fixed Effects with Instrumental Variables estimators.

In Table Four I instrument education with democracy and globalisation. Once again, all *EDUC* estimates are negative and statistically significant against fertility. For instance, using column four, lower panel, for a 10% points increase in secondary enrolment, there will be a reduction in 6.3% points in total fertility rates in the community.

About the control variables, life expectancy keeps its positive and significant effect on fertility, suggesting that in Africa uncertainty about survival rates of offspring is still high. The agricultural sector estimates in the first panel keep their positive and significant effects on fertility as well, however those estimates are not entirely clear cut in the second panel. In addition,

fixed capital is not clear cut or is income per capita.

Moreover, in the first-stage regressions the instruments for secondary enrolment are always individually and overall statistically significant, which reduce the issue of weak instruments in the analysis. More specifically, democracy by its better governance effect positively influence education, and the proxy for globalisation plays a positive role on secondary enrolment. This positive effect of economic globalisation on education is picking up the fact that a number of those countries already have a rather diversified economy, eg Botswana, Mauritius, Namibia and South Africa have fairly sophisticated services and industrial sectors already in place and therefore these countries are not only exporting unskilled-agricultural goods to developed countries. Also, the internal trade that takes place within SADC itself, eg South Africa exports financial services and mobile phone technology to most of those SADC countries, might be playing a positive role on education as well.

Hence, the results from the first-stage regressions are in line with the documented positive importance that openness have on total factor productivity, which includes human capital, Andersen and Dalgaard (2011). In similar vein, Galor and Weil (2000) state that what separates the Malthusian regime from the sustained growth regime is a particular acceleration in technological progress combined with human capital, which in the SADC case can take place because of a particular shock, eg democratisation and globalisation, which can have the effect of triggering a prospective take-off, Galor and Moav (2002).

Table 4: Fixed Effects with Instrumental Variables Estimates of Education on Fertility.

FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)
EDUC	-.429 (-7.32)	-.454 (-8.32)	-.446 (-5.96)	-.447 (-5.88)	-.481 (-2.40)
EXPECT		.489 (6.39)	.450 (6.33)	.444 (5.66)	.438 (4.27)
AGRIC			.069 (1.85)	.069 (1.83)	.084 (2.69)
INV				.002 (0.18)	.000 (0.01)
GDP					.042 (0.29)
F* test	132.77	112.14	111.23	109.82	95.35
R ²	0.57	0.47	0.54	0.54	0.22
IV	POL	POL	POL	POL	POL
	.126 (6.42)	.131 (6.76)	.091 (5.43)	.091 (5.36)	.037 (2.69)
F test	41.22	29.19	57.89	43.42	101.97
FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)
EDUC	-.471 (-10.09)	-.523 (-12.09)	-.625 (-7.03)	-.628 (-7.03)	-1.07 (-2.51)
EXPECT		.552 (7.28)	.525 (6.15)	.518 (5.53)	.490 (3.12)
AGRIC			-.045 (-0.93)	-.046 (-0.94)	.070 (1.34)
INV				.003 (0.17)	-.016 (-0.53)
GDP					.435 (1.51)
F* test	126.41	109.92	74.84	73.91	26.94
R ²	0.49	0.40	0.41	0.41	0.01
IV	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL
	.701 (8.73)	.758 (9.63)	.450 (6.04)	.455 (6.04)	.162 (2.42)
F test	76.19	53.06	66.83	50.08	90.12

T-ratios in parentheses. Number of observations: $NT = 450$. *FERTIL* is child per woman, *EDUC* is secondary school enrolment, *EXPECT* is life expectancy at birth, *AGRIC* is agriculture ratio to GDP, *INV* is the gross fixed capital formation ratio to GDP and *GDP* is income per capita. *POL* is a proxy for democracy and *GLOBAL* is a proxy for economic globalisation. FE-IV is the Fixed Effects with Instrumental Variables estimator.

In a nutshell, secondary education enrolment has been playing its expected role in reducing fertility rates in the SADC, which confirms previous efforts using European historical data from countries which had not yet experienced their own demographic transition, Dribe (2008), Murphy (2010) and Becker, Cinnirella and Woessmann (2010). The significance of this result is fourfold.

Firstly, lower fertility rates are important because that can have a positive effect on capital per worker, productivity and consequently on growth, Galor (2012). Secondly, it is fair to say that those southern African countries (some of which have been growing fast and consistently in the last twenty years or so, eg Angola, Botswana, Mauritius and Mozambique) are not in a Malthusian stagnation or on a sustained growth path regime. Therefore, it is plausible that those countries in the sample are in fact going through the Post-Malthusian regime. Indeed this seems to be the case, ie in addition to the education and income estimates reported, Figure Five shows that urbanisation is on the rise and that the agricultural share to GDP has been decreasing (from approximately 21% in 1980 to 16% of the GDP in 2009) over time in the community. All in all, these are important characteristics that other (now developed) countries displayed in their own past, Galor (2005), and that these southern African countries are already displaying.

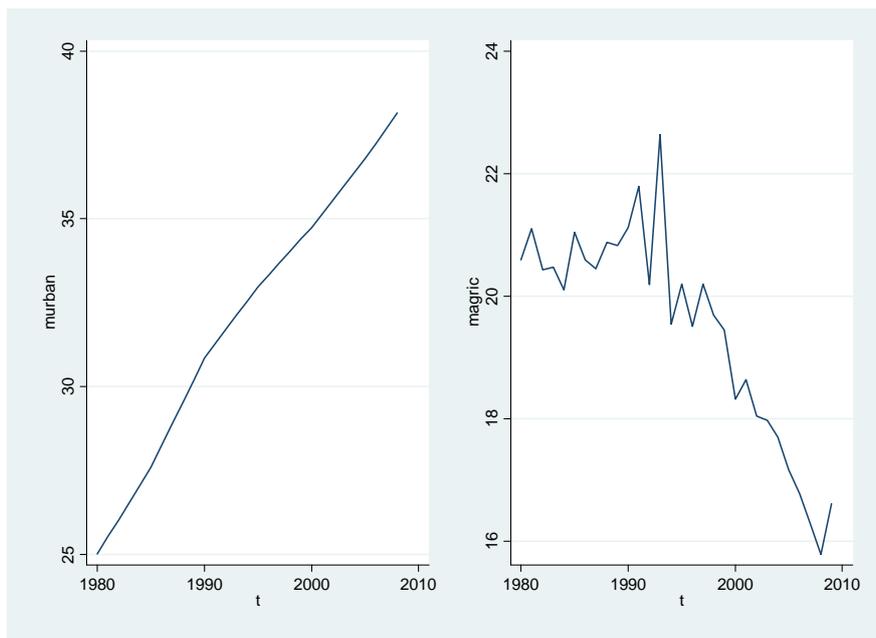


Figure 5: Urbanisation and agricultural share to GDP, SADC, 1980-2009. Source: World Development Indicators.

Thirdly, the results robustly suggest that the community is, although still not in the sustained growth regime, already experiencing before its very own demographic transition, the trade-off between quantity and quality of

children because of higher demand for educated people who can operate particular technologies in the services and industrial sectors, which is also an important ingredient of the transition from the Malthusian stagnation to sustained growth, Becker, Cinnirella and Woessmann (2010).

Fourthly, Galor and Moav (2002) predict that those already with human capital, even during the Malthusian regime, have also higher survival rates and at some point in time, when there is enough human capital in place and usually after a shock, eg democratisation or globalisation, a virtuous circle might be created between human capital and technological progress, and consequently sustained growth takes place.

Moreover, life expectancy is a variable which displays consistent results, ie positive effects on total fertility rates. These results are in line with the historical evidence that suggests that in the 17th and 18th centuries Europe presented reductions in mortality rates that were matched by increases in total fertility, Galor (2012), and also with Dribe (2008) who suggests the same for 19th-century Sweden, which implies that those developing countries of the SADC are experiencing the same process of development that took place in Europe. Perhaps it is fair to speculate that in the future increases in life expectancy will generate lower fertility in the region, which would be in line with the prediction by Soares (2005).

Furthermore, although urbanisation is on the rise in the region, the agricultural sector is still important in southern Africa, and the results regarding the role of agriculture on fertility rates confirm the prediction that agrarian and unskilled goods and quality offspring are not necessarily complementary to each other, Becker, Cinnirella and Woessmann (2010).

The variable for fixed capital formation does not present significant estimates, which suggests that the region is not yet fully industrialised and therefore capital formation is still not playing any negative role on total fertility rates, because of skill complementarities and higher relative wages for women in services and industry, which would take place in the second stage of an industrial revolution, Galor and Moav (2006) and Galor and Weil (1996). All in all, the role of the modern sectors of those economies is being picked up by education⁵.

⁵I have also used the share of industry and services to GDP as control variables. Although the role of education is robust on fertility, the results for manufacturing and services are not clear cut either. Available on request.

In addition, income per capita presents some results (in three out of six regressions) which suggest that southern Africa is not in a Malthusian regime in which higher income would increase fertility. In fact, the evidence, with the caveat that not all income estimates are statistically significant, indicates that the substitution effect is already dominating the income effect in the community, Becker (1960). However, it must be born in mind that the sample contains a fair degree of heterogeneity in terms of economic development, eg Malawi differs from South Africa, and the mixed evidence regarding income and fertility suggests that income per capita is not the main driving force of reduced fertility in the community, Galor (2012), which reinforces the results about the role of education on fertility. Finally, about the instrumental variables estimates, the first-stage regressions results of the positive effects of democracy and globalisation on secondary education bode well, to say the least, with some of the broad developmental objectives of the SADC, ie democracy and integration.

In essence, all the evidence, ie reduction in fertility rates caused by education, increase in urbanisation, reduction in the agricultural share to GDP, no positive effect of income on fertility, when put together, indicates that southern Africa, although still not yet industrialised (which is illustrated by the no effect of fixed capital on fertility) and therefore not into the sustained growth regime, has indeed already escaped the Malthusian stagnation and is well into the Post-Malthusian regime or in transition.

3 Final Remarks

Using a dataset covering the period between 1980 and 2009, I have investigated the role of secondary school enrolment in determining total fertility rates in a panel of fifteen sub-Saharan African countries that are all members of the SADC. The results, based on panel time-series analysis, suggest that education has had a negative and significant effect on fertility in the community. More specifically, education proved to be a robust determinant of fertility, which also highlights its indirect role in determining prosperity in the community through higher capital per worker, increased productivity, economic growth and changes in the composition of the population.

In addition, although Bates, Coatsworth and Williamson (2007) argue that Africa right after its independence in the 1960s has shown similar char-

acteristics that Latin America had right after its own independence in the 19th century, eg political instability, conflict and economic stagnation, and Acemoglu, Johnson and Robinson (2001) highlight the importance of "extractive" institutions being implemented in Africa during its colonial period, factors that might have delayed Africa's own demographic transition, the evidence suggests that southern Africa has escaped the worst of a Malthusian stagnation and is already showing characteristics of a region in transition. In fact, Young (2012) argues that sub-Saharan Africa has witnessed since the 1990s a considerable increase in consumption of vital durables such as housing, schooling and health, which is on par with other developing regions.

Moreover, bearing in mind that Galor and Moav (2002) argue that for sustainable growth to take place a higher proportion of educated "quality type" people combined with technological progress must be in place when a shock, eg democratisation and globalisation, takes place, so that failed takeoffs are minimised, the importance of education can not be emphasized enough. To put it another way, Nelson and Phelps (1966) argue that educated people are innovators and also adaptable to technological change, which highlights the role of education on fertility and sustained development in a globalised world.

About future work, firstly, investigating the roles of primary and female education on fertility rates would be a natural extension to this paper. Secondly, the role of access to finance and how it can affect education and fertility is an interesting and of practical importance subject that deserves some attention and which can complement the present study, Galor (2012). In addition, a more systematic investigation of the role of globalisation as a reinforcing mechanism, on education in Africa would be an interesting avenue to explore, Galor and Mountford (2008). Also, given the no effect of fixed capital formation on fertility, it would be interesting to investigate the role of the large informal urban services sector on fertility in southern Africa.

The quality of the evidence presented is, to a certain extent, boosted because I make use of the unified growth theory to put the results in economic and historical context, and also because I take advantage of panel time-series analysis which deals with important empirical issues such as heterogeneity, cross-section dependence and endogeneity in relatively thin panels. Essentially, this analysis is important because it allows me to specifically study

the SADC region, instead of treating the community either as a dummy or as an outlier to be removed from the sample. Therefore, the empirical analysis conducted represents a step forward in terms of achieving insightful estimates, avoiding unwarranted generalisations and in improving our knowledge on the subject in sub-Saharan Africa.

To conclude, the SADC experience is informative firstly because it encapsulates a number of countries, which no doubt share important characteristics and goals, but which also have their own idiosyncrasies. Secondly, all the evidence presented, descriptive and analytical, suggests that southern Africa, although not yet a Solow industrialised region and with all its known challenges, has already escaped its Malthusian stagnation, which suggests that the southern part of the continent is transitioning to a more sustained growth regime.

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