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

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Abstract

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

Keywords: Education, fertility, Africa.

JEL Classification: I20, J13, O55.

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

1 Introduction

The African continent is known for its recent political independence from European rule (taking place mostly in the 1960s), for a number of political regime changes—particularly during the cold war—for civil and military conflict, which are usually associated with natural resources and genetic diversity, and for a rather poor macroeconomic performance, *eg* the late 1980s and early 1990s saw even negative growth rates taking place in a number of countries. More recently though, the continent has seen some economic structural changes and reforms being implemented, which combined with a certain degree of political stability, have generally been matched by better economic performance, Bates, Coatsworth and Williamson (2007), Young (2012) and Pinkovskiy and Sala-i-Martin (2014).

Bearing the above in mind, I investigate the role of secondary school enrolment in determining total fertility rates in the Southern African Development Community (SADC), a community of countries which advocates the importance of regional integration, democracy and prosperity as tools to eradicate poverty. The SADC includes, *eg* Angola and Mozambique presenting positive growth rates since the 1990s and even with some double figures from 2004 onwards, Botswana and Mauritius presenting positive growth for the whole period studied, South Africa presenting positive growth, although modest, since the end of Apartheid in 1994, and a country such as Zimbabwe which has presented negative growth since 1999. In essence, I use data from all fifteen SADC countries between 1980 and 2009, and panel time-series analysis to study whether secondary enrolment plays any role on fertility in the community. More specifically, I use the Pooled OLS, Fixed Effects, Mean Group, Common Correlated Effects and Fixed Effects with Instrumental Variables estimators to deal with statistical endogeneity, heterogeneity, cross-section dependence and reverse causality, and democracy and globalisation are the instrumental variables providing secondary enrolment with contemporaneous external variation, to make sure that the estimates are robust and informative.

Interestingly enough, although the SADC countries differ in terms of economic and institutional development, *eg* with Botswana, Mauritius and South Africa being more economically and politically developed than most of the other countries in the community, they also share common factors: most of them went through the above-mentioned economic and political changes from the 1960s onwards. In addition, other structural changes are taking place in the community, *eg* fertility as well as the share of the agricultural sector to GDP have been decreasing over time, and secondary enrolment and urbanisation rates have been on the rise.

To illustrate, Figure one depicts the decreasing fertility in all SADC countries; with countries such as Mauritius (a mostly urban country with the lowest fertility in the community) and South Africa already presenting low fertility, with Angola and the Democratic Republic of the Congo (DRC) still presenting high fertility, and countries like Namibia and Zimbabwe presenting considerable reductions in fertility over time. All the same, the reduction in fertility in the SADC is in line with Galor (2011) who suggests that in 19^{th}-century Europe fertility decreased, roughly at the same time, in countries with different levels of development.

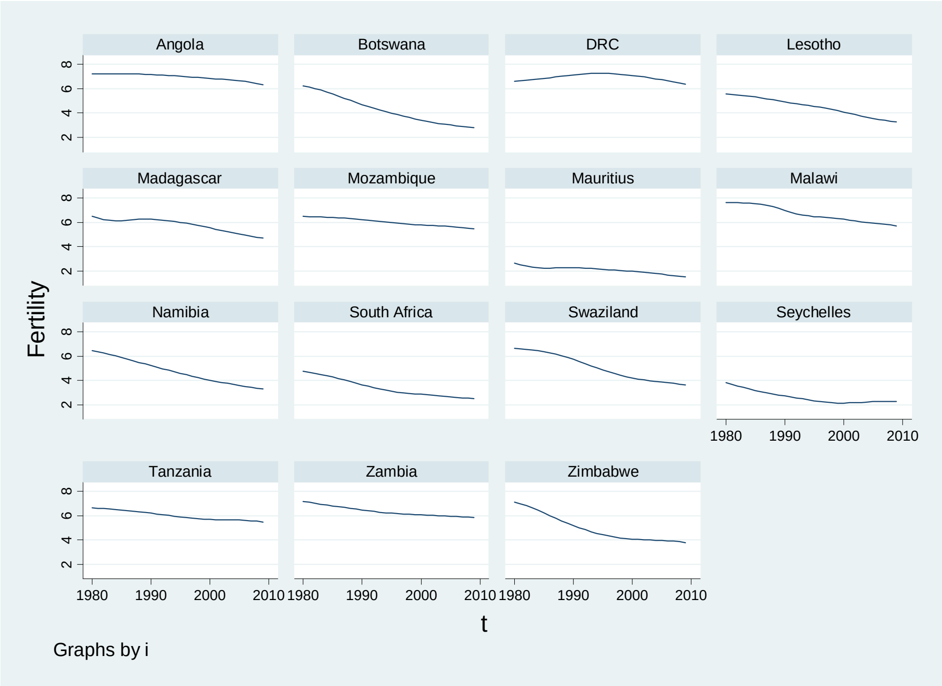

Figure 1: Total fertility rates, SADC, 1980-2009. Source: United Nations.

To better understand and contextualise the contemporaneous development of the SADC, I rely on unified growth theory models, Galor and Weil (1999), Galor and Weil (2000) and Galor and Moav (2002), which divide the process of development into three distinct regimes. The underlining theory suggests that initially there is the Malthusian epoch in which increases in income—usually coming from external shocks, *eg* the Black Death in 14^{th}-century Europe or, to a lesser extent, the AIDS epidemic in Africa in the 1990s—have the effect of increasing fertility. After some time though, given the "positive checks" (disease, famine and malnutrition), this natural 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 industrialisation and technological progress take place, without too much human capital though. In addition, during this transitional period, life expectancy as well as fertility tend to increase, Galor (2011). Finally, during the sustained growth regime, technological progress and industrialisation take off, human capital formation increases and in fact takes a central role in production, fertility sees a reduction and the demographic transition takes place, Galor (2005)[1].

The evidence I report suggests that, firstly, secondary enrolment has been a robust determinant of fertility in the community. More intuitively, because of higher demand for human capital coming from the modern sectors of those economies, *eg* services and manufacturing, which creates an incentive towards quality instead of quantity of children (by an increase in returns to education), secondary enrolment is associated with lower fertility in a community of countries that has not yet gone through its own demographic transition, Murphy (2015).

Secondly, because of uncertainty about survival of children, the rise in life expectancy that the community has been experiencing is still not accompanied by lower fertility rates, Galor (2011)[2]. Thirdly, the agricultural sector of those countries, because of non-complementarities between unskilled-agricultural goods and lower fertility, is associated with higher fertility, Becker, Cinnirella and Woessmann (2010). Lastly, there is some evidence suggesting that increases in income, because of a rise in opportunity costs of raising children, reduce fertility in the SADC, Becker (1960), Galor and Weil (1996) 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 results, particularly the roles of secondary enrolment and income on fertility, suggest that the SADC has escaped the Malthusian epoch. However, the community has not yet entered the sustained growth regime of development, *eg* at this stage there is no evidence that fixed capital formation is directly associated—by complementarities between manufactured and services goods and higher relative wages for women in modern sectors of an economy—with lower fertility, Galor and Moav (2006) and Galor and Weil (1996).

[1] Alternatively, Hansen and Prescott (2002) propose an unified growth model in which income and population are positively related to each other, however the model is silent about the decline in population growth taking place after the industrial revolution in England, and 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 in Europe by better employment opportunities for women and higher relative wages, already in the 14^{th} century.

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

The importance of acquiring a better understanding of the role of secondary enrolment on fertility in southern Africa is because lower fertility implies more capital per worker, higher productivity and therefore higher growth rates, and also because the take off into the sustained growth regime, usually caused by a shock, requires a critical level of human capital so that the virtuous cycle between human capital and technological progress can take place, Galor and Moav (2002). Bearing in mind the numerous factors that might have delayed Africa's own demographic transition, *eg* late extractive colonialism, Acemoglu, Johnson and Robinson (2001), the evidence I report suggests that southern Africa is going through its very own Post-Malthusian regime, or transitioning from the Malthusian epoch into sustained growth.

2 Background

In addition to the contributions above, Soares (2005) and Cervellati and Sunde (2005 and 2013) propose models in which exogenous increases in life expectancy are followed—because of an increase in the human capital investment horizon, but with a lag—by reductions in fertility and increases in human capital and Angeles (2010) provides evidence of the lagged effect of life expectancy on fertility in a panel of countries between 1955 and 2005. These models also predict that the interaction between life expectancy and fertility leads to technological progress and sustained economic growth. Furthermore, Doepke (2004) suggests that free education combined with effective child labour laws can reduce fertility in developing countries (he compares Brazil with South Korea), and Doepke (2005) suggests that lower child mortality is associated with lower fertility. On the other hand, Galor (2011) presents evidence which suggests that in 18^{th}- and 19^{th}-centuries England, increases in life expectancy were associated with increases in fertility because of the precautionary demand for children during that transitional period.

The literature on the role of education on fertility has also studied the European trade-off between quantity and quality of children taking place in the 19^{th} century. Firstly, Dribe (2008) uses Swedish data from 1880 to 1930, at county and national level, to report that the number of teachers per 100 children (aged between 7 and 14) is associated with lower fertility, and Murphy (2015) uses twenty years of French departmental-level data between 1876 and 1896 to report that female literacy reduced fertility in France as well. Moreover, Becker, Cinnirella and Woessmann (2010 and 2012) use data from Prussian counties in the 19^{th} century, 1849 and 1816, 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 in 19^{th}-century Prussia.

In addition, Ainsworth, Beegle and Nyamete (1996) report, using data from fourteen sub-Saharan African countries from the 1980s to early 1990s, that primary schooling reduces fertility in about half of the countries and that secondary education reduces fertility in all 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. Furthermore, 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 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). On the other hand, 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[3].

In essence, this non-exhaustive review suggests firstly that the verdict is still open on the roles of life expectancy and education on fertility (Cervellati and Sunde 2005 and 2013, and Galor 2011, and Murtin 2013 and Conley, McCord and Sachs 2007). Secondly, one way or another, higher life expectancy plays a role on fertility and on decisions to invest in human capital, and it also highlights the interplay amongst education, lower fertility and technological progress on sustained growth. Needless to say that these variables are going through changes in southern Africa as we speak, and are therefore of significant importance for Africa's development. Thirdly, the empirical evidence, although not unanimous, mostly covering countries in periods which they had not yet experienced their own demographic transition, which includes contemporaneous Africa, suggests that education (because of higher demand for human capital which tends to increase the returns to education), was already playing an important role in reducing fertility and consequently

[3] See Galor (2005 and 2011) or Guinnane (2011) for extensive surveys of the literature.

on growth.

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

3 Empirical Analysis

3.1 The Data

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, Lesotho, Madagascar, Mozambique, Mauritius, Malawi, Namibia, South Africa, Swaziland, Seychelles, Tanzania, Zambia and Zimbabwe. To illustrate the importance of these countries in the African context, these fifteen countries accounted for approximately 52% of the total GDP in sub-Saharan Africa in 2009.

The variable total fertility rates, $FERTIL$, is defined as the number of children per woman—which is the number of children that would be born to each woman with age-specific fertility rates—and the data are provided by the United Nations Population Division. For education I use secondary school enrollment as percentage of the corresponding age group, $EDUC$, and the data are provided by the World Bank. It is plausible to expect that, because of higher demand for fairly educated people from modern sectors, which tends to increase returns to education, secondary enrolment leads to more investment in the quality than in the quantity of children, or that higher secondary enrolment is associated with lower fertility even before a region experiences its own demographic transition, Becker, Cinnirella and Woessmann (2010).

In addition, following the underlining theory, Galor (2011), I use standard control variables. First, I use a variable accounting for life expectancy, $EXPECT$, which is defined by life expectancy in terms of number of years at birth. The data come from the United Nations and it is expected that an increase in life expectancy might lead to an increase in fertility, particularly in developing countries where uncertainty about survival rates of children is still high, Galor (2011). Moreover, I use the agricultural sector to GDP ratio, $AGRIC$, and the data are from the World Bank. It is plausible to expect that more agrarian societies, because of non-complementarities between agrarian goods and lower fertility, tend to favour quantity instead of quality of children and therefore it is predicted that the higher the importance of agriculture, the higher the fertility, Becker, Cinnirella and Woessmann (2010).

Furthermore, I use the gross fixed capital formation to GDP ratio, INV, which includes more sophisticated land improvements such as ditches and drains, machinery and equipment, roads and railways, schools and hospitals, and commercial and industrial buildings, as a proxy for general infrastructure and industrialisation, and the data are from the World Bank. It is predicted that fixed capital formation is associated with lower fertility by skill complementarities in services and manufacturing and higher relative wages for women in those particular modern sectors of those economies, Galor and Moav (2006) and Galor and Weil (1996). Lastly, I control for income per capita, GDP, and the data come from the World Bank. It is expected that higher income, bearing in mind the different developmental stages of the countries in the SADC, might lead to a reduction in fertility because of higher opportunity costs of raising children which take place when countries reach a particular developmental threshold, Becker (1960), or because of higher household income which tends to be associated with increases in women's relative wages which in turn leads to lower fertility, Galor and Weil (1996) and Herzer, Strulik and Vollmer (2012).

To give a flavour of the main variables of interest, Figure two depicts the country-averaged data on fertility and secondary enrolment in all countries, and it shows that during the whole period fertility in the community has been decreasing over time, *ie* from roughly six children per woman in 1980 to approximately four in 2009. Moreover, secondary enrolment has been on the rise throughout the period, from less than 30% of the corresponding population age group in 1980 to more than 50% in 2009.

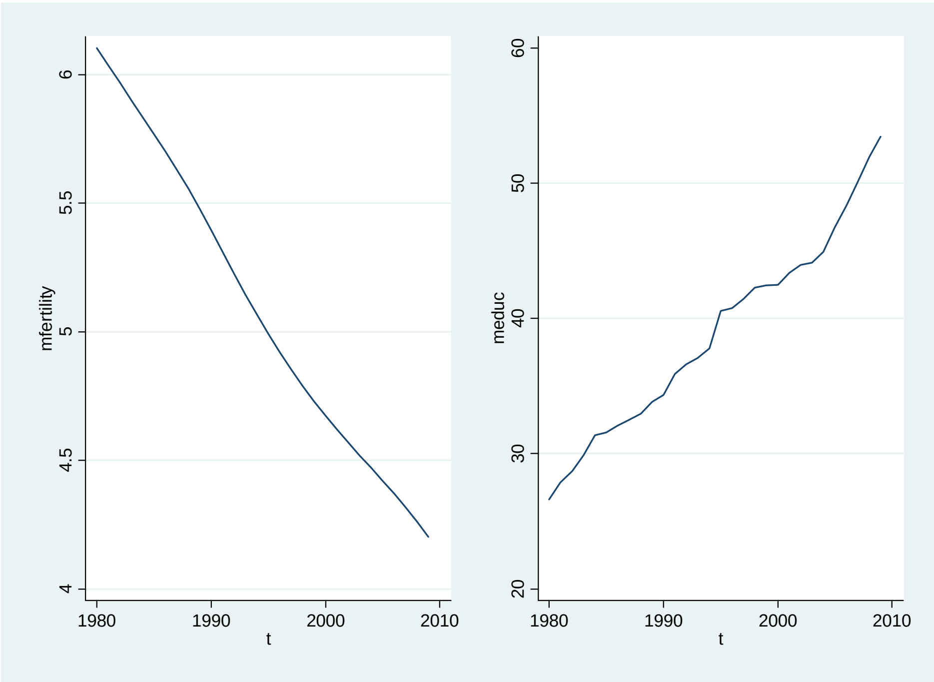

Figure 2: Total fertility rates and secondary school enrolment, SADC, 1980-2009. Sources: United Nations and World Bank.

Table one presents the descriptive statistics and the correlation matrix of the variables, in logs. The two main variables of interest, fertility and secondary enrolment, 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 might reduce uncertainty about survival of children, increase the horizon of investment in human capital and consequently play a role in reducing fertility in the community, Soares (2005), Doepke (2005) and Conley, McCord and Sachs (2007).

The other control variables present the expected correlations with fertility, *ie* the agricultural sector presents a positive correlation with fertility, fixed capital formation presents a negative correlation with fertility and income presents a negative correlation with fertility.

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

	Obs	Mean	Std Dev	Min	Max	Source
FERTIL	450	5.09	1.61	1.54	7.62	United Nations
EDUC	450	38.86	28.00	3.04	117.85	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
GDP	433	7.31	2.03	1.46	1.48	World Bank
	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

* represents significance at the 5% level.

Figure three depicts the OLS regression line between secondary enrolment and fertility in all countries. The relationship is negative and statistically significant, which suggests an economic relationship between secondary enrolment and lower fertility in the SADC or that, because of higher demand for reasonably educated people who can work in services and manufacturing and the increasing returns to education that comes with it, the community is already trading-off quantity for quality of children.

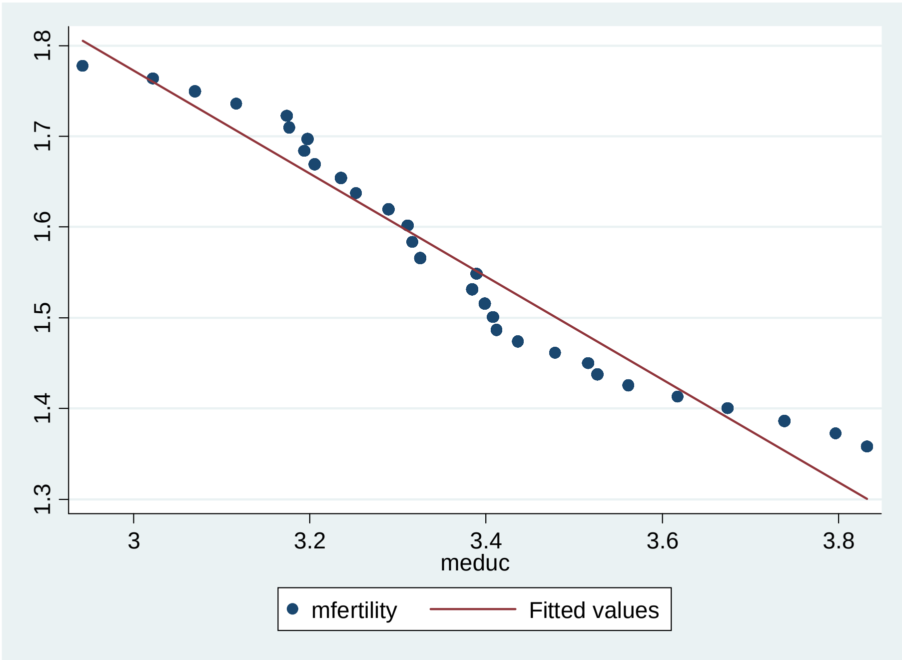

Figure 3: OLS Regression Line, total fertility rates and secondary school enrolment, SADC, 1980-2009. Sources: United Nations and World Bank.

3.2 The Empirical Strategy

I estimate equations with different pooled estimators (the baseline Pooled OLS (POLS), the Fixed Effects (FE), the Mean Group (MG), the Common Correlated Effects (CCE) and Fixed Effects with Instrumental Variables (FE-IV) estimators), so that different econometric issues are dealt with and informative estimates provided. The heterogeneous MG estimated equation is as follows,

$$\begin{aligned} FERTIL_{it} &= \alpha_i + \beta_i EDUC_{it-1} + \gamma_i EXPECT_{it} + \delta_i AGRIC_{it} + \\ &\quad \epsilon_i INV_{it} + \varepsilon_i GDP_{it} + \upsilon_{it} \end{aligned} \tag{1}$$

where $FERTIL$ are the number of children per woman, $EDUC$ is secondary enrolment 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 and GDP

is income per capita. All variables are in logs.

Since I have a $T > N$ dataset, with $T = 30$ annual consecutive observations and $N = 15$ countries, the empirical strategy is based on panel time-series analysis. Panel time-series allows me to deal with important econometric issues in thin panels; statistical endogeneity, heterogeneity, cross-section dependence and reverse causality. In essence, panel time-series allows a specific analysis of the SADC, with all its idiosyncrasies and differences within, without treating it either as an outlier or as a dummy, Conley, McCord and Sachs (2007), and therefore a clearer picture of the community can be obtained.

Firstly, although some of the variables are either ratios or indices, and therefore bounded within closed intervals, I also evoke Phillips and Moon (1999) result which suggests that the issue of spurious regressions is 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 nested in the error term might be correlated with the regressors—and heterogeneity of intercepts is dealt with by the one-way FE with robust standard errors estimator. Furthermore, heterogeneity of intercepts and slopes is dealt with by the MG estimator, Pesaran and Smith (1995), which estimates different OLS regressions for each country and then averages them up. Both estimators provide consistent estimates when $T \to \infty$, Smith and Fuertes (2010).

Essentially, although the SADC countries shared some political and economic transitions in their recent history, which makes the homogeneity of slopes a plausible assumption, the FE and MG estimators also account for important econometric issues in $T > N$ panels, statistical endogeneity and heterogeneity of slopes, or for the fact that those 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, and these country differences are picked up by the heterogeneous intercepts of the FE estimator and more directly by the heterogeneous intercepts and slopes of the MG estimator.

Thirdly, one can argue that, given the trade, political and geographical links amongst the countries in the sample, cross-section dependence can be present. Thus, I use the CCE estimator proposed by Pesaran (2006), which also allows for heterogeneous intercepts and slopes, and which introduces in the mean group regressions individual cross-section averages of all variables as additional regressors and these averages, if statistically significant, are proxies for unobserved common factors[4].

Fourthly, although I follow the underlining theories of the demographic transition, Galor (2011), to minimise reverse causality, some would argue that reverse causality is a possibility, or that higher fertility might lead to lower secondary enrolment, Becker, Cinnirella and Woessmann (2010). I therefore use the FE-IV two-stage Least Squares estimator which provides estimates that are asymptotically consistent and efficient as $T \rightarrow \infty$, and this estimator retains the time series consistency even if the instrument set is only predetermined, Arellano (2003).

In terms of instruments used, with the assumption that deeper lags of secondary enrolment are uncorrelated with the residual ($E(educ_{it-n}v_{it} = 0)$) but correlated with contemporaneous secondary enrolment in mind, firstly I make use of the lag of secondary enrolment as a baseline internal identifying instrument for secondary enrolment. Then I use the popular and normalised, so that it ranges from zero to one, polity2 variable (POL) from the Polity IV database to account for the external democratic shock 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 Apartheid. In addition, I use a variable for economic globalisation, $GLOBAL$, provided by Dreher (2006) and which takes into account trade to GDP, and also, *eg* foreign direct and portfolio investment and import barriers, to account for the latest wave of globalisation taking place in the world. Since I use these instruments separately the estimated systems are just identified.

Figure four depicts the transition to more democratic regimes taking

[4]In addition, Kapetanios, Pesaran and Yamagata (2011) suggest that the CCE estimator is less biased even when the common factors are non-stationary.

place in 1990 (first panel) and the second panel depicts the latest wave of globalisation affecting this community of countries, which also increases after the 1990s.

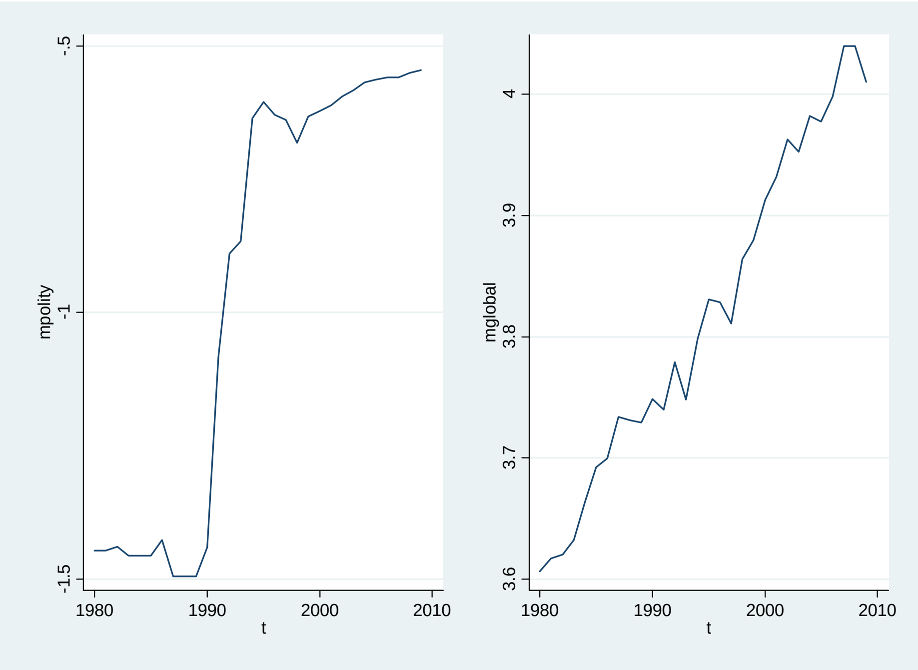

Figure 4: Democracy and globalisation, SADC, 1980-2009. Sources: Polity IV and Dreher (2006).

What is expected of these instruments? Firstly, education is persistent over time and a positive effect of lagged education on contemporaneous secondary enrolment is expected, Murtin (2013). Also, it is plausible that lagged, or past, education is not correlated with contemporaneous, or even with unexpected, fertility. Secondly, democracy, given its internal rationale of political competition and turnover, combined with the fact that the SADC is a relatively poor community of countries, works as a redistributive device towards the median voter, Meltzer and Richard (1981) and Acemoglu and Robinson (2000), and it might play a positive role on education, *eg* by better governance and more efficient allocation, or redistribution, of resources towards education, Tavares and Wacziarg (2001) and Gallego (2010). In addition, it is plausible that democracy affects fertility through education, *eg* democracy and its redistribution can not have an effect on fertility decisions without an educated population that can take advantage of, *eg* better contraceptive technologies.

Lastly, taking into account the new Kaldor facts advanced by Jones and Romer (2010), which includes the rise of globalisation (fact 1) and education (fact 5), and Rodrik (1998) suggestion that more open economies tend to spend more in, *eg* education, in order to provide "social insurance against external risk", it is expected that globalisation might play a positive role on secondary enrolment. Complementary to the above, political scientists advance the "compensation hypothesis", Kaufman and Segura-Ubiergo (2001) and Avelino, Brown and Hunter (2005), which suggests that governments try to minimise the social costs associated with globalisation by spending more on education. Furthermore, although globalisation facilitates the dissemination of knowledge, technologies and even norms, the use of better contraceptive technologies still requires an educated population that can make use of such technologies[5].

Figure five depicts the OLS regression lines between the external instrumental variables and secondary enrolment and, consistent with prior expectations, both panels display positive relationships between democracy, globalisation and secondary enrolment.

[5] Alternatively, Galor and Mountford (2008) suggest that, at least in non-industrialised developing countries trading with developed countries, globalisation might negatively affect education because developing countries end up specialising in non-skilled agricultural goods.

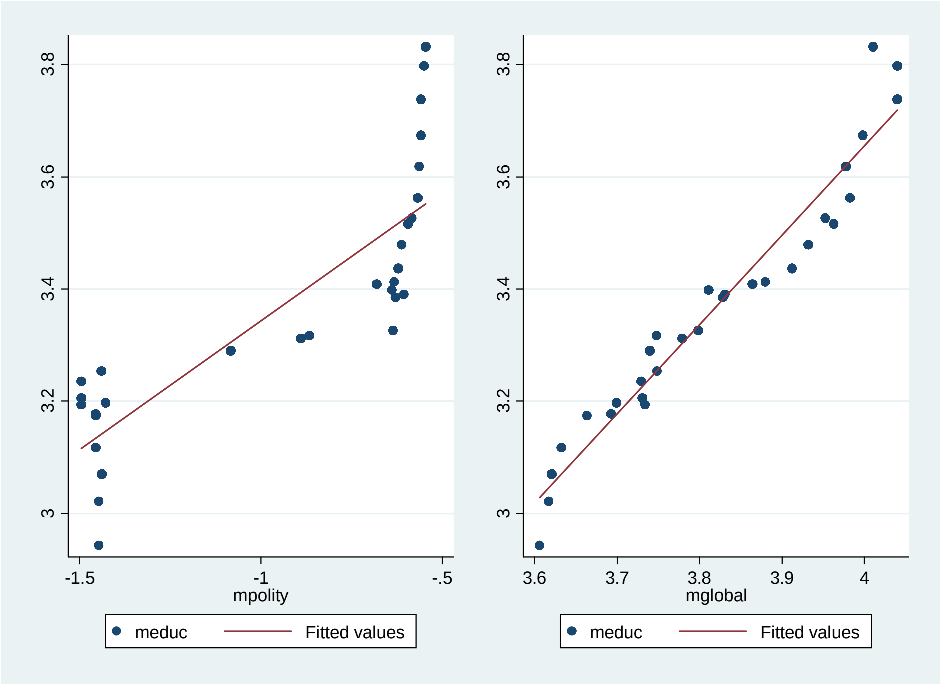

Figure 5: OLS Regression Lines between democracy, globalisation and secondary enrolment, SADC, 1980-2009. Sources: Polity IV, Dreher (2006) and World Bank.

3.3 Results and Discussion

3.3.1 Heterogeneity

In Table Two I report the robust POLS (first panel), the robust FE estimates (second panel) and then the MG estimates in the third panel. All secondary enrolment estimates are negative and mostly statistically significant against fertility. For instance, the FE estimate in column four, second panel, suggests that for each percentage point increase in secondary enrolment, there will be a .23 percentage point reduction in fertility in the community, a result (in terms of sign and size) which is in line with the previous literature, Becker, Cinnirella and Woessmann (2012)[6].

About the control variables; the agricultural sector is associated with higher fertility, Becker, Cinnirella and Woessmann (2010) and income with

[6]In addition, in the individual country regressions of specification five, secondary enrolment presents negative estimates in twelve countries, of which ten are statistically significant. The individual country regressions are available on request.

lower fertility in the community, Becker (1960) and Herzer, Strulik and Vollmer (2012). Life expectancy, although not significant in the third panel, when using the FE estimator, presents positive and significant estimates on fertility, which suggests that an increase in life expectancy is associated with higher fertility, Galor (2011). Fixed capital formation does not present coherent estimates, which suggests that services and manufacturing in most of those countries are small and still not having the expected effect of directly reducing fertility in the community.

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

FERTIL	POLS (1)	POLS (2)	POLS (3)	POLS (4)	POLS (5)
EDUC	-.343 (-19.49)	-.248 (-14.44)	-.173 (-7.70)	-.180 (-7.89)	-.211 (–9.46)
EXPECT		-.834 (-8.94)	-.709 (-7.59)	-.664 (-6.63)	-.609 (-6.30)
AGRIC			.137 (8.78)	.130 (8.20)	.103 (6.26)
INV				-.030 (-1.52)	-.016 (-0.86)
GDP					-.008 (-8.56)
Fe	no	no	no	no	no
Rob SE	yes	yes	yes	yes	yes
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)
Fe	yes	yes	yes	yes	yes
Rob SE	yes	yes	yes	yes	yes
F test	18.79	24.52	33.97	26.39	35.08
R^2	0.55	0.30	0.46	0.46	0.06
FERTIL	MG (1)	MG (2)	MG (3)	MG (4)	MG (5)
EDUC	-.339 (-4.29)	-.227 (-3.40)	-.194 (-3.28)	-.181 (-3.06)	-.095 (-2.50)
EXPECT		-1.18 (-1.39)	-.006 (-0.02)	-.051 (-0.11)	-.302 (-0.38)
AGRIC			.127 (3.10)	.114 (2.87)	.019 (0.94)
INV				.030 (1.36)	.043 (2.51)
GDP					-.228 (-3.28)
Wald	18.44	13.17	19.86	17.49	51.53

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

3.3.2 Cross-section Dependence and Reverse Causality

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

In the second panel life expectancy keeps its positive and significant effect and the share of the agricultural sector to GDP presents positive and significant estimates against fertility. Income presents negative and significant effects on fertility, however fixed capital formation does not present entirely coherent estimates.

Moreover, the CCE averages of fertility are significant, which suggests that there are unobserved common factors, or diffusion, in the community in terms of fertility. In the first-stage regressions (lower part of the second panel) the identifying instrument presents the expected effect against secondary enrolment, *ie* lagged secondary enrolment is persistent on itself. Furthermore, the t-stats of the identifying instruments are all significantly different from zero as well as the F-tests for overall significance, which minimise the issue of weak instruments (the complete first-stage regressions are reported in the appendix).

Table 3: CCE and FE-IV Estimates, SADC, 1980-2009.

FERTIL	CCE (1)	CCE (2)	CCE (3)	CCE (4)	CCE (5)
EDUC	-.055 (-1.00)	-.098 (-2.46)	-.094 (-2.92)	-.094 (-3.26)	-.091 (-2.91)
EXPECT		.328 (0.45)	-.019 (-0.06)	.306 (0.53)	.031 (0.06)
AGRIC			.018 (0.97)	.026 (1.36)	.027 (1.45)
INV				.005 (0.70)	.019 (2.53)
GDP					-.033 (-0.98)
Fertil ave	.943 (5.06)	.732 (3.01)	.794 (3.60)	.824 (4.06)	.645 (3.72)
Wald test	1.01	6.56	20.32	18.94	16.90
FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)
EDUC	-.366 (-18.12)	-.319 (-18.25)	-.255 (-13.47)	-.255 (-13.40)	-.112 (-5.31)
EXPECT		.702 (11.53)	.624 (11.42)	.642 (10.85)	.632 (12.56)
AGRIC			.157 (9.59)	.156 (9.48)	.037 (2.16)
INV				-.009 (-0.79)	.001 (0.18)
GDP					-.233 (-11.03)
R^2	0.55	0.30	0.46	0.46	0.06
IV	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$	$EDUC_{-2}$
	.962 (67.81)	.979 (69.22)	.946 (59.29)	.945 (59.18)	.904 (46.24)
F test	4598	2457	1613	1210	1026

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

In Table Four I instrument secondary enrolment with democracy and globalisation. All $EDUC$ estimates are negative and statistically significant against fertility. For instance, using column four, second panel, for a 10% points increase in secondary enrolment, there will be a reduction in 6.3% points in fertility in the community.

About the control variables; life expectancy keeps its positive and significant effect on fertility and the agricultural sector estimates in the first panel keep their positive and significant effects on fertility as well, however the estimates are not coherent in the second panel. Fixed capital is not coherent nor is income.

In the first-stage regressions the instruments for secondary enrolment are individually and overall statistically significant, which reduce the issue of weak instruments. More specifically, democracy, by better governance and more efficient allocation, or redistribution, of resources towards education positively influences secondary enrolment, and globalisation, because opening economies tend to spend more in, *eg* education in order to provide "social insurance against external risk", plays a positive role on secondary enrolment as well. The results from the first-stage regressions are in line with the documented positive effect that democracy and globalisation have on education, Gallego (2010) and Rodrik (1998).

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)
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)
R^2	0.57	0.47	0.54	0.54	0.22
IV	POL	POL	POL	POL	POL
	.126 (6.42)	.131 (6.76)	.091 (5.43)	.091 (5.36)	.037 (2.69)
F test	41.22	29.19	57.89	43.42	101.97
FERTIL	FE-IV (1)	FE-IV (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)
EDUC	-.471 (-10.09)	-.523 (-12.09)	-.625 (-7.03)	-.628 (-7.03)	-1.07 (-2.51)
EXPECT		.552 (7.28)	.525 (6.15)	.518 (5.53)	.490 (3.12)
AGRIC			-.045 (-0.93)	-.046 (-0.94)	.070 (1.34)
INV				.003 (0.17)	-.016 (-0.53)
GDP					.435 (1.51)
R^2	0.49	0.40	0.41	0.41	0.01
IV	GLOBAL	GLOBAL	GLOBAL	GLOBAL	GLOBAL
	.701 (8.73)	.758 (9.63)	.450 (6.04)	.455 (6.04)	.162 (2.42)
F test	76.19	53.06	66.83	50.08	90.12

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

3.3.3 Robustness [needs work]

In this section I present regressions with alternative control variables, *ie* primary completion, child mortality, gender gap, conflict and income per worker. Then I use a different estimator, the Augmented Mean Group (AMG), and different specifications that allow for nonlinearities in income and for fertility dynamics, to make sure that the secondary enrolment estimates are robust.

About the alternative controls, primary completion, $PRIM$, is defined as primary school completion as percentage of the relevant age group and the data are from the World Bank. It is expected that higher primary completion decreases fertility, Murtin (2013). Child mortality, $CHILD$, is defined as the probability that a child will die before the age of one and the data are from the UNICEF. It is expected that higher child mortality might increase fertility by an increase in replacement, Murtin (2013). I use a variable for gender gap, GAP, which is the ratio of girls to boys in primary and secondary education and the data are from the World Bank. It is expected that the lower the educational gap between girls and boys (captured by an increase in GAP), the lower the fertility, Galor and Weil (1996) and Murphy (2015).

I also use a variable for conflict, $CONFL$, which includes information on international violence and war, civil violence and war, and ethnic violence and war, and the data are from the Polity IV. It is expected that conflict might decrease fertility by a negative income shock suffered by the family if the husband dies in conflict, Vandenbroucke (2014). Lastly, I use GDP per worker, $GDPW$, to account for productivity changes and the data are from the Penn World Table. It is plausible to expect that higher productivity in developing countries might increase fertility, Lehr (2009) and Murtin (2013).

Moreover, I use the AMG heterogeneous estimator, Eberhardt and Teal (2010), which consists of two stages. In the first stage a first difference pooled OLS regression is estimated and estimated year dummy coefficients $\hat{\mu}_t$ are collected. In the second stage individual country regressions are estimated and the $\hat{\mu}_t$ variable is introduced on the RHS alongside a linear trend term to account for unobserved common factors across countries that evolve linearly over time. The individual country regressions are then averaged *à la* Pesaran and Smith (1995).

The estimated equation is as follows,

$$\begin{aligned} FERTIL_{it} &= \alpha_i + \beta_i EDUC_{it-1} + \gamma PRIM_{it-1} + \delta_i CHILD_{it-1} \\ &\quad + \epsilon_i AGRIC_{it} + \varepsilon_i INV_{it} + \zeta_i GAP_{it} + \eta_i CONFL_{it} \\ &\quad + \theta_i GDPW_{it} + \vartheta_i GDPW_{it}^2 + \vartheta_i FERTIL_{it-1} + \iota_i \hat{\mu}_t + \upsilon_{it} \end{aligned} \quad (2)$$

where $FERTIL$ are the number of children per woman, $EDUC$ is lagged secondary enrolment, $PRIM$ is lagged primary completion rates, $CHILD$ is child mortality before the age of one lagged once, $AGRIC$ is the share of the agricultural sector to GDP, INV is the share of gross fixed capital formation to GDP, GAP is the ratio of girls to boys in primary and secondary education, $CONFL$ is international and civil conflict, $GDPW$ is income per worker and its squared term, $FERTIL_{-1}$ is the lagged dependent variable and $\hat{\mu}_t$ is the "common dynamic process" (CDP).

In Tables five, six and seven I report regressions which allow for nonlinearities in productivity, different instrumentation and then for fertility dynamics. The secondary enrolment estimates keep their negative and mostly statistically significant effects on fertility. About the control variables; the share of the agricultural sector to GDP keeps its positive, although not wholly significant, estimates against fertility and fixed capital formation keeps its (non-conclusive) role on fertility as well. Lagged child mortality does not present coherent estimates, however lagged life expectancy presents negative estimates in Table seven, with some of them being significant, which suggests that perceptions about life expectancy might change with time and affect fertility differently than reported above, Montgomery (2000) and Angeles (2010).

Although Murphy (2015) and Becker, Cinnirella and Woessmann (2013) report estimates suggesting that the female literacy reduces fertility in 19^{th}-century France and Prussia, and Conley, McCord and Sachs (2007) report far from conclusive female literacy estimates in Africa, the variable gender gap presents mostly positive and significant estimates against fertility. It is fair to say that secondary enrolment is the variable picking up the role of higher women's relative wages in the SADC. The variable for conflict does not present coherent estimates and the estimates are possibly reflecting the fact that most countries in the SADC have not experienced conflict, with the exceptions of Angola, the DRC and Mozambique. Although not in contrast to Lehr (2009), productivity and its squared term in Table five present mostly positive and then negative effects on fertility, however the estimates are not wholly significant and in Table seven productivity is mostly positive, but not significant either. Moreover, differently from Murtin (2013) the $PRIM$ estimates are not significant against fertility (although his non-OECD estimates are not always significant either), but in line with early results presented by Ainsworth, Beegle and Nyamete (1996).

Lastly, the instrumental variables are all positive and mostly significant (and in columns 3 I use the third lag of education as the instrument for secondary enrolment and in Table six I also instrument child mortality with its own lag), which minimise the issue of weak instruments.

Table 5: FE, MG, FE-IV and AMG Estimates, SADC, 1980-2009.

FERTIL	FE (1)	MG (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	AMG (6)
EDUC	-.231 (-6.99)	-.247 (-2.42)	-.349 (-12.97)	-.317 (-3.82)	-.519 (-2.91)	-.018 (-0.71)
CHILD	.004 (0.07)	.082 (0.65)	-.017 (-0.49)	-.016 (-0.35)	-.100 (-1.21)	-.004 (-0.09)
AGRIC	.226 (7.45)	.030 (1.17)	.187 (7.96)	.201 (5.17)	.121 (1.62)	.003 (0.58)
INV	-.014 (-0.82)	.010 (0.33)	-.023 (-1.60)	-.020 (-1.31)	-.039 (-1.59)	.002 (0.26)
GAP	.222 (1.06)	-.157 (-0.43)	.406 (3.92)	.337 (3.30)	.435 (2.69)	.108 (2.12)
CONFL	.104 (1.61)	.154 (1.03)	.163 (3.30)	.132 (2.75)	.154 (2.37)	.006 (0.26)
GDPW	.463 (2.00)	-14.90 (-1.11)	.409 (2.75)	.407 (2.59)	.239 (1.00)	4.69 (1.09)
$GDPW^2$	.022 (-1.42)	.782 (1.11)	-.015 (-1.55)	-.016 (-1.53)	-.002 (-0.18)	-.250 (-1.13)
CDP						.912 (5.99)
F test	55.81					
R^2	0.49		0.32	0.32	0.19	
Wald		51.10				12.72
IV			$EDUC_{-3}$	POL	GLOBAL	
			.706 (21.35)	.087 (3.62)	.255 (2.20)	
F test			159.13	31.64	29.91	

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

Table 6: FE, MG, FE-IV and AMG Estimates, SADC, 1980-2009.

FERTIL	FE (1)	MG (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	AMG (6)
EDUC	-.211 (-4.73)	-.206 (-2.16)	-.291 (-7.80)	-.352 (-4.19)	-.187 (-2.00)	-.158 (-1.41)
PRIM	-.050 (-0.94)	-.042 (-0.65)	.000 (0.02)	.040 (0.66)	-.067 (-1.01)	-.095 (-1.89)
CHILD	-.021 (-0.37)	.116 (0.95)	-.003 (-0.09)	-.007 (-0.21)	-.006 (-0.20)	.129 (1.01)
AGRIC	.247 (7.73)	.024 (1.56)	.228 (9.52)	.216 (6.86)	.258 (8.04)	.039 (1.42)
INV	-.019 (-1.12)	-.020 (-0.57)	-.019 (-1.31)	-.018 (-1.20)	-.019 (-1.31)	-.013 (-0.37)
GAP	.185 (0.94)	-.547 (-0.67)	.339 (3.34)	.323 (3.09)	.250 (2.52)	-.695 (-0.82)
CONFL	.056 (0.83)	.008 (1.45)	.047 (0.80)	.027 (0.43)	.063 (1.04)	-.008 (-1.42)
GDPW	.298 (1.26)	-3.21 (-0.39)	.165 (0.92)	.018 (0.08)	.362 (1.45)	-5.11 (-0.57)
$GDPW^2$	-.012 (-0.80)	.184 (0.41)	-.001 (-0.16)	.008 (0.51)	-.016 (-0.95)	.278 (0.57)
CDP						.159 (1.64)
F test	1613					
R^2	0.54		0.49	0.43	0.56	
Wald		8.41				5.85
IV			$EDUC_{-3}$	POL	GLOBAL	
			.793 (15.66)	.102 (4.75)	.398 (3.86)	
F test			178.07	66.74	62.87	
			$CHILD_{-2}$	$CHILD_{-2}$	$CHILD_{-2}$	
			.998 (58.43)	1.00 (57.58)	.990 (54.48)	
F test			1198	1226	1225	

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

Table 7: Dynamic FE, MG, FE-IV and AMG Estimates, SADC, 1980-2009.

FERTIL	FE (1)	MG (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	AMG (6)
EDUC	-.011 (-2.08)	-.053 (-2.18)	-.009 (-2.06)	-.047 (-2.45)	-.115 (-1.35)	-.026 (-1.76)
EXPECT	-.051 (-2.74)	.443 (1.30)	-.067 (-6.35)	-.046 (-2.80)	-.020 (-0.47)	.181 (0.81)
AGRIC	.007 (1.16)	.015 (1.38)	.006 (2.43)	.012 (2.46)	.021 (1.47)	.002 (0.45)
INV	.000 (0.09)	-.000 (-0.22)	.000 (0.57)	-.001 (-0.71)	-.007 (-0.90)	.000 (0.24)
GAP	.030 (2.05)	-.085 (-1.21)	.036 (3.33)	.072 (3.06)	.144 (1.56)	.005 (0.14)
CONFL	-.012 (-1.06)	-.030 (-1.04)	-.019 (-3.74)	-.003 (-0.40)	.018 (0.60)	-.036 (-1.24)
GDPW	.008 (1.03)	-.018 (-1.58)	.003 (1.08)	.020 (2.40)	.047 (1.38)	.004 (0.18)
$FERTIL_{-1}$	.988 (56.67)	.909 (4.80)	.998 (94.82)	.924 (24.23)	.798 (4.95)	.617 (3.22)
CDP						.218 (1.85)
F test	12029					
R^2	0.99		0.99	0.99	0.96	
Wald		5283				83.53
IV			$EDUC_{-3}$	POL	GLOBAL	
			.612 (13.11)	.053 (3.10)	.115 (1.36)	
F test			158.08	73.67	67.84	

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

Table 8: Dynamic FE, MG and FE-IV Estimates, SADC, 1980-2009.

FERTIL	FE (1)	MG (2)	FE-IV (3)	FE-IV (4)	FE-IV (5)	FE-IV (6)
EDUC	-.023 (-7.15)	-.037 (-1.51)	-.022 (-5.32)	-.078 (-2.34)	.229 (0.65)	-.047 (-4.79)
EXPECT	-.008 (-0.62)	.143 (0.47)	.008 (0.45)	-.056 (-2.24)	-.060 (-0.61)	-.011 (-0.52)
AGRIC	.003 (0.86)	.001 (0.08)	.003 (0.91)	.016 (1.84)	-.034 (-0.54)	.009 (2.13)
INV	-.002 (-1.12)	-.001 (-0.32)	-.006 (-3.03)	-.006 (-2.09)	.017 (0.59)	-.006 (-3.00)
GAP	.046 (3.91)	-.102 (-1.88)	.029 (2.29)	.059 (3.14)	-.070 (-0.47)	.039 (2.75)
GDP	.018 (1.21)	-2.57 (-1.21)	.049 (3.97)	.070 (3.47)	-.019 (-0.17)	.058 (4.17)
GDP2	-.000 (-0.18)	-.184 (-0.58)	-.001 (-1.93)	-.002 (-2.08)	-.004 (-1.05)	-.001 (-2.25)
GDP3	1.03e-06 (0.06)	.140 (0.99)	.000 (0.84)	.000 (1.68)	.000 (0.77)	.000 (1.62)
$FERTIL_{-1}$	.940 (77.30)	.967 (5.20)	.953 (83.55)	.938 (41.28)	1.21 (3.60)	.942 (70.63)
FE i.t	yes					
Rob SE	yes					
F test	1948.02					
R^2	0.93		0.89	0.66	0.42	0.80
Wald		500.17				
IV			$EDUC_{-2}$	POL_{-2}	$GLOBAL_{-2}$	GOV_{-2}
			.796 (31.71)	.042 (2.32)	-.059 (-0.64)	.327 (6.42)
F test			443.17	61.70	66.61	75.46
IV			$EXPECT_{-2}$	$EXPECT_{-2}$	$EXPECT_{-2}$	$EXPECT_{-2}$
			.396 (13.70)	.017 (67.06)	.373 (11.13)	.404 (13.76)
F test			98.42	1342.63	101.14	94.97

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

3.3.4 Discussion

In a nutshell, secondary enrolment is associated with lower fertility in the SADC, a result that confirms previous efforts using historical data from countries which had not yet experienced their own demographic transition, Ainsworth, Beegle and Nyamete (1996), Dribe (2008), Murphy (2015), Becker, Cinnirella and Woessmann (2010), Lehr (2009) and Murtin (2013). Furthermore, perhaps because I account explicitly for secondary enrolment, the results I report are stronger than the ones reported by Conley, McCord and Sachs (2007) who only account for the role of female literacy on fertility. The significance of the results are fourfold.

Firstly, lower fertility is important because that can have a positive effect on capital per worker, productivity and consequently on growth, Galor (2011). Secondly, although Conley, McCord and Sachs (2007) state that Africa "remain mired in a Malthusian crisis" it is fair to say that those southern African countries (some of which have been growing fast and consistently in the last twenty years or so, *eg* Angola, Botswana, Mauritius and Mozambique) are not in a Malthusian stagnation or on a sustained growth path regime. It is plausible that those countries are going through the Post-Malthusian regime. Indeed this seems to be the case, *ie* in addition to the secondary enrolment and income estimates, Figure six shows that urbanisation is on the rise and that the agricultural share to GDP has been decreasing (from approximately 21% in 1980 to 16% of the GDP in 2009) in the community. These are important characteristics that other (now developed) countries presented in their own past, Galor (2005), and that these SADC countries are already presenting.

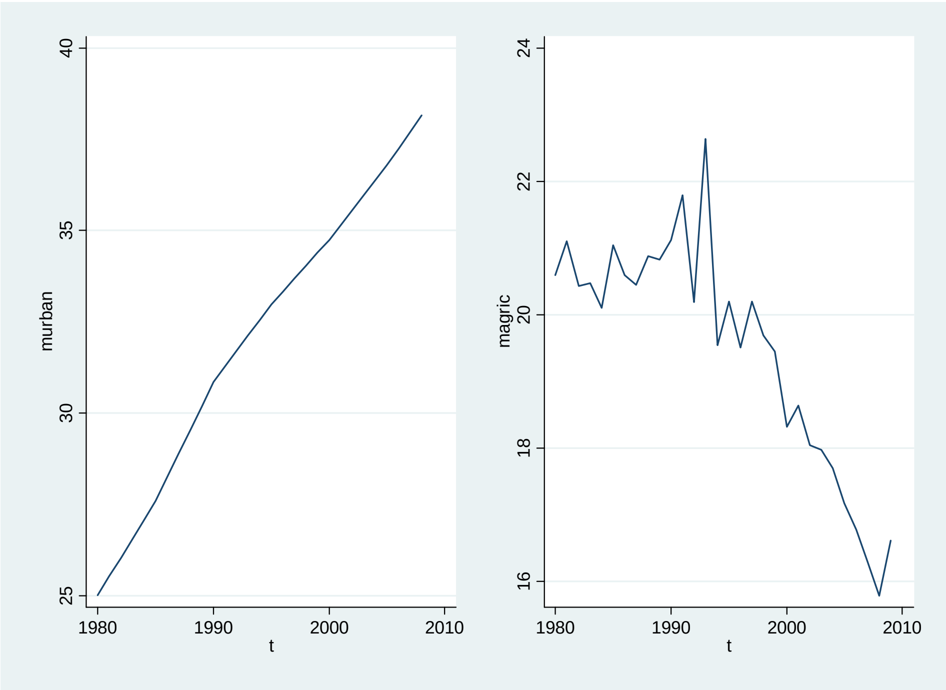

Figure 6: Urbanisation and agricultural share to GDP, SADC, 1980-2009. Source: World Bank.

Thirdly, the results robustly suggest that the community, although not in the sustained growth regime, is already experiencing before its very own demographic transition the trade-off between quantity and quality of children (triggered by higher demand for fairly educated people) and this demand for human capital increases the returns to education and incentivises the trade-off, which is also an important ingredient of the transition from the Malthusian epoch to sustained growth, Becker, Cinnirella and Woessmann (2010).

Fourthly, 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, *eg* democratisation or globalisation, a virtuous cycle might be created between human capital and technological progress, and consequently sustained growth takes place. Alternatively, it can be argued that a negative shock, *eg* the AIDS epidemic of the 1990s in Africa, combined with other (positive) shocks, democratisation and globalisation, can also lead to a virtuous cycle in the community, Voigtländer and Voth (2013).

Moreover, although in contrast to Conley, McCord and Sachs (2007), life expectancy is a variable which presents fairly consistent results, *ie* positive effects on total fertility rates. The results are in line with the historical evidence that suggests that in the 17^{th} and 18^{th} centuries Europe presented reductions in mortality rates that were matched by increases in total fertility, Galor (2011), and also with Dribe (2008) who suggests the same for 19^{th}-century Sweden, which further suggests that those developing countries of the SADC are experiencing the same process of development that took place in Europe. Perhaps it is fair to speculate that in the future increases in life expectancy will generate lower fertility in the community, which would be in line with the prediction by Soares (2005). All the same, and bearing in mind the AIDS epidemic of the 1990s, the lagged $EXPECT$ estimates reported in Table seven are in line with Montgomery (2000) who suggests that perception about reductions in mortality, or increases in life expectancy, takes time to change and with Angeles (2010) evidence of the lagged effect of life expectancy on lower fertility.

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

The variable for fixed capital formation does not play any negative role on fertility, by skill complementarities and higher relative wages for women in services and manufacturing, which would take place in the second stage of an industrial revolution, Galor and Moav (2006) and Galor and Weil (1996). All in all, the role of the modern sectors of those economies on fertility is being picked up by secondary enrolment[7].

In addition, the income estimates further suggest that southern Africa is not in the Malthusian epoch in which higher income would increase fertility. The evidence, with the caveat that not all income estimates are statistically significant, indicates that the substitution effect is already dominating the income effect in the community, Becker (1960) and Conley, McCord and Sachs (2007). Although I account for heterogeneity of intercepts and slopes by using the MG and CCE estimators, it must be born in mind that the sample contains a fair degree of heterogeneity in terms of economic development, *eg* Malawi differs from South Africa, and the mixed evidence of income and fertility suggests that income as such is not the main driving force of reduced fertility in the community, Galor (2011), which reinforces the results about the role of secondary enrolment on fertility. In this vein, Herzer, Strulik and Vollmer (2012) argue that income growth, a proxy for technological progress, which usually leads to higher relative wages for women might be providing incentives for reduced fertility, but because of an increase in the cost of raising children with respect to forgone higher household income, Galor and Weil (1996).

Lastly, about the instrumental variables, the first-stage regressions estimates of the positive effects of democracy and globalisation on secondary education bode well, to say the least, with some of the broad developmental objectives of the SADC, *ie* democracy and integration and their direct positive role on secondary enrolment, Gallego (2010) and Rodrik (1998).

In essence, the evidence, *ie* reduction in fertility rates caused by secondary enrolment, increase in urbanisation, reduction in the agricultural share to GDP, no positive effect of income on fertility, when put together, suggests that the SADC, although still not a Solow economy (which is il-

[7] I have also used the share of manufacturing and services to GDP as control variables as well as female labour force participation and foreign aid. Although the role of secondary enrolment is robust on fertility, the results for manufacturing, services, female labour force participation and aid are not coherent either.

lustrated by the no effect of fixed capital on fertility) and therefore not into the sustained growth regime, has already escaped the Malthusian stagnation epoch and is well into the Post-Malthusian regime or in transition[8].

4 Final Remarks

Using a dataset covering the period between 1980 and 2009, I have studied 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 secondary enrolment has had a negative and significant effect on fertility. More specifically, secondary enrolment proved to be a robust determinant of fertility, which also highlights its indirect role in determining prosperity in the community by higher capital per worker, increased productivity, economic growth and changes in the composition of the population.

The quality of the evidence presented is, to a certain extent—and bearing in mind all limitations in terms of data quality, availability and span in the community, and not forgetting that the SADC is still a high fertility region, Strulik and Vollmer (2013)—boosted because I make use of unified growth theory to put the results in economic and historical context, and also because I take advantage of panel time-series analysis to deal with empirical issues such as statistical endogeneity, heterogeneity, cross-section dependence and reverse causality in thin panels. The analysis is important because it allows me to specifically study the SADC (during a period that captures important regional and international changes), instead of treating the community either as a dummy or as an outlier to be removed from a larger sample. Therefore, the empirical analysis conducted represents a step forward in terms of achieving informative estimates and in improving our knowledge on the subject in sub-Saharan Africa.

Although Bates, Coatsworth and Williamson (2007) argue that Africa right after its independence in the 1960s showed 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,

[8] Furthermore, particular reinforcing mechanisms such as, *eg* abortion laws, are conservative in nature in the SADC, with the exceptions of South Africa and Zambia, which reinforces the role of secondary enrolment on lower fertility.

Johnson and Robinson (2001) highlight the importance of "extractive" institutions being implemented in Africa during its colonial period, factors that might have delayed Africa's own demographic transition, the evidence suggests that southern Africa has escaped the worst of a Malthusian stagnation and is already showing characteristics of a region in transition. In fact, Young (2012) argues that sub-Saharan Africa has witnessed since the 1990s a considerable increase in consumption of vital durables such as housing, schooling and health, which is on par with other developing regions and Pinkovskiy and Sala-i-Martin (2014) state that "Africa is on time" to achieve the Millennium Development Goal of reducing poverty.

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

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