University of Pretoria
Department of Economics Working Paper Series

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Manoel Bittencourt
University of Pretoria

Working Paper: 2014-02
January 2014

Department of Economics
University of Pretoria
0002, Pretoria
South Africa
Tel: +27 12 420 2413

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

Manoel Bittencourt†

January 26, 2014

Abstract

In this paper we investigate whether secondary school enrolment has played any role on total fertility rates in all fifteen members of the Southern African Development Community (SADC) between 1980 and 2009. The evidence, based on panel time-series analysis (we make use of the Pooled OLS, Fixed Effects and Fixed Effects with Instrumental Variables estimators), robustly suggest that education has indeed reduced fertility rates in the region, or that the community is already trading-off quantity for quality of children. The results are important not only because lower fertility, caused by education, implies more capital per worker, higher productivity and therefore higher growth rates, but also because—in accordance to the unified growth theory—they suggest that southern Africa is experiencing its own transition from the Malthusian epoch into a sustained (modern) growth regime.

Keywords: Education, fertility, Africa.

JEL Classification: I20, J13, O55.

*We thank seminar participants at Pretoria for comments.

†Department of Economics, University of Pretoria, Lynnwood Road, Pretoria 0002, RSA, Email: manoel.bittencourt@up.ac.za.

"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 rather recent political independence from European rule (mostly in the 1960s), for a number of political regime changes, particularly during the cold war (with some countries sidelining with the former Soviet Union and others with the United States, Berger, Corvalan, Easterly and Satyanath 2013), for civil and military conflicts, which tend to be associated with the role played by natural resources, Besley and Persson (2008), and for a rather poor macroeconomic performance (*i.e.*, in terms of economic activity the late 1980s and early 1990s saw even negative growth rates taking place). More recently though, the continent has seen some economic structural changes, adjustments and reforms being implemented, not to mention a certain degree of political stability, that have generally been matched by better economic performance overall, Bates, Coatsworth and Williamson (2007).

Bearing the above eventful background in mind, we 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 rather diverse set of nations, *e.g.*, 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 here, 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, we use data from all fifteen SADC members between 1980 and 2009, and panel time-series analysis to study whether education played any role on fertility in the region.

Interestingly enough, although these SADC countries differ in terms of economic and institutional development (*e.g.*, 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, fundamental structural changes are taking place in the southern part of the continent, *e.g.*, 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, we pay special attention to these fifteen countries which are part of a club, or umbrella, or of a panel that professes 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 periods, to better understand and contextualise the 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, *e.g.,* the Black Death in 14^{th}-century Europe—will have the effect of increasing fertility rates. After some time though, given the usual "preventive checks" (disease, famine and malnutrition), this somewhat natural economy converges back to its original equilibrium, *i.e.*, all sorts of 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 (technological progress) takes place, without too much human capital being in place 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 not only increases, but takes a central role, fertility rates see a reduction and eventually the demographic transition takes place.

The evidence we report suggest that, firstly, during the period investigated, secondary education enrolment has been a robust determinant of total fertility rates in the region. More specifically, education is associated with lower fertility in a region that has not yet gone through its own in-

dustrial revolution or demographic transition, Galor (2005). Secondly, the rise in life expectancy that the region has been experiencing for some time is accompanied by higher fertility rates, Galor (2012). Thirdly, the agricultural sector of those economies, because of non-complementarities between unskilled-agricultural goods and lower fertility, is indeed associated with higher fertility rates, Galor, Moav and Vollrath (2009). Lastly, there is some evidence suggesting that income increases, via the substitution effect, lower fertility in the SADC, Becker (1960). All in all, the evidence indicates that southern Africa has already escaped the Malthusian epoch, however the region has not yet entered the sustained, or modern, growth regime of development, *e.g.*, at this stage there is no evidence that physical capital accumulation (or industrialisation) is associated, via higher relative wages for women, with lower fertility rates, Galor and Weil (1996).

Moreover, the importance of acquiring a better understanding of the role of education on fertility rates in southern Africa is not only because lower fertility implies more capital per worker, higher productivity and therefore higher growth rates, but 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 have delayed Africa's own demographic transition, it is fair to say that southern Africa is going through its very own Post-Malthusian regime, or transitioning from the Malthusian epoch into a more sustained growth regime.

In addition to the seminal contributions mentioned above[1], Hansen and Prescott (2002) propose a unified growth model in which income and population are positively related to each other, however the model is somehow "silent" about the decline in fertility taking place after the industrial revolution in England. In a slightly different vein, Soares (2005) proposes a model in which (exogenous) reductions in mortality (or increases in life expectancy) will be followed, 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 invest-

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

ment 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 (or higher life expectancy) is associated with lower fertility rates. On the other hand, Galor (2012) presents some evidence which suggests that in 18^{th}- and 19^{th}-centuries England, increases in life expectancy were associated with increases in fertility.

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 19^{th} century. Initially, Dribe (2008) uses Swedish data from 1880 and 1930, at county and national level, to report that the number of teachers per 100 children (aged between 7 and 14) reduces fertility rates. Moreover, Becker, Cinnirella and Woessmann (2010 and 2012) use data from Prussian counties in the 19^{th} 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 19^{th}-century Prussia[2].

In essence, this (admittedly) 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 importance of education and lower fertility on technological progress and sustained growth. Needless to say that all these variables are going through profound changes in southern Africa as we speak, and are therefore of paramount 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. We conduct a case study of an important club of African developing countries—which share particular characteristics

[2] Alternatively, 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 via better employment opportunities for women, and therefore higher relative wages, already in the 14^{th} centuty.

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. We do that by taking advantage of the unified growth theory and panel time-series analysis, which allow us to put the evidence into context and also to deal with particular econometric issues in thin panels (heterogeneity and endogeneity), which enables us to provide—to the best of our knowledge, for the first time—informative and contextual estimates so that our knowledge of a very idiosyncratic, and also diverse within, southern Africa is deepened.

The remainder of the paper is as follows: the next section describes the data and the empirical strategy used, and then it reports and discusses the results obtained. Section Three concludes the paper.

2 Empirical Analysis

2.1 The Data

The dataset we 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 ($T = 30$ and $N = 15$). To illustrate the importance of these nations 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 essentially the number of children that would be born to each woman with age-specific fertility rates—and the data are compiled and provided by the United Nations. For education we use secondary school enrollment 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 21^{st}-century Africa plays a similar role that primary education had in 19^{th}-century Europe, *i.e.*, the provision of basic technical skills. 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, *e.g.*, Becker, Cinnirella and Woessmann (2012).

In addition, following the underlining theory, we use rather standard control variables for the analysis. First, we 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 actual increase in life expectancy (or a reduction in child mortality) might lead to an increase in fertility (particularly in developing countries where uncertainty regarding survival of offspring rates is still high), Galor (2012). Moreover, we 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 (brawn) instead of quality of children and therefore it is predicted that the higher the importance of agriculture, the higher the fertility rates, Galor, Moav and Vollrath (2009).

Furthermore, we 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, or industrialisation, is associated with lower total fertility rates via higher relative wages for women, Galor and Weil (1996). Lastly, we 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 developmental stage of our sample of countries, might lead to a decline in fertility, or to a shift to more quality instead of quantity of children, Becker (1960).

To give a flavour of the main variables of interest, in Figure One we plot the averaged-data on fertility and education in all fifteen countries in our sample, and what we can take from this initial eye-ball evidence is that during the whole period investigated here, 1980-2009, fertility rates in southern Africa have been decreasing consistently over time, *i.e.*, from roughly six children per woman in 1980 to approximately four in 2009. Moreover, education, in the role of secondary enrolment, 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. All in all, it can plausibly be suggested at this early stage that there is a prospective negative relationship

between these two variables taking place in our sample.

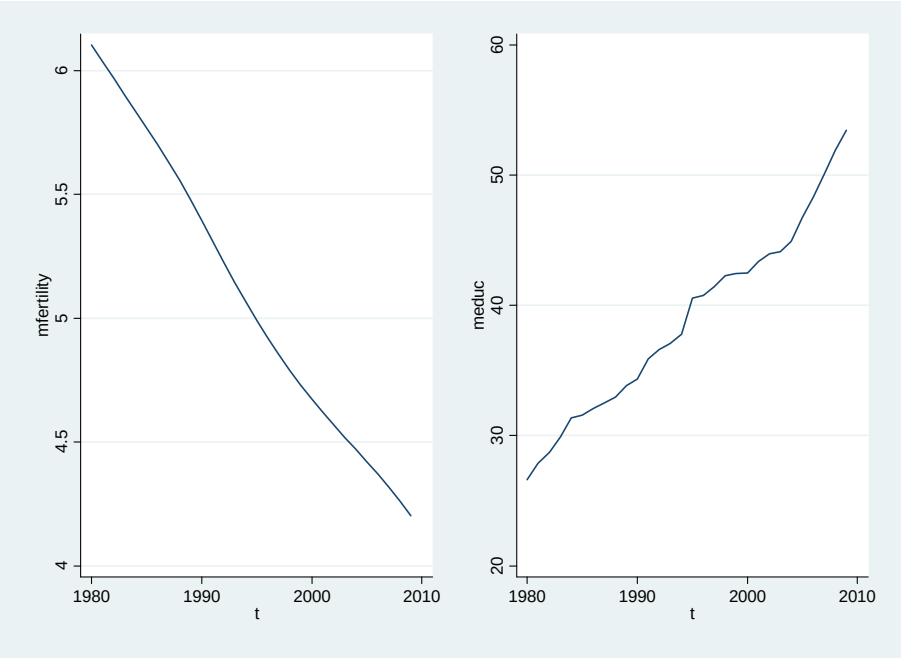

Figure 1: Fertility rates and secondary education, SADC, 1980-2009. Sources: United Nations and World Development Indicators.

Moreover, in Table One we present the correlation matrix of the variables, in logs, used for the analysis. Initially, our two main variables of interest, fertility rates and secondary education, present, as expected, 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, or reduce the costs of investment in human capital, and consequently play a role in reducing total fertility in the region, 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, our proxy for physical capital formation, or industrialisation, presents the expected negative correlation with fertility, which suggests that industrialisation leads to

reduced fertility because of strong 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, via the substitution effect which dominates the income effect, might reduce fertility in the region.

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.

Finally, in Figure Two we plot the OLS regression line between secondary education enrolment and total fertility rates, in logs, 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 higher secondary enrolment reduces total fertility rates.

In a nutshell, this initial descriptive inspection of the data, with all the known caveats associated with descriptive analyses, suggests that there is indeed a negative relationship between education and fertility, or that the region is already trading-off quantity for quality of children (*e.g.*, the data plots show the consistent decrease in fertility rates and also the increase in secondary enrolment taking place in the region throughout the period, the statistical correlation between education and fertility is negative and significant (and of a good size), and the OLS regression line indicates a significant negative economic relationship between education and fertility taking place in the community).

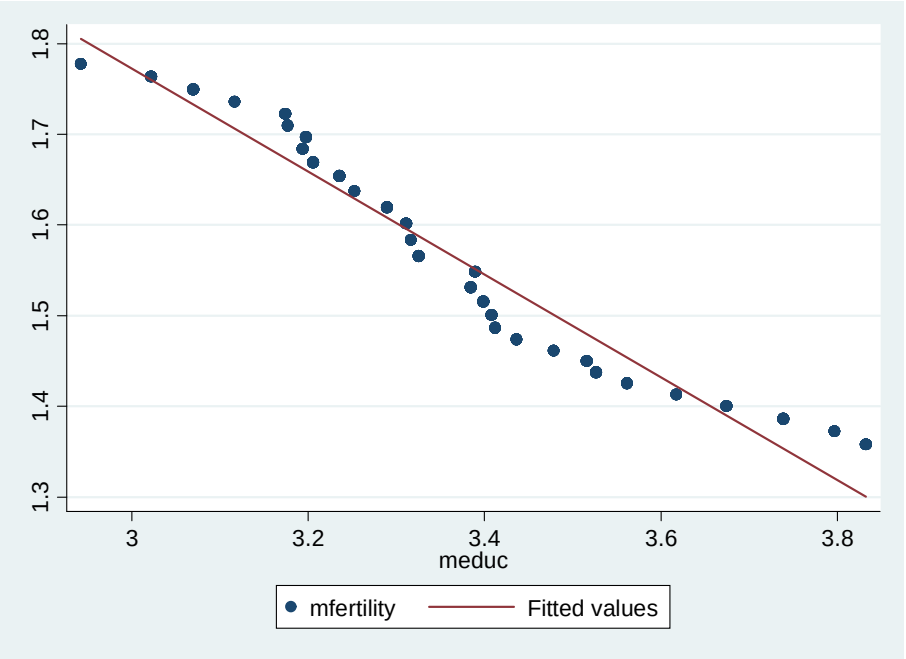

Figure 2: OLS Regression Line, fertility rates and secondary education, SADC, 1980-2009. Sources: United Nations and World Development Indicators.

2.2 The Empirical Strategy

Since we have a $T > N$ dataset, ($T = 30$ and $N = 15$), the empirical strategy is based on panel time-series analysis. This is interesting in itself because panel time-series allows us not only to deal with important econometric issues in relatively thin panels—heterogeneity and endogeneity biases—but also to specifically further our knowledge of sub-Saharan Africa without having to incur in the usual removal of African countries from large cross-sectional and panel data analyses. With panel time-series we can specifically analyse the SADC case, with all its idiosyncrasies and differences within, without treating it either as an outlier or as a dummy, and therefore we can get not only a clearer picture of the region, but also minimise unwarranted generalisations.

Firstly, although some of the variables are either ratios or indices, and therefore bounded within closed intervals, we also evoke Phillips and Moon (1999) and their 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 in empirical models when $T \to \infty$, Smith and Fuertes (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 rather 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 (*e.g.*, 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.

Furthermore, some would argue that reverse causality is a possibility, or that economic endogeneity is present, or that lower fertility might also lead to higher education and not the inverse, Becker, Cinnirella and Woessmann (2010). We 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 $T \to \infty$, and the FE-IV estimator retains the time series consistency even if the instrument set is only predetermined, Arellano (2003)[3].

In terms of instruments utilised, with the assumption ($E(educ_{it-1}v_{it} = 0)$) in mind, firstly we make use of the lag of education as a baseline identifying instrument for contemporaneous education. Then we 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

[3]Perhaps it is worth mentioning that Bond (2002) argues that GMM-type estimators are not an alternative under $T > N$ because of the overfitting problem.

and Hoeffler (2013). In addition, we use a variable for urbanisation, defined as the percentage of urban population ($URBAN$), from the World Development Indicators, and which captures the shift taking place in southern Africa from rural areas to the cities, as an external proxy for development, Kuznets (1955) and Galor (2005). Finally, we use a variable for economic globalisation, $GLOBAL$, which is provided by Dreher (2006) and which takes into account not only trade to GDP, but also, *e.g.*, 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.

For the sake of clarity, in Figure Three we plot all the above-mentioned external instrumental variables series and we can see the shift to more democratic institutions taking place in 1990, which coincides with the end of the ideological conflict between the West and the former USSR. In addition, in the second panel we can visualise the consistent increase in urbanisation taking place in the region (from a mere 25% to approximately 38% of the total population living in urban areas), as well as the latest wave of globalisation affecting this community of countries (which also increases sharply after the 1990s).

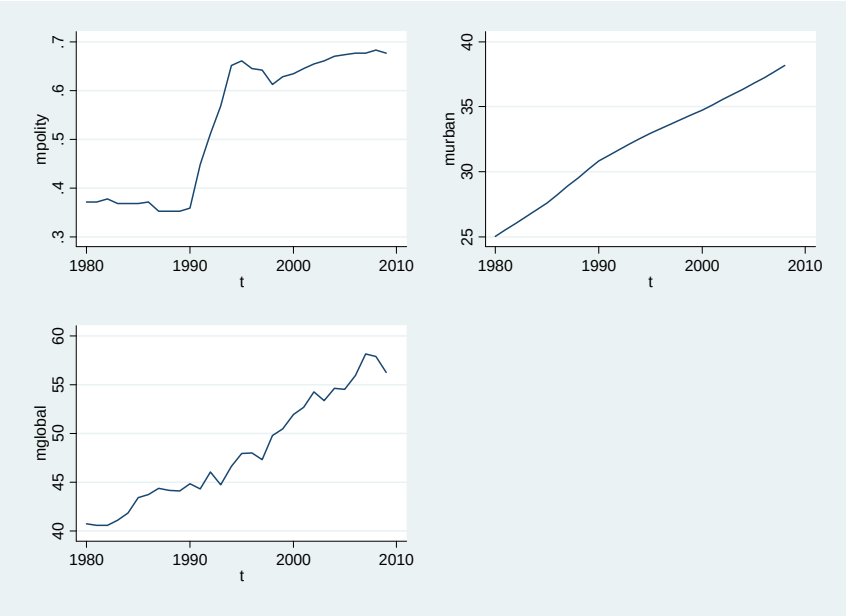

Figure 3: Democracy, urbanisation and globalisation, SADC, 1980-2009. Sources:Polity IV, World Development Indicators and Dreher (2006).

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, *e.g.*, via better governance and more efficient allocation of resources, Tavares and Wacziarg (2001). Thirdly, urbanisation, in the sense that it is not only easier to acquire education in the cities, but urban areas also demand people with some human capital to work in services and manufacturing, might play a positive role on education, Kuznets (1955), Galor (2005) and Dribe (2008). Finally, it is expected that globalisation, at least in non-industrialised developing countries, might negatively affect education because developing countries will specialise in non-skilled agricultural goods, Galor and Mountford (2008).

We therefore estimate equations with different pooled estimators (the baseline Pooled OLS (POLS), which assumes homogeneity of intercepts and slopes (admittedly a rather heroic assumption in our panel given the cross-country differences present), the FE and FE-IV estimators), so that different econometric issues are dealt with and more reliable estimates provided. The one-way FE estimated equation is therefore as follows,

$$FERTIL_{it} = \alpha_i + \beta EDUC_{it-1} + \beta EXPECT_{it} + \gamma AGRIC_{it} + \delta INV_{it} + \epsilon GDP_{it} + \upsilon_{it} \tag{1}$$

in which $FERTIL$ 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 this section we run baseline regressions with education on the RHS against total fertility rates, and then we include the control variables in a step-wise fashion for robustness sake. After presenting the estimates we discuss and contextualise the results in light of the previous literature.

In Table Two we 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, income per capita has the ability of reducing fertility rates in the community, which indicates at this stage that the substitution effect is already dominating the income effect in southern Africa, or that southern Africa is already trading-off quantity for quality of children, 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 (or a reduction in mortality) is, in fact, reducing the costs of child rearing and increasing fertility in those developing countries, Galor (2012). Finally, the proxy for physical capital accumulation is not really presenting clear-cut estimates, which somehow confirms the fact that the manufacturing sector in those countries (with some exceptions) is rather small and therefore still not having the expected effect of reducing fertility in the region via higher relative wages for women, Galor and Weil (1996).

Table 2: POLS and FE 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 we report the FE-IV estimates. In the first panel we instrument education with its own lag, $EDUC_{-2}$, and in the second panel we use democracy, POL, as our identifying instrument for secondary enrolment. Initially, all $EDUC$ estimates are negative and statistically significant against total fertility rates (irrespective of which instrument we make use of). For example, using column five, second panel, the $EDUC$ estimate suggests that for each percentage point increase in secondary enrolment, there will be a reduction in .48 percentage point in total fertility.

In addition, life expectancy confirms its positive and significant role on fertility, *i.e.*, that higher life expectancy in southern Africa leads to a reduction in the costs of child rearing and consequently to an increase in 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, the variables for physical capital accumulation and income per capita do not present entirely clear-cut estimates (although income presents a negative and significant effect on fertility in the first panel, which points to the importance of the substitution effect taking place in the region).

Moreover, in the first-stage regressions our identifying instruments display the expected signs against secondary enrolment, *i.e.*, lagged education (via its persistent effect on itself) and democracy (via its better governance effect) positively influence education. Furthermore, the t-stats of our 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 our regressions (available on request).

Table 3: FE-IV Estimates of Education on Fertility, 1980-2009.

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	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$
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

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 and POL is a proxy for democracy. FE-IV is the Fixed Effects with Instrumental Variables estimator.

In Table Four we report the FE-IV estimates, but now we instrument education with urbanisation and globalisation respectively. 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 region.

About the control variables, life expectancy keeps its positive and significant effect on fertility, suggesting that in Africa a reduction in mortality does not necessarily reduces fertility rates, but it can, in fact, lead to higher fertility because of particular uncertainties regarding survival rates of offspring.

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, our proxy for industrialisation is not clear cut or is income per capita.

Moreover, in the first-stage regressions (available on request) our instruments for secondary enrolment are always individually and overall statistically significant, which reduce the issue of weak instruments in the analysis. More specifically, urbanisation displays a positive effect on education, confirming the fact that it tends to be easier to acquire education in urban areas and also that cities tend to demand some human capital, and our proxy for globalisation plays a positive role on secondary enrolment. This positive effect of economic globalisation on education is probably picking up the fact that a number of those countries have already a rather diversified economy, *e.g.*, 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. Also, the internal trade that happens within SADC itself, *e.g.*, 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 we report are in line with the documented (positive) importance that openness have on total factor productivity, which obviously includes human capital, Andersen and Dalgaard (2011). In similar vein, Galor and Weil (2000) state that what separates the Malthusian epoch from the sustained growth regime is a particular acceleration in technological progress combined with human capital, which in our SADC case can take place because of a particular shock, *e.g.*, globalisation, which could have the effect of triggering a prospective take-off, Galor and Moav (2002).

Table 4: FE-IV Estimates of Education on Fertility, 1980-2009.

FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)
EDUC	-.546 (-15.51)	-.495 (-15.68)	-.452 (-10.01)	-.452 (-10.03)	-.385 (-3.00)
EXPECT		.605 (8.49)	.576 (8.87)	.578 (8.18)	.590 (8.81)
AGRIC			.072 (2.81)	.071 (2.82)	.056 (2.39)
INV				-.001 (-0.11)	-.000 (-0.04)
GDP					-.056 (-0.66)
F* test	103.48	113.87	119.37	118.21	133.83
R^2	0.55	0.44	0.50	0.50	0.38
IV	URBAN	URBAN	URBAN	URBAN	URBAN
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

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. $URBAN$ is the share of the urban population 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 experienced their own demographic transition, Dribe (2008) and Becker, Cinnirella and Woessmann (2010). This result is significant for a number of reasons. 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 rather fast in the last twenty years or so, *e.g.*, Angola, Botswana, Mauritius and Mozambique) are not in a Malthu-

sian stagnation epoch or on a sustained growth path regime. Therefore, it is plausible that those countries in our sample are, in fact, going through the Post-Malthusian regime. Indeed this seems to be the case, *i.e.*, in addition to the estimates reported, the region already displays a consistent reduction in fertility rates and an increase in secondary enrolment (Figure One). Moreover, the second panel of Figure Three and Figure Four illustrate 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.

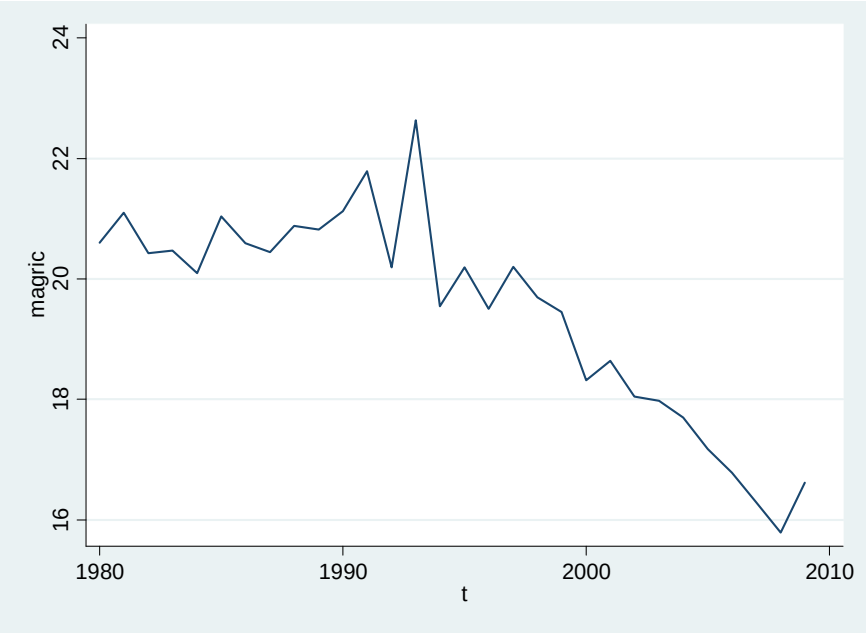

Figure 4: Agricultural share to GDP, SADC 1980-2009. Source: World Development Indicators.

Thirdly, following from the above, the results robustly suggest that the region is, although still not in the sustained growth regime (most of those SADC countries have not yet experienced their own industrial revolution, with South Africa perhaps being the only exception), already experiencing, before their very own demographic transition, the trade-off between quantity and quality of children, which is an important ingredient of the transition

from the Malthusian stagnation to sustained growth, Becker, Cinnirella and Woessmann (2010).

In addition, mortality rates have been decreasing in the region for all sorts of different (exogenous to the community) reasons (as they have in Europe in the 18^{th} century), *e.g.*, the epidemiological revolution triggered by the spreading of health technologies, Soares (2005). However, this reduction in mortality does not invalidate the negative causal relationship between education and fertility rates. Along those lines, Galor and Moav (2002) predict that those already with human capital, even during the Malthusian epoch, have also higher survival rates and at some point in time, when there is enough human capital in place and usually after a shock, *e.g.*, globalisation or democracy, 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 fairly consistent results, *i.e.*, positive effects on total fertility rates. These results are in line with the historical evidence that suggests that in the 17^{th} century Europe presented reductions in mortality rates that were matched by increases in total fertility, Galor (2012), which implies that those developing countries of the SADC are experiencing the same process of development that took place in Europe in the 17^{th} century. 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 predominant 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, Galor and Mountford (2008).

The other two control variables do not present entirely clear-cut results. The variable for physical capital accumulation does not present significant estimates, which somehow confirms that the region is not yet fully industrialised (or in the sustained growth regime) and therefore capital accumulation and technological progress are still not playing any (negative) role on total fertility rates via higher relative wages for women, Galor and Weil (1996)[4].

[4]We have also used the share of services to GDP as a control variable. Although the role of education is robust on fertility, the results for services are not clear cut either. Available on request.

Moreover, 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 probably already dominating the income effect in the region, Becker (1960). In addition, bearing in mind that our sample contains a fair degree of heterogeneity in terms of economic development, the mixed evidence regarding income and fertility suggests that income per capita is not the main driving force of reduced fertility in the region, 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 trade on secondary education bode well, to say the least, with some of the broad developmental objectives of the SADC.

In essence, all the above evidence (*i.e.*, reduction in fertility rates caused by increase in 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 industrialisation 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, in this paper we 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 region. More specifically, education proved to be a robust determinant of fertility, which also highlights its indirect role in determining prosperity in the community via 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 char-

acteristics that Latin America had right after its own independence in the 19^{th} century, *e.g.*, political instability, conflict and economic stagnation, and Acemoglu, Johnson and Robinson (2001) highlight the importance of "extractive" institutions being implemented in Africa during the 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, we also have to bear 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, *e.g.*, globalisation and democracy, happens, so that failed takeoffs are minimised. To put it another way, Nelson and Phelps (1966) argue that educated people are not only innovators, but also adaptable to technological change, which highlights the role of education on fertility and sustained development in a globalised world.

The quality of the evidence presented is, to a certain extent, boosted not only because we make use of the unified growth theory to put the results in economic and historical context, but also because we take advantage of panel time-series analysis which deals with important empirical issues such as heterogeneity bias and endogeneity in relatively thin panels. Essentially, this analysis is important because it allows us 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 here 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.

Regarding future work, firstly, investigating the role of primary education on fertility rates would be a natural extension to this paper. Secondly, the role of access to finance and how it can affect fertility (and education) is an interesting, and of practical importance, subject that deserves some attention and could also complement the present study, Galor (2012). In addition, a more systematic investigation of the role of trade openness, or

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 physical capital accumulation on fertility, it would be interesting to investigate the role of the large informal urban sector on fertility in southern 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 (not to mention that this sort of sample provides us with interesting panel variation). In similar vein, 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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