Evidence on Primary Education and Fertility Rates from Southern Africa

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Abstract

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 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), suggests that primary education has reduced fertility rates in the SADC, 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 with unified growth theory—they suggest that the SADC is experiencing its own transition from the Malthusian regime into sustained growth. (JEL I20, J13, O55).

I. Introduction

Africa is known for its recent political independence from European rule, for a number of political regime changes taking place (particularly) during the cold war, for civil and military conflict, and for poor macroeconomic performance. 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 been matched by better economic performance, Bates, Coatsworth and Williamson (2007), Young (2012) and Pinkovskiy and Sala-i-Martin (2014).

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), a community of countries that advocates the importance of democracy and regional integration as tools for development. 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 the Apartheid regime in 1994, and with a country like Zimbabwe which has presented negative growth 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 and Fixed Effects with Instrumental Variables estimators in order 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 the community.

For the above I rely on unified growth theory models (Galor and Weil, 2000, and Galor and Moav, 2002) to better understand and contextualise the recent development of the southern African region. The underlining theory divides the process of development of an economy into three regimes. Firstly, the Malthusian epoch in which increases in income—conceivably 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", this 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 technological progress and industrialisation take place, without too much human capital in place though. In addition, during this transitional period, life expectancy as well as fertility tend to increase, Galor (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 takes place, Galor (2005).

The evidence I report suggests that, firstly, primary education completion rates have been a robust determinant of total fertility rates in the community. Essentially, because of higher demand for fairly skilled people who can operate basic technologies in services and manufacturing, which increases returns to education, education is associated with lower fertility in a region that has not yet gone through its own demographic transition, Murphy (2010). Secondly, the rise in life expectancy that the community has been experiencing in the last decades (even when taking into account the AIDS epidemic of the 1990s) is accompanied, conceivably because of uncertainty about survival of children in the short run, by higher fertility rates, Galor (2011). Thirdly, because of non-complementarities between agricultural and non-skilled goods, and lower fertility, the agricultural sector of those economies is associated with higher fertility rates, Becker, Cinnirella and Woessmann (2010).

Fourthly, there is some 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, because of higher opportunity costs of raising children, lower fertility in the community, Becker (1960) and Herzer, Strulik and Vollmer (2012). All in all, the evidence—particularly the roles of education and

income in reducing fertility, and the effect that life expectancy has on fertility—suggests that the SADC have escaped the Malthusian epoch.

The importance of acquiring a better understanding of the role of education on fertility rates 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 already demanding people with some 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 circle 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 which is possibly transitioning from the Malthusian epoch into more sustained growth.

In terms of previous empirical 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 secondary education reduces fertility, and

Murphy (2010) 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 data from Prussian counties in the 19^{th} century 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 primary education reduces fertility in the long run. Lastly, Bittencourt (2014) uses contemporaneous African data to report evidence that secondary education reduces fertility in a panel of southern African countries[1].

In essence, the previous empirical evidence, which includes samples of countries in a time period which they had not yet experienced their own demographic transition, just like Africa now, mostly suggests that education (or the higher returns associated with it) plays an important role in reducing fertility rates. Hence, this paper is a natural development of the previous literature on the subject. I conduct a case study of a community of African developing countries that attempts to pinpoint in more detail the effects of primary completion rates on total fertility. I do that by taking advantage of unified growth theory and panel time-series analysis (not to mention more contemporaneous data that takes the current growth spurt into account) which allow me to put the evidence into 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 and Methodology

The dataset 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 (DRC), Lesotho, Madagascar, Mozambique, Mauritius, Malawi, Namibia, South Africa, Swaziland, Seychelles, Tanzania, Zambia and Zimbabwe.

The variable for total fertility, $FERTIL$, 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 the quality than in the quantity of children, or that higher primary completion rates reduce total fertility rates. This quantity-quality trade-off happens because of incentives coming from 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 theory. First, I account for life expectancy, $EXPECT$, which is life expectancy in terms of number of years at birth. The data come from the United Nations and it is predicted that an increase in life expectancy leads to an increase in fertility, particularly in developing countries where uncertainty about survival of children is still relatively high in the short run, Galor (2011). 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 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 the gross fixed capital formation to GDP, INV, as a proxy for industrialisation and the data are from the World Bank. It is predicted that industrialisation is associated with lower total fertility rates because of complementarities between industrialised-skilled goods and lower fertility, Galor and Moav (2006), and also because of higher demand for women from services and manufacturing which tend to increase women's 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 because 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 come from the World Bank. It is expected that higher income in societies that have already escaped the Malthusian epoch, because of higher opportunity costs of raising children when income increases, leads to a decline in fertility, Becker (1960) and Herzer, Strulik and Vollmer (2012). Alternatively, it can be argued 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 wages, because of higher demand for women from particular modern sectors of an economy, which in turn increases opportunity costs of raising children and then to lower fertility, Galor and Weil (1996).

Figure one depicts total fertility in all SADC countries and it illustrates 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 relatively 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 in the community. All in all, the SADC includes a diverse set of countries in different stages of development.

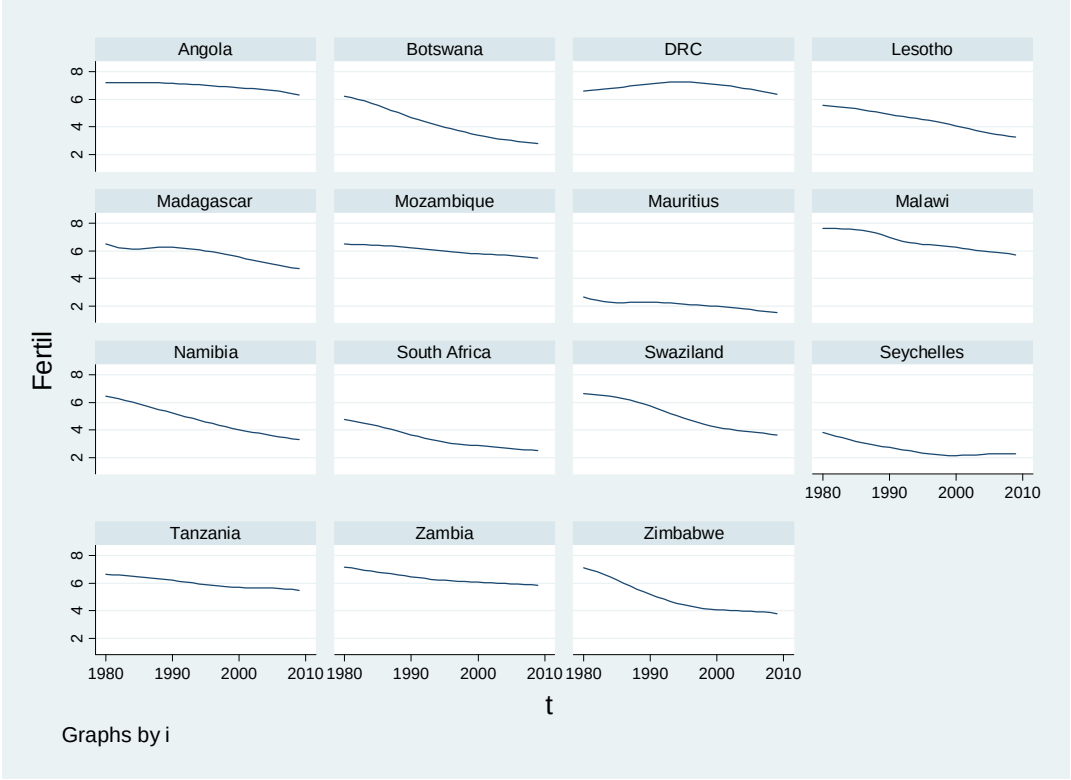

Figure 1: Fertility rates, SADC, 1980-2009. Source: United Nations.

Figure two depicts the averaged-data on fertility and education in the sample, and the first panel confirms that during the whole period fertility rates 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 OLS regression line between primary completion and total fertility rates (the data are now in logs), and the plot shows that there is an economic relationship between higher primary completion rates and lower fertility taking place in the community, or that the community is already trading off quantity for quality of children.

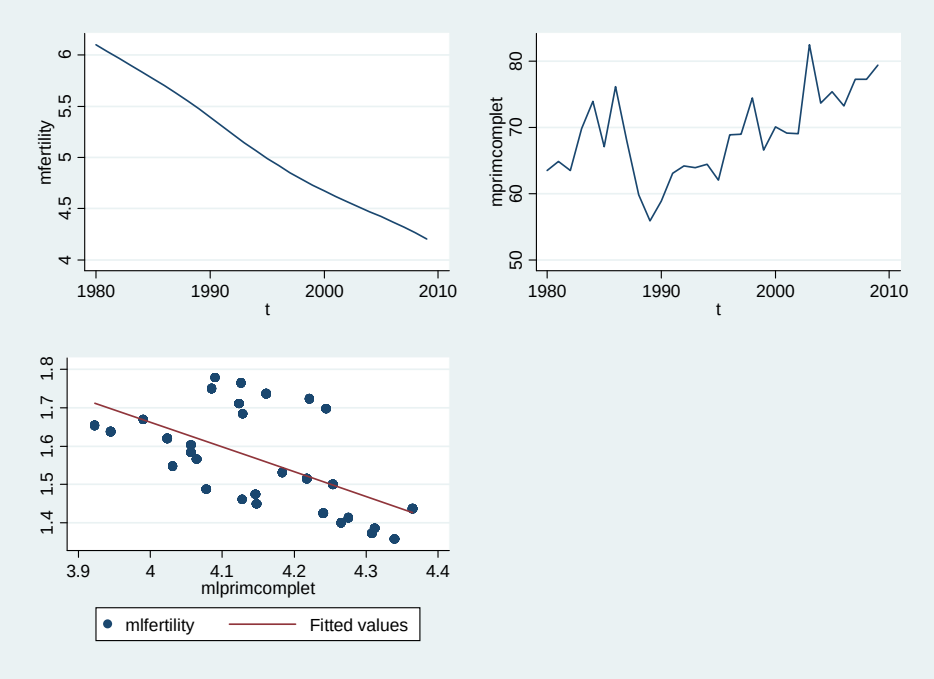

Figure 2: Fertility rates, primary education and the OLS regression line between fertility rates and primary education, SADC, 1980-2009. Sources: United Nations and World Bank.

Table one presents the descriptive statistics and the correlation matrix of the variables. Initially, the two main variables of interest, fertility rates and primary education confirm the above eye-ball evidence and present a negative and statistically significant correlation with each other. In addition, 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 reduces fertility, Soares (2005), Doepke (2005), and Conley, McCord and Sachs (2007).

Furthermore, the ratio of 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 probably 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 per capita displays a negative correlation with fertility, which indicates that there are opportunity costs of raising

children in the community 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.

The empirical strategy, given that I have a $T > N$ dataset, $T = 30$ and $N = 15$, is based on panel time-series analysis. Panel time-series allows me to deal with important econometric issues in relatively thin panels—statistical endogeneity, heterogeneity and reverse causality—and also to specifically further our knowledge of sub-Saharan Africa without having to incur in the removal of African countries (or the use of dummies, Conley, McCord and Sachs, 2007) that often takes place in large cross-sectional and panel data analyses.

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 one-way Fixed Effects (FE) with robust standard errors estimator, which provides consistent estimates when $T \rightarrow \infty$, Smith and Fuertes (2010). Essentially, although those countries shared some political and economic transitions in their recent history, which makes the homogeneity of slopes a plausible assumption, the heterogeneous intercepts of the FE estimator also accounts for the fact that some of the countries present different characteristics in terms of economic and political development, *eg* Botswana, Mauritius and South Africa are relatively richer and more politically stable than most other countries in the community[2].

Thirdly, 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 $T \rightarrow \infty$, Arellano (2003).

In terms of instruments used, with the assumption that deeper lags of education are uncorrelated with the error term ($E(educ_{it-n}v_{it} = 0)$) in mind, firstly I make use of the lag of education as a baseline internal identifying instrument for contemporaneous primary education. It is expected, because of education's persistence over time, a positive effect of lagged education on contemporaneous primary completion. Secondly, 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, coincidentally coming with the end of the cold war in the 1990s, that the community saw taking place back then 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 of the political regime and constraints on the executive. In addition, 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 the Apartheid, which precludes the use of dichotomous regime classifications *à la* Papaioannou and Siourounis (2008). Overall, since I use the instruments separately, the estimated systems are just identified.

It is expected that democracy should play a positive role on education, by better governance and more efficient, or redistributive, allocation of resources towards public goods, in this case 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 towards the median voter, Acemoglu and Robinson (2000).

Figure three (first panel) depicts the external instrumental variable series which illustrates the shift to more democratic institutions taking place in 1990 in the community. Moreover, the OLS regression line in the second panel of Figure 3 indeed points towards a positive economic relationship taking place between both variables in the community.

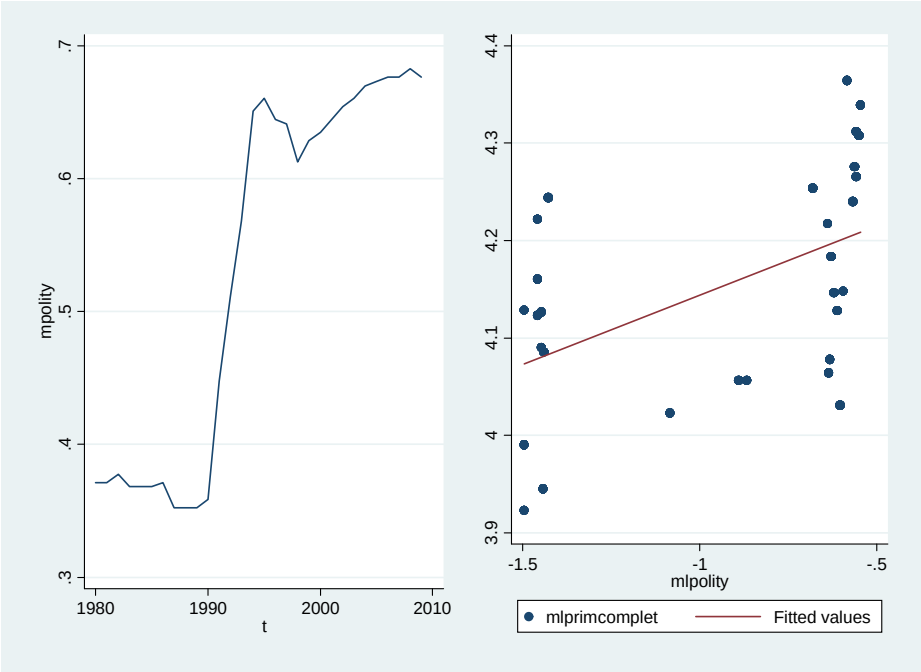

Figure 3: Democracy and the OLS regression line between democracy and primary education, SADC, 1980-2009. Sources: Polity IV and World Bank.

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

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

where $FERTIL$ are the number of children per woman, $EDUC$ is primary completion rates, $EXPECT$ 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.

III. 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 rates. 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 (2010).

About the controls, the agricultural sector is associated with mostly significantly higher fertility rates, which highlights the role of non-complementarities between unskilled-agricultural goods and lower fertility in the community, Becker, Cinnirella and Woessmann (2010). In addition, income per capita is associated with lower fertility rates in the community, which points to higher opportunity costs of raising children when income increases, Becker (1960) and Herzer, Strulik and Vollmer (2012).

Furthermore, 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, increases fertility (at least in the short run) in those developing countries, 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 indicates that the FE estimator, which takes into account heterogeneity, eg different stages of development, is the more appropriate one 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 completion rates. Firstly, all $EDUC$ estimates are negative and statistically significant against total fertility rates. 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 total fertility.

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 per capita 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 wages for women and lower fertility, Galor and Moav (2006) and Galor and Weil (1996); and secondly to higher opportunity costs in raising children taking place in the community when income increases, Becker (1960) and Herzer, Strulik and Vollmer (2012). Moreover, economic 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 display the expected signs against primary education, *ie* lagged education by its persistent effect on itself and democracy by its better redistributive and governance effects, Gallego (2010), positively determine education. 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.

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 completion rates have been reducing fertility rates in the SADC,

which confirm previous efforts using data from countries which had not yet experienced their own demographic transition, Dribe (2008), Murphy (2010), Becker, Cinnirella and Woessmann (2010) and Murtin (2013). Importantly, the evidence reported here is stronger than the one in Ainsworth, Beegle and Nyamete (1996), perhaps because I take advantage of more data (which includes the growth spurt taking place in Africa from 1995 onwards, Pinkovskiy and Sala-i-Martin, 2014) 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 countries (a sample which includes some SADC countries) primary education presents a positive effect on fertility. Overall though, the results I report suggest that the community is experiencing the trade-off between quantity and quality of children, which is an important ingredient of the transition from the Malthusian regime to sustained growth, Becker, Cinnirella and Woessmann (2011), and also that the modern sectors of those countries (although small) are already demanding people with some human capital who can operate production technologies in services and manufacturing, a factor which increases returns to education and leads to lower fertility, Galor (2011).

Furthermore, lower fertility rates are important because they 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 circle is created between human capital and technological progress, and sustained growth might take place. All in all, 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 sustainable growth is to take place.

Although in contrast to Conley, McCord and Sachs (2007), life expectancy is a variable

displaying consistent estimates, *ie* positive effects on total fertility rates, results which are 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. The results 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). On the contrary, fixed capital, 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 rates by skill complementarities and increases in women's wages, Galor and Moav (2006) and Galor and Weil (1996).

The economic globalisation estimates—although negative and mostly significant in the FE and FE-IV regressions, indicate 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 results are in line with some of the objectives of the SADC, *ie* integration and development. Income per capita presents estimates which confirm that the community is not in the Malthusian epoch in which higher income would increase fertility. 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 when income increases, Becker (1960) and Herzer, Strulik and Vollmer (2012).

Lastly, about the instrumental variables, the first-stage regressions results of the positive effects of democracy on primary education confirm that democracy increases efficiency in widening access, or in redistributing 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.

All in all, the above are important 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, it is fair to say that this 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.

IV. Conclusion

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

In addition, 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 "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 (although still a high-fertility region, Strulik and Vollmer, 2013) has escaped the worst of 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.

It must be born in mind though, 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 (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 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.

Table 4: 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)	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

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 see Galor (2005) 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, I do not use time effects dummies. In addition, 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.