Evidence on Primary Education and Fertility Rates from Southern Africa

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Abstract

Unified growth theory advances that the process of economic development is characterised by an increase in demand for human capital which creates incentives for lower fertility rates. I study whether primary school completion rates have 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 data and analysis, suggests that primary education has reduced fertility in the SADC, or that the community is already trading-off quantity for quality of children. The evidence is significant because lower fertility, caused by education, implies more capital per worker, higher productivity and higher growth rates, and even more significantly because—in accordance with unified growth theory—it suggests that the SADC is experiencing its own transition from the Malthusian epoch into sustained growth.

Keywords: education, fertility, Africa.

JEL Classification: I20, J13, O55.

"In particular, it may be that society should build more human capital relative to tangible capital the more dynamic is the technology." Richard Nelson and Edmund Phelps

I. Introduction

As put by Nelson and Phelps (1966), human capital and technologies move hand in hand in the process of economic development, or the more dynamic technologies are, the more human capital, relative to physical capital, is needed. Moreover, unified growth theory advances that the process of economic development is characterised by higher economic growth rates (which are determined by technological progress) and by an increase in demand for human capital, and also by a reduction in fertility rates.

Bearing the above in mind, I study the role of primary school completion rates in determining total fertility rates in the Southern African Development Community (SADC). I use data from all fifteen SADC countries between 1980 and 2009, and panel time-series analysis (I use the Pooled OLS, Fixed Effects and Fixed Effects with Instrumental Variables estimators to deal with statistical endogeneity, heterogeneity and reverse causality in thin panels, and democracy is the identifying external instrument for primary education) to study whether primary education played any role on fertility in a community of countries which presents common characteristics and objectives, but also (economic and institutional) differences.

More about the SADC: the SADC is a community of countries that advocates "regional integration and democratic principles" as tools to "enhance the standard and quality of life" and to "achieve development and economic growth". Although with common objectives, this community includes a diverse set of countries, *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 from the 1980s onwards, with South Africa presenting positive growth, although modest, since the end of Apartheid in 1994, and with a country like Zimbabwe which presented negative growth from 1999 to 2009. To further

illustrate the diversity seen in the community, Figure one depicts the trend of the services sector to GDP in all countries of the community and it shows the positive trend taking place in most countries, *eg* Botswana, Lesotho, Mozambique, Mauritius, Malawi, Namibia, South Africa, Seychelles and Tanzania, the stagnation of Zimbabwe and the contraction taking place in Angola and the Democratic Republic of the Congo (DRC).

Figure 1: Services to GDP ratio, SADC, 1980-2009. Source: World Bank.

I rely on unified growth theory, Galor and Weil (2000) and Galor and Moav (2002), to better understand and contextualise the recent development of the community. The underlining theory divides the process of development of an economy into three regimes. Firstly, the Malthusian epoch in which increases in income—coming from external shocks, *eg* the Black Death in 14^{th}-century Europe or the AIDS epidemic in 20^{th}-century Africa—have the effect of increasing fertility rates. After some time though, given the "positive checks" (disease, famine and malnutrition), this economy converges back to its original equilibrium, *ie*

shocks have no long-run effects on income, only on population density, Ashraf and Galor (2013). Secondly, there is the Post-Malthusian regime in which income increases and some technological progress and industrialisation take place, without too much human capital in place though. In addition, during this transitional period, life expectancy tends to increase, Galor (2005 and 2011). Lastly, in the sustained growth regime technological progress and industrialisation take off, demand for educated workers who can operate production technologies increases; in fact, because of technological progress human capital returns increase and it takes a central role in the production process, fertility rates see a reduction and the demographic transition is eventually completed, Galor (2005).

The evidence I report suggests, firstly, that primary education has been a robust determinant of fertility in the community. Because of higher demand for skilled people who can operate basic technologies in services and manufacturing, which increases returns to education, primary education is associated with lower fertility in a region that, with exceptions, still has some high-fertility countries, Strulik and Vollmer (2013). Secondly, the rise in life expectancy that the community has been experiencing in the last decades (even when taking the AIDS epidemic of the 1990s into account) is still not enough, given the uncertainty about survival of children in the short run, to reduce fertility, Galor (2011). Thirdly, given non-complementarities between agricultural and non-skilled goods, and lower fertility, the agricultural sector of those economies is associated with higher fertility, Becker, Cinnirella and Woessmann (2010).

Fourthly, there is evidence that economic globalisation reduces fertility, by the spreading to developing countries of better health technologies and information, Soares (2007). Lastly, there is evidence suggesting that income increases, given higher opportunity costs of raising children, lower fertility in the community, Becker (1960) and Herzer, Strulik and Vollmer (2012). All in all, although Conley, McCord and Sachs (2007) state that Africa "remain mired in a Malthusian crisis of high mortality, high fertility, and rapid population growth", the evidence—particularly the roles of primary education and income in reducing fertility,

and the effect that life expectancy has on fertility—suggests that the SADC has escaped the Malthusian (stagnation) epoch and is transitioning to sustained growth.

The importance of acquiring a better understanding of the role of primary education on fertility in the SADC is threefold: firstly, lower fertility implies more capital per worker, higher productivity and higher growth rates. Secondly, lower fertility (caused by education) implies that the modern sectors of those economies—although small—are demanding people with human capital who can work in services and manufacturing, and that in itself increases returns to education which in turn triggers the quantity-quality trade-off. Thirdly, the take off into the sustained growth regime, usually caused by a shock, *eg* democratisation, requires a critical level of human capital so that the virtuous cycle between human capital and technological progress can take place, Galor and Moav (2002). Given the overall evidence, and bearing in mind the numerous factors that might have delayed Africa's own demographic transition in the past, *eg* late extractive colonialism, Acemoglu, Johnson and Robinson (2001), it is hard not to emphasize the importance of understanding the interplay between education and fertility in a community (as diverse as it is) which, when interpreting the results within the unified growth theory, is transitioning from the Malthusian epoch into sustained growth.

In terms of previous literature, firstly, Ainsworth, Beegle and Nyamete (1996) report evidence, using data from fourteen sub-Saharan African countries from the 1980s and early 1990s, which suggests that primary schooling reduces fertility in only about half of the countries in the sample, and Drèze and Murthi (2001) use Indian data at district level between 1981 and 1991 to report that female education is associated with lower fertility. Secondly, Conley, McCord and Sachs (2007) use data from 1960 to 2004 to report that female literacy "do not seem to matter" as much as mortality in Africa, and Dribe (2008) uses Swedish data from 1880 to 1930 at county and national level to report that the number of teachers per 100 children reduces fertility.

Thirdly, Lehr (2009) uses data from 95 countries between 1960 and 1999, which are

in different stages of development, to report that, although secondary education reduces fertility, primary education is positively associated with fertility, and Murphy (2015) uses French departmental-level data between 1876 and 1896 to report that female literacy reduces fertility in France. In addition, Becker, Cinnirella and Woessmann (2010, 2012 and 2013) use 19^{th}-century data from Prussian counties to report that school enrolment and female education reduces the child-woman ratio as well, and Murtin (2013) uses a panel of 70 countries covering the period 1870-2000 to report that secondary education reduces fertility in the long run (even in his non-OECD subsample). Lastly, Bittencourt (2014) uses contemporaneous African data to report that secondary education reduces fertility in a panel of southern African countries[1].

In essence, the previous evidence, which includes samples of countries in a time period which they had not yet experienced their own demographic transition, just like Africa now, is not unequivocal about the role of education on fertility. Hence, this paper is a natural development of the previous literature. I conduct a study of a community of African developing countries that attempts to pinpoint in more detail (than Ainsworth, Beegle and Nyamete, 1996 and Conley, McCord and Sachs, 2007) the effects of primary education on fertility. I do that by taking advantage of unified growth theory and panel time-series analysis, which includes more recent data that takes the current growth spurt and also the effect of the external democratic shock affecting the community into account, which allow me to put the evidence into economic and historical context and also to deal with particular econometric issues in thin panels, *ie* statistical endogeneity, heterogeneity and reverse causality, which enables me to provide informative and contextual estimates so that our knowledge of an idiosyncratic, and diverse within, southern Africa is furthered.

II. The Data

The dataset covers the period 1980-2009, 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.

Total fertility rates, $FERTIL$, is the number of children per woman—or the number of children that would be born to each woman with age-specific fertility rates—and the data are from the United Nations Population Division. For education I use primary school completion as percentage of the relevant age group, $EDUC$, and the data are provided by the World Bank. It is expected that education leads to more investment in quality than in quantity of children, or that higher primary education reduces fertility. Unified growth theory advances that the quantity-quality trade-off happens because of higher demand for basic skills for use in services and manufacturing, which tends to increase the returns to education and consequently to trigger the trade-off even before a region's demographic transition takes place, Becker, Cinnirella and Woessmann (2013).

The choice of control variables follows the underlining theories of demographic transition, Galor (2011). First, I account for life expectancy, $EXPECT$, which is life expectancy in terms of number of years at birth. The data are from the United Nations and it is predicted that an increase in life expectancy might not be enough to reduce fertility, particularly in developing countries where uncertainty about survival of children is still relatively high in the short run, Galor (2011). Moreover, I use the importance in percentage terms of the agricultural sector on the respective GDPs of those countries, $AGRIC$, and the data are from the World Bank. It is predicted that more agrarian societies tend to favour quantity instead of quality of children because of non-complementarities between agricultural and non-skilled goods, and lower fertility, Becker, Cinnirella and Woessmann (2010).

Furthermore, I use gross fixed capital formation to GDP, INV, as a proxy for industrialisation and the data are from the World Bank. Given the complementarities between industrialised-skilled goods and lower fertility, it is predicted that industrialisation is associated with lower fertility, Galor and Moav (2006), and also because of higher demand for women from services and manufacturing which tend to increase women's relative wages and

to reduce fertility, Galor and Weil (1996). I also use a variable for economic globalisation, $GLOBAL$, provided by Dreher (2006) which takes into account trade to GDP and also, *eg* foreign direct and portfolio investment, and import barriers. It is expected that globalisation, at least in non-industrialised developing countries trading with developed countries, might positively affect fertility as developing countries specialise in non-skilled agricultural goods which do not require human capital, Galor and Mountford (2008).

Lastly, I control for income per capita, GDP, and the data are from the World Bank. It is expected that higher income in societies that have already escaped the Malthusian epoch, given the higher opportunity costs of raising children when income increases, leads to a reduction in fertility, Becker (1960) and Herzer, Strulik and Vollmer (2012). Alternatively, some will argue that the negative effect of changes in income on fertility is because higher household income tends to be associated with an increase in women's relative wages, given the higher demand for women from particular modern sectors of an economy, which in turn increases opportunity costs of raising children and to lower fertility, Galor and Weil (1996).

Figure two depicts total fertility rates in all SADC countries and it shows firstly that most countries are experiencing reductions in fertility (the DRC is perhaps the only exception). Secondly, countries such as Mauritius, South Africa and Seychelles are already experiencing low fertility. Thirdly, there are countries still presenting high fertility, *eg* Angola, the DRC and Tanzania, and lastly there are countries such as Botswana, Lesotho and Zimbabwe which have experienced significant reductions in fertility over time. All in all, although diverse in terms of development, the SADC countries are mostly experiencing reductions in fertility over time and Galor (2011) argues that in 19^{th}-century Europe fertility decreased roughly at the same time in countries which also differed in terms of development, perhaps similarly to contemporaneous Africa.

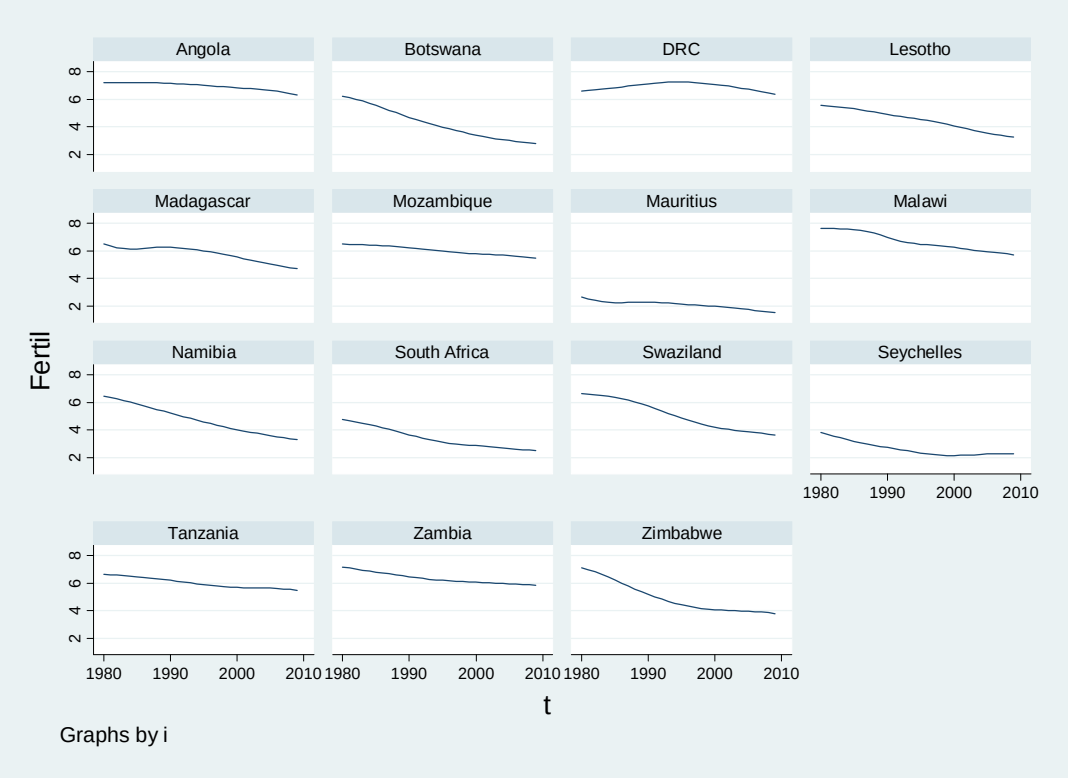

Figure 2: Total fertility rates, SADC, 1980-2009. Source: United Nations.

Figure three depicts the country-averaged data on fertility and primary education, and the first panel confirms that during the whole period fertility in the SADC as a whole have been decreasing over time, *ie* from roughly six children per woman in 1980 to approximately four in 2009. Moreover, primary education has been on the rise throughout the period, from roughly 60% of the corresponding population age group in 1980 to approximately 80% in 2009. The third panel depicts the simple OLS regression line between primary education and fertility (the data are now in logs), and it shows that there is an economic relationship between (higher) primary education and (lower) fertility taking place in the community, or that the community is already trading off quantity for quality of children.

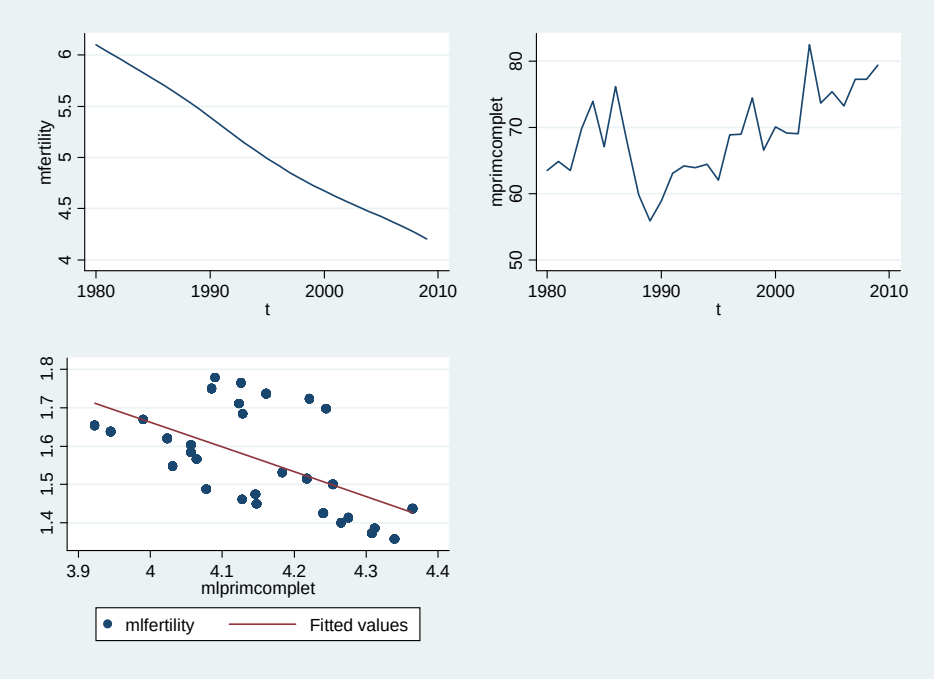

Figure 3: Total fertility rates, primary school completion rates and the simple OLS regression line between total fertility rates and primary school completion rates, SADC, 1980-2009. Sources: United Nations and World Bank.

Table one presents the descriptive statistics and the correlation matrix of the variables. Initially, the two main variables of interest, fertility and primary education confirm the above eye-ball evidence and present a negative and statistically significant correlation with each other. Life expectancy presents a negative and significant correlation with fertility, which suggests that an increase in life expectancy reduces uncertainty about survival of children, increases the horizon of investment in human capital and eventually reduces fertility, Soares (2005), Doepke (2005), Conley, McCord and Sachs (2007) and Angeles (2010).

The agricultural sector to GDP presents a positive correlation with fertility and fixed capital formation presents the expected negative correlation with fertility. The negative correlation between globalisation and fertility is capturing the role of openness, *eg* by the spreading of better health technologies and information, in lowering fertility in the community, Soares (2007). Lastly, income displays a negative correlation with fertility, which suggests that there are opportunity costs of raising children with increasing income.

Table 1: Descriptive Statistics and the Correlation Matrix, SADC, 1980-2009.

Variables	Obs	Mean	Std Dev	Min	Max	Sources
FERTIL	450	5.09	1.61	1.54	7.62	United Nations
EDUC	291	69.23	25.73	14.02	127.47	World Bank
EXPECT	450	53.87	8.94	40.18	73.00	United Nations
AGRIC	435	19.43	13.70	1.81	59.74	World Bank
INV	450	20.91	10.46	2.06	76.69	World Bank
GLOBAL	410	48.27	14.47	13.01	77.85	Dreher (2006)
GDP	433	7.31	2.03	1.46	1.48	World Bank

	FERTIL	EDUC	EXPECT	AGRIC	INV	GLOBAL	GDP
FERTIL	1						
EDUC	-0.657*	1					
EXPECT	-0.663*	0.602*	1				
AGRIC	0.709*	-0.731*	-0.491*	1			
INV	-0.282*	0.289*	0.388*	-0.311*	1		
GLOBAL	-0.384*	0.405*	0.133*	-0.663*	0.288*	1	
GDP	-0.234*	0.076	0.158*	-0.231*	0.265*	0.237*	1

* represents significance at the 5% level.

III. Methodology

I estimate the following equation,

$$\begin{aligned} FERTIL_{it} &= \alpha_i + \beta EDUC_{it-1} + \beta EXPECT_{it} + \gamma AGRIC_{it} + \\ &+ \delta INV_{it} + \epsilon GLOBAL_{it} + \varepsilon GDP_{it} + \upsilon_{it} \end{aligned} \tag{1}$$

where $FERTIL$ is total fertility rates, or the number of children per woman, $EDUC$ is primary school completion rates lagged once (it is expected that the effect of education on

fertility is not immediate and the lag also reduces endogeneity concerns), $EXPECT$ 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, $GLOBAL$ is economic globalisation and GDP is income per capita. All variables are in logs.

The strategy, given that I have a $T > N$ dataset, $T = 30$ years and $N = 15$ countries, is based on panel time-series analysis. Firstly, although some of the variables are either ratios or indices, *eg* fertility and globalisation, and hence bounded within closed intervals, I evoke Phillips and Moon (1999) result which suggests that the issue of spurious regressions is less of a problem in panels because of the averaging taking place in panel estimators which reduces the noise coming from such regressions.

Secondly, the issues of statistical endogeneity and heterogeneity are dealt with by the Fixed Effects (FE) with robust standard errors estimator, which provides consistent estimates when $T \to \infty$, Smith and Fuertes (2010). Although those countries shared economic and institutional transitions in their recent history (and have common objectives), which makes the homogeneity of slopes a plausible assumption, the heterogeneous intercepts of the FE estimator also account for the fact that some of the countries present different characteristics in terms of economic and institutional development, or characteristics that change across countries but not over time, *eg* Botswana and Zimbabwe are both former British colonies, but with a particular set of institutions each. Specifically, given the different economic performance displayed by both countries since independence, it is conceivable that Botswana follows some aspects of the English common law more closely than Zimbabwe. Overall, it is plausible that the SADC countries display homogeneous characteristics and also specific, but uncorrelated across each other, fixed characteristics, which makes the FE estimator particularly suitable in this context.

Thirdly, although I follow the underlining theories of the demographic transition, Galor (2011), to minimise model uncertainty and omitted variables, some would argue that reverse causality is a possibility, or that lower fertility leads to higher education, Becker, Cinnirella

and Woessmann (2010). Therefore I use the Fixed Effects with Instrumental Variables (FE-IV) estimator which provides estimates that are asymptotically consistent and efficient as $T \to \infty$, Arellano (2003).

With the assumption that deeper lags of education are uncorrelated with the error term ($E(educ_{it-n}v_{it} = 0)$) but correlated with contemporaneous education in mind, firstly I make use of the lag of primary education as a baseline internal identifying instrument for contemporaneous primary education. It is expected, given education's persistence over time, a positive effect of lagged education on contemporaneous primary completion, Murtin (2013). Moreover, it is plausible that lagged education is not correlated with (unexpected) contemporaneous fertility.

In addition, I use the normalised, so that it ranges from zero to one, polity2 variable (POL) from the Polity IV database to account for the external democratic shock that the community saw taking place back in the 1990s and which continues to the day, Bates, Block, Fayad and Hoeffler (2013). The POL variable is the difference between the $DEMOC$ and $AUTOC$ indicators and these indicators contain information on the competitiveness and openness of executive recruitment, competitiveness of political participation and constraints on the executive. Moreover, the POL variable captures the fact that some of the countries in the community transitioned from dictatorship to democracy more than once in their recent history, and also that some countries presented hybrid regime characteristics, *eg* South Africa during Apartheid, which precludes the use of dichotomous regime classifications *à la* Papaioannou and Siourounis (2008). Furthermore, since I use the instruments separately, the estimated systems are just identified[2].

It is expected that democracy plays a positive role on education, by better governance and more efficient, or redistributive, allocation of resources towards public goods, in this case primary education, Tavares and Wacziarg (2001) and Gallego (2010). More specifically, given democracy's internal rationale of political competition and turnover, combined with the fact that southern Africa is a relatively poor region, democracy works as a redistributive device

to the median voter who is located towards the left of the income distribution, Acemoglu and Robinson (2000). Moreover, it is plausible that democracy affects fertility by education, *ie* democracy and its redistribution can not have a direct effect on fertility decisions without an educated population, who are able to respond to incentives coming from higher demand for skills and who are also able to make use of modern contraceptive methods, in place.

Figure four (first panel) depicts the external instrumental variable series and it illustrates the shift to more democratic institutions taking place in 1990 in the community. Moreover, the simple OLS regression line in the second panel of Figure four points towards a positive economic relationship between democracy and provision of primary education in the community.

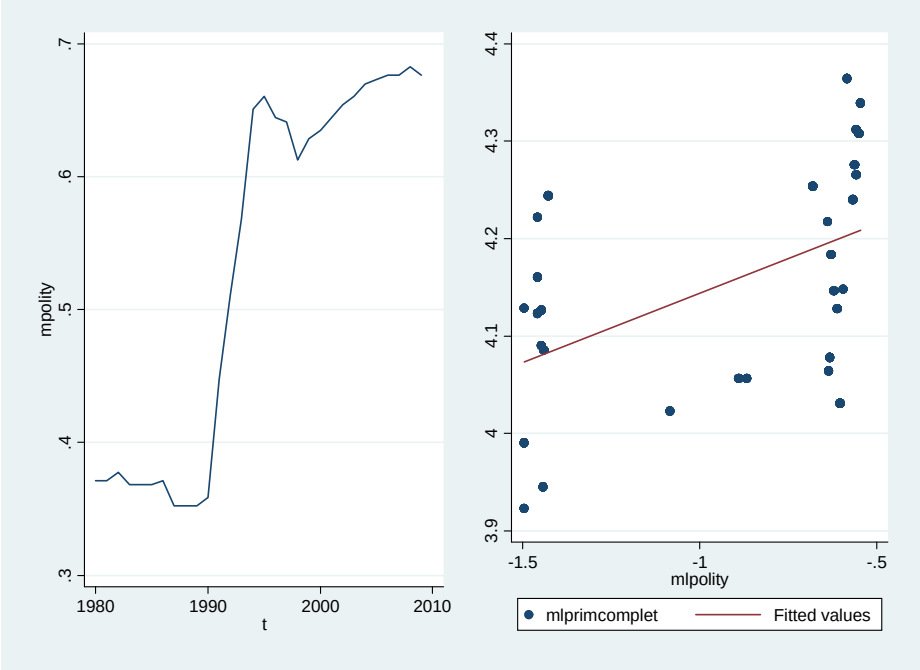

Figure 4: Democracy and the simple OLS regression line between democracy and primary school completion rates, SADC, 1980-2009. Sources: Polity IV and World Bank.

IV. Results and Discussion

In Table Two I report the baseline robust POLS (first panel) and then the robust FE estimates (second panel). All POLS and FE primary education estimates are negative and statistically significant against fertility. For instance, the FE estimate in column five suggests that for each percentage point increase in primary education, there will be a .13 percentage point reduction in fertility in the community, a result which is consistent with previous efforts which use data from other regions before their own demographic transition, Murphy (2015).

About the controls: the agricultural sector is associated with mostly significantly higher fertility, which confirms the role of non-complementarities between unskilled-agricultural goods and lower fertility, Becker, Cinnirella and Woessmann (2010). Income is associated with lower fertility, which suggests higher opportunity costs of raising children when income increases, Becker (1960) and Herzer, Strulik and Vollmer (2012).

Life expectancy, when using the preferred FE estimator, presents positive and significant estimates on fertility, which suggests that increases in life expectancy, combined with uncertainty about survival of children, are not enough to reduce fertility (at least in the short run) in the community, Galor (2011). Although with negative estimates, in this instance fixed capital formation does not present wholly significant effects on fertility nor does economic globalisation in the second panel.

Lastly, the F* test in the second panel suggests that the null hypothesis of homogeneous intercepts is rejected, which suggests that the FE estimator, which takes into account heterogeneity and fixed specific characteristics is the more appropriate estimator in this context.

Table 2: Pooled OLS and Fixed Effects Estimates, SADC, 1980-2009.

FERTIL	POLS (1)	POLS (2)	POLS (3)	POLS (4)	POLS (5)	POLS (6)
EDUC	-.619 (-13.20)	-.373 (-7.39)	-.076 (-1.88)	-.077 (-1.93)	-.085 (-2.04)	-.097 (-2.15)
EXPECT		-1.10 (-7.65)	-.904 (-8.24)	-.883 (-7.71)	-.919 (-6.12)	-.890 (-5.80)
AGRIC			.237 (12.49)	.236 (12.56)	.265 (12.77)	.262 (12.35)
INV				-.022 (-0.97)	-.035 (-1.31)	-.027 (-0.97)
GLOBAL					.119 (2.21)	.140 (2.44)
GDP						-.004 (-2.54)
Fixed effects	no	no	no	no	no	no
Rob SE	yes	yes	yes	yes	yes	yes
F test	174.35	196.04	321.42	239.48	101.65	92.81
R^2	0.56	0.70	0.70	0.65	0.65	0.65
FERTIL	FE (1)	FE (2)	FE (3)	FE (4)	FE (5)	FE (6)
EDUC	-.226 (-2.35)	-.233 (-2.63)	-.131 (-3.38)	-.131 (-4.22)	-.130 (-3.99)	-.045 (-1.79)
EXPECT		.958 (2.77)	.415 (1.97)	.549 (3.02)	.681 (4.08)	.619 (6.11)
AGRIC			.302 (11.74)	.298 (11.76)	.243 (8.39)	.047 (1.04)
INV				-.075 (-2.24)	-.052 (-1.57)	-.023 (-1.63)
GLOBAL					-.178 (-2.27)	-.077 (-0.91)
GDP						-.250 (-3.82)
Fixed effects	yes	yes	yes	yes	yes	yes
Rob SE	yes	yes	yes	yes	yes	yes
F test	5.54	5.51	61.31	58.28	46.99	610.66
F* test	72.07	76.15	134.12	146.93	187.66	365.84
R^2	0.43	0.09	0.50	0.47	0.32	0.06

T-ratios in parentheses. Number of observations: $NT = 450$.

In Table Three I report the FE-IV estimates. In the first panel I instrument primary education with its own lag, $EDUC_{-2}$, and in the second I use democracy, POL, as the

identifying external instrument for primary education. Firstly, all $EDUC$ estimates are negative and statistically significant against fertility. For example, using column five, second panel, the $EDUC$ estimate suggests that for each percentage point increase in primary education, there will be a reduction in .46 percentage points in fertility, a larger effect than the ones reported in Table Two which illustrates the role of the external variation coming from the instrumental variable POL.

Secondly, life expectancy keeps its positive and significant role on fertility as well as the share of the agricultural sector to GDP with positive and significant estimates. On the other hand, fixed capital formation and income present negative and significant estimates on fertility, which firstly points to the importance of demand for human capital from services and manufacturing and the role of complementarities between skilled goods, higher relative wages for women and lower fertility, Galor and Moav (2006) and Galor and Weil (1996); and secondly to higher opportunity costs in raising children when income increases, Becker (1960) and Herzer, Strulik and Vollmer (2012). Globalisation presents negative and mostly significant estimates on fertility, which suggests that openness can reduce fertility by the spreading of health technologies, flows of knowledge and values across the developing world, Soares (2007).

Lastly, in the first-stage regressions the identifying instruments (estimates which are reported in the lower part of both panels) display the expected signs against primary education, *ie* lagged education by its persistent effect on itself and democracy by its redistributive and better governance effects, Gallego (2010), positively determine primary education. 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.

Table 3: Fixed Effects with Instrumental Variables Estimates, SADC, 1980-2009.

FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	FE-IV (6)
EDUC	-.267 (-4.48)	-.249 (-5.05)	-.149 (-4.35)	-.143 (-4.32)	-.140 (-4.50)	-.060 (-2.49)
EXPECT		1.02 (9.98)	.399 (5.35)	.523 (6.72)	.650 (8.30)	.588 (10.36)
AGRIC			.310 (16.99)	.307 (17.45)	.256 (12.76)	.056 (2.68)
INV				-.073 (-4.22)	-.055 (-2.97)	-.034 (-2.54)
GLOBAL					-.144 (-3.78)	-.033 (-1.16)
GDP						-.255 (-12.70)
F* test	60.65	75.36	152.16	165.88	199.73	391.48
R^2	0.45	0.08	0.50	0.47	0.34	0.05
IV	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$
	.884 (23.28)	.886 (23.44)	.872 (22.38)	.873 (22.36)	.875 (21.97)	.846 (20.86)
F $test_{iv}$	541.78	275.12	194.88	145.89	112.73	98.48
FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	FE-IV (6)
EDUC	-1.04 (-4.02)	-1.03 (-4.18)	-.694 (-4.12)	-.614 (-4.20)	-.462 (-4.11)	-.314 (-2.06)
EXPECT		.843 (4.71)	.523 (3.56)	.655 (4.68)	.707 (6.19)	.657 (6.70)
AGRIC			.191 (4.44)	.196 (5.19)	.170 (5.26)	.105 (3.20)
INV				-.083 (-3.27)	-.059 (-2.61)	-.043 (-2.24)
GLOBAL					-.159 (-3.52)	-.121 (-3.15)
GDP						-.111 (-1.80)
F* test	27.59	24.37	41.90	53.78	91.24	163.31
R^2	0.45	0.28	0.51	0.50	0.38	0.14
IV	POL	POL	POL	POL	POL	POL
	.071 (4.18)	.071 (4.18)	.068 (4.20)	.071 (4.28)	.080 (4.19)	.048 (2.41)
F $test_{iv}$	17.49	8.86	13.69	10.45	7.35	9.36

T-ratios in parentheses. Number of observations: $NT = 450$.

In a nutshell, primary education is associated with lower fertility in the SADC, which

confirm previous efforts using data from countries which had not yet experienced their own demographic transitions, Murphy (2015), Murtin (2013) and Becker, Cinnirella and Woessmann (2010). Importantly, the reported evidence is stronger than the one in Ainsworth, Beegle and Nyamete (1996), perhaps because I take advantage of more data (which includes the growth spurt and the democratic shock taking place in Africa from 1995 onwards) and better estimators (I deal with statistical endogeneity, heterogeneity and reverse causality). Moreover, the evidence I report, although not entirely comparable, is in contrast to Lehr (2009) where she reports that in pretransition and transition countries (samples which include some SADC countries) primary education presents a positive effect on fertility. Overall though, the evidence suggests that the modern sectors of those SADC countries (although small in some cases) are demanding people with human capital who can operate production technologies in services and manufacturing, and also that they are already experiencing the trade-off between quantity and quality of children, which, according to unified growth theory, is an important characteristic of the transition from the Malthusian epoch to sustained growth, Becker, Cinnirella and Woessmann (2011), Guinnane (2011) and Galor (2011)[3].

Furthermore, lower fertility is significant because it can have a positive effect on capital per worker, productivity, on the much needed economic growth and on the composition of the population, Galor (2011). Equally important, Galor and Moav (2002) predict that those already with human capital, even during the Malthusian epoch, have higher survival rates and at some point in time, when there is enough human capital in place and usually after a shock, *eg* the implementation of democratic institutions, a virtuous cycle is created between human capital and technological progress, and sustained growth might take place. All the same, it cannot be emphasized enough the importance of having a certain stock of human capital in place in a community of developing countries like the SADC if sustained growth is to take place.

Although in contrast to Conley, McCord and Sachs (2007) and Angeles (2010), life expectancy is a variable displaying consistent estimates, *ie* positive effects on fertility, evidence

which is in line with the evidence presented by Galor (2011) who suggests that in 18^{th}- and 19^{th}-centuries England, increases in life expectancy, or reductions in mortality, were associated with increases in fertility as well as with Dribe (2008) who suggests the same for the Swedish case. All the same, Montgomery (2000) suggests that perception about reduced mortality, or higher life expectancy, takes time to change and can therefore affect how life expectancy affects fertility and Soares (2005) suggests that increases in life expectancy indeed take time to affect fertility. It is therefore plausible that in the long-run the data might pick that negative relationship up. Also, Guinnane (2011) suggests that in a number of instances fertility rates decreased even before reductions in mortality, which makes the subject worth pursuing in the future. The evidence about the role of agriculture on fertility rates confirm the prediction that agrarian, and unskilled, goods and quality children are not complementary to each other, Becker, Cinnirella and Woessmann (2010) and Guinnane (2011). On the contrary, fixed capital formation, with the caveat that the SADC is not a Solow community and the industrial sector in most countries is still small, is associated with lower fertility by skill complementarities and increases in women's relative wages, Galor and Moav (2006) and Galor and Weil (1996).

The globalisation estimates—although negative and mostly significant in the FE and FE-IV regressions, suggest that openness, by facilitating access to health technologies, foreign direct investment and flows of knowledge, can induce lower fertility, Soares (2007)—have to be taken with caution since not all of them are statistically significant. Bearing the above in mind, the globalisation evidence is in line with some of the objectives of the SADC, *ie* regional integration as a tool to "enhance the standard and quality of life". Income presents estimates which confirm that the community is not in the Malthusian epoch in which higher income would increase fertility and my estimates are not in contrast to the POLS and FE estimates reported by Conley, McCord and Sachs (2007) either. In fact, and bearing in mind the heterogeneity in terms of development seen in the community, the evidence indicates that higher income is associated with higher opportunity costs of raising children, Becker

(1960) and Herzer, Strulik and Vollmer (2012).

Lastly, about the instrumental variables: the first-stage regressions evidence of the positive effects of democracy on primary education confirm that democracy widens access, or redistributes resources, towards education, Gallego (2010), and they also bode well with some of the broad developmental objectives of the SADC, which include consolidation of democracy in the community as a tool to "achieve development and economic growth".

Overall, the above are significant characteristics that other, now developed, countries displayed in their own past, Galor (2005), and that the SADC is already displaying, *ie* the trade-off between quantity and quality of children caused by primary education when returns to education increase. Thus, according to unified growth theory, it is fair to say that this diverse community of countries (some of which have been growing fast, others which have been growing consistently, in the last twenty years or so, *eg* Angola, Botswana, Mauritius, Mozambique and South Africa) are going through the Post-Malthusian regime of development.

V. Conclusion

Using a dataset covering the period between 1980 and 2009, I have studied the role of primary school completion rates in determining total fertility rates in the SADC. The evidence suggests that primary education has had a negative and significant effect on fertility in the community, which highlights the role of increasing returns to education—from higher demand for human capital from the modern sectors of those economies—and also democracy's and education's indirect roles in determining prosperity in the community by higher capital per worker, increased productivity and economic growth.

Although Bates, Coatsworth and Williamson (2007) argue that Africa right after its independence in the 1960s has shown similar characteristics that Latin America had right after its own independence in the 19^{th} century, *eg* political instability, conflict and economic stagnation, and Acemoglu, Johnson and Robinson (2001) highlight the importance of "ex-

tractive" institutions being implemented in Africa during its colonial period, factors that might have delayed Africa's own demographic transition, the overall evidence suggests that southern Africa has escaped the Malthusian stagnation epoch and is already showing characteristics of a region in transition. In fact, Young (2012) argues that sub-Saharan Africa has witnessed since the mid 1990s a considerable increase in consumption of vital durables such as schooling, health and housing, which is on par with other developing regions and Pinkovskiy and Sala-i-Martin (2014) categorically state that "Africa is on time" in terms of achieving the Millennium Development Goal of reducing poverty.

It must be born in mind though, that Galor and Moav (2002) argue that for sustained growth to take place a higher proportion of educated "quality type" people combined with technological progress must be in place when a (positive) shock, *eg* democratisation, takes place, so that failed takeoffs are minimised. To put it another way, Nelson and Phelps (1966) argue that educated people are innovators and also adaptable to technological change, which reinforces the role of education on fertility and sustained development in a globalised world.

A Appendix

I report extra regressions in which female labour force participation (FEM) is included as an extra control variable and also where I use both instruments, lagged education and democracy, together. Female labour force participation is the percentage of female to total female population who are older than fifteen years old and the data are from the International Labour Organisation. The $EDUC$ estimates are consistent with the ones reported above, however FEM does not present coherent effects on fertility. Moreover, the different tests of the first-stage regressions in the lower panel indicate that the instruments are valid.

In the second panel I report regressions, including a dynamic one—which include the variable gender gap, $GENGAP$, which is the ratio of girls to boys in primary and secondary education and the data are provided by the World Bank—where I use the Mean Group (MG) estimator, Pesaran and Smith (1995), to account for heterogeneity of intercepts and slopes.

The MG estimates different OLS regressions for each country and then averages them up and it provides consistent estimates when $T \to \infty$, Smith and Fuertes (2010). The $EDUC$ estimates are, yet again, consistent with the ones reported above.

Table 4: Fixed Effects with Instrumental Variables and Mean Group Estimates, SADC, 1980-2009.

FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	FE-IV (6)	FE-IV (7)
EDUC	-.297 (-5.46)	-.280 (-5.93)	-.169 (-5.43)	-.161 (-5.46)	-.153 (-5.64)	-.147 (-4.85)	-.092 (-3.93)
EXPECT		.864 (8.04)	.233 (3.18)	.370 (4.82)	.496 (6.59)	.497 (6.08)	.522 (8.48)
AGRIC			.309 (17.85)	.303 (18.23)	.253 (13.60)	.234 (12.04)	.044 (1.90)
INV				-.072 (-4.44)	-.056 (-3.27)	-.039 (-2.22)	-.021 (-1.56)
GLOBAL					-.135 (-3.98)	-.153 (-4.25)	-.052 (-1.84)
FEM						-.004 (-0.04)	.022 (0.23)
GDP							-.240 (-10.53)
F* test	69.89	72.24	160.86	178.36	226.46	235.19	408.45
R^2	0.46	0.01	0.56	0.53	0.40	0.36	0.06
IV							
$EDUC_{-2}$	.846 (21.15)	.849 (21.38)	.832 (20.29)	.833 (20.35)	.844 (19.86)	.797 (16.64)	.794 (16.54)
POL	.034 (3.29)	.035 (3.37)	.031 (3.06)	.032 (3.20)	.026 (2.35)	.029 (2.30)	.024 (1.79)
F test	273.01	186.60	148.33	119.61	93.13	53.10	46.46
Sargan	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FERTIL	MG (1)	MG (2)	MG (3)	MG (4)	MG (5)
EDUC	-.530 (-3.25)	-.363 (-2.42)	-.144 (-2.80)	-.044 (-1.65)	-.058 (-1.91)
EXPECT		-1.66 (-1.72)	-1.61 (-1.35)	-.873 (-1.09)	-.493 (-0.76)
GENGAP			.119 (0.25)	.443 (1.97)	.080 (0.52)
GDP				-.245 (-3.43)	-.022 (-1.05)
$FERTIL_{-1}$					.657 (4.47)
Wald	10.58	10.25	9.75	63.95	216.80

T-ratios in parentheses. Number of observations: $NT = 450$.

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Notes

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[1]This literature review is in no way exhaustive. For extensive surveys of the literature in Economics and Demography see Galor (2005), Galor (2011) or Guinnane (2011).

[2]Moreover, given that the dataset presents a relatively long T, $T = 30$, and that the regressions already have macroeconomic variables picking up common macro time effects on the RHS, *eg* globalisation and income, and the democratic shock as an instrumental variable, I do not use time effects dummies. In addition, although I report a dynamic regression in the Appendix, since I use robust standard errors in the regressions, I follow Achen (2001) advice and do not include the lagged-dependent variable on the RHS to avoid unnecessary dominance of the lagged-dependent variable over the explanatory variables.

[3]I have also run regressions with the urbanisation ratio on the RHS and deeper lags of primary education and also deeper lags of education as the baseline internal instrumental variable for primary education and education kept its negative and significant estimates on fertility. Available on request.