Trade Openness and Fertility Rates in Africa: Panel-Data Evidence*

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Abstract

Trade openness, or globalisation, is one of the new Kaldor facts. And unified growth theory advances that the process of economic development is characterised by an increase in demand for human capital which in turn creates incentives for lower fertility rates. Bearing that in mind, we study the role of trade openness, also a characteristic of economic development, on fertility in Africa during the 1962-2010 period. The results, based on panel-data analysis, suggest that trade openness in itself is (in fact) associated with lower fertility in Africa. More interestingly, by digging deeper in our dataset the results then suggest that trade openness in manufacturing and with the European Union are strongly associated with lower fertility as well. The results are significant for the obvious reasons: lower fertility, caused in this case by openness and its technologies, knowledge diffusion and learning, implies more capital per worker, higher productivity and higher growth rates, but even more significantly because—in accordance to unified growth theory—they suggest that Africa is transitioning from the Malthusian epoch into sustained growth.

Keywords: openness, fertility, Africa.

JEL Classification: F6, J10, N37, O55.

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1 Introduction

One of the new Kaldor facts proposed by Jones and Romer (2010) states: "Increased flows of goods, ideas, finance and people - via globalisation as well as urbanisation - have increased the extent of the market for all workers and consumers." Furthermore, unified growth theory, Galor and Weil (2000), advances that the process of economic development is characterised, amongst other things, by an increase in demand for educated people, who can operate production technologies, which in turn creates incentives for lower fertility rates. Eventually the demographic transition takes place. Unified growth theory also advances that the process of economic development which took place in Europe in the 19^{th} century will eventually spread to the whole world, including Africa. And Figure 1 illustrates this process of globalisation, or trade openness, urbanisation and lower fertility taking place in Africa over time rather well.

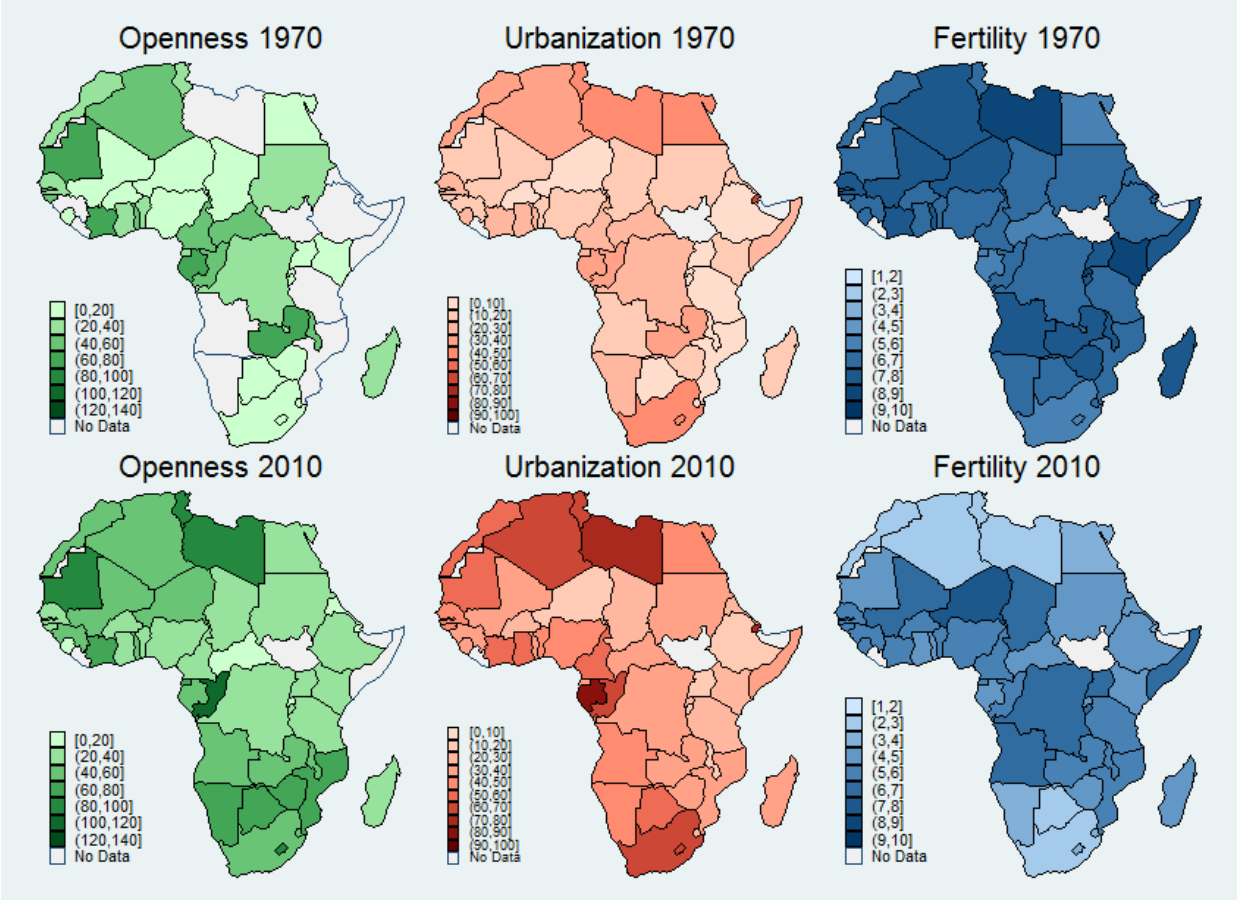

Figure 1: Trade openness, urbanisation and fertility in Africa, 1970 and 2010. Sources: WITS and World Bank

Bearing the above in mind, we study the role of trade openness on fertility rates in 52 African

countries (the whole of Africa) during the 1962-2010 period. And given the dimension of our dataset ($N = 52$ countries and $T = 48$ years), the method is based on panel-data analysis. We estimate fixed-effects equations without and then with instrumental variables in order to account for statistical endogeneity, all sorts of omitted factors and economic endogeneity in panels.

More specifically, we start by testing the hypothesis, put forward and tested by Galor and Mountford (2008) and further tested by Gries and Grundmann (2014), that trade openness has a positive effect on fertility in developing countries which export mostly agricultural products (or low-skilled products). Given that Africa is a developing continent that exports mostly agricultural products and imports manufactured goods (high-skilled goods) we expect to find positive effects of trade openness on fertility. But that is not really what we find.

About the results: firstly, we do not find evidence for the Galor and Mountford (2008) prediction, say, our trade openness variable has a negative effect on fertility in Africa. Secondly, by disaggregating the trade openness data by different categories, we find that imports of manufactured goods have a significant negative effect on fertility. Thirdly, we further disaggregate the trade openness data by country (China, European Union and US) and we find that trade openness with the European Union (but not with China and the USA) has a negative effect on fertility. Figures 2 and 3 illustrate the fact that, although growth in trade openness with China taking place since the 1990s is remarkable, the European Union still is the main trade partner of Africa [we need more beef here].

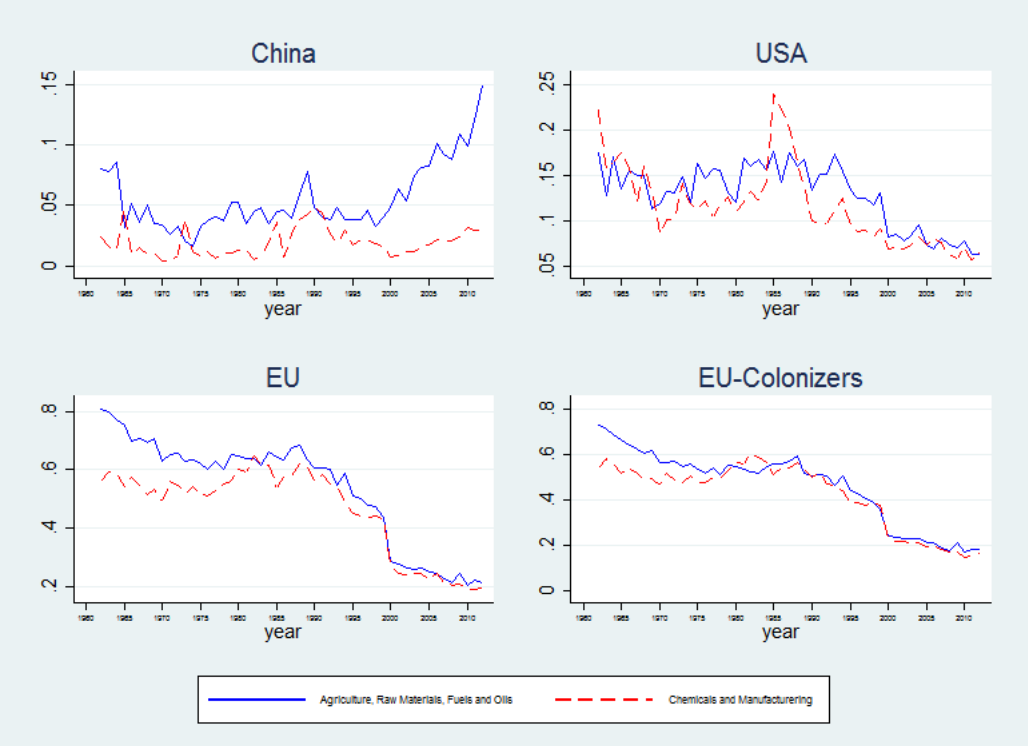

Figure 2: African exports to China, European Union and US. Source: WITS

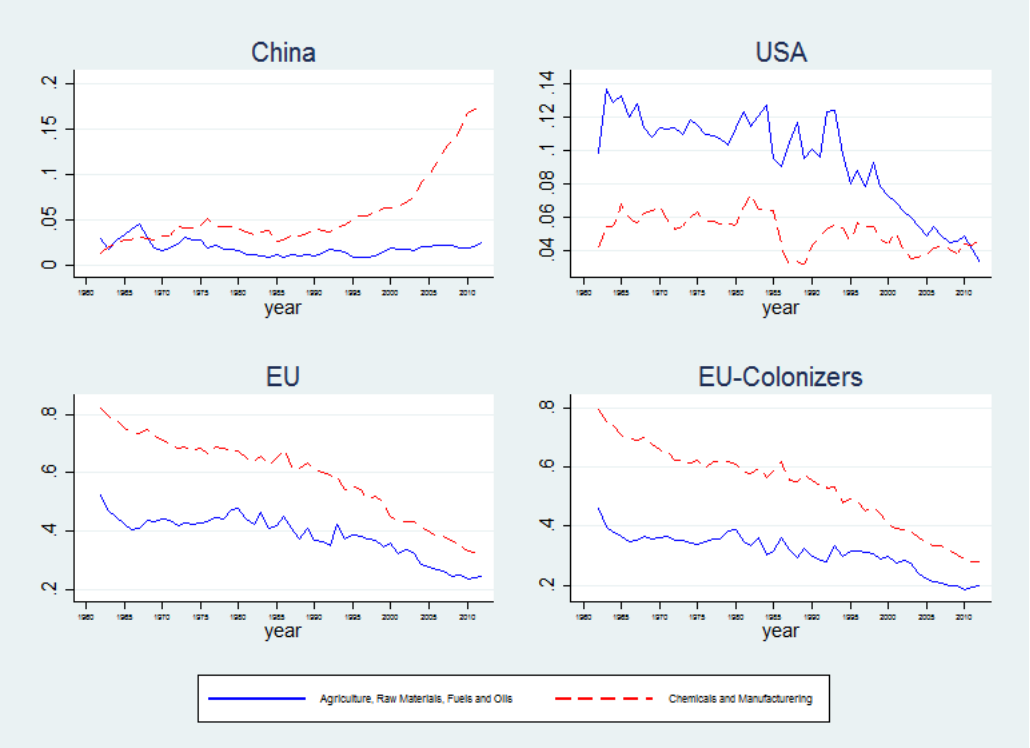

Figure 3: African imports from China, European Union and US. Source:WITS

We interpret our results as being more in line with Coe and Helpman (1993) and their prediction that foreign technologies increase productivity, and with Keller (2001) and Acharya and Keller (2008), and the importance they give to diffusion of technologies and knowledge and the learning process associated with it, in creating, in our case, incentives for lower fertility. Furthermore, our results are in line with Baldwin, Martin and Ottaviano (2001) and the importance they give to reducing costs of transferring ideas and technologies from the developed North to the developing South so that convergence takes place. All in all, our results suggest that technological diffusion, knowledge and learning (merely manisfestations of manufactured goods imports) are creating incentives for lower fertility in Africa.

We contribute to the literature in at least a couple of fronts. Firstly, our sample covers the whole of Africa, with all its common factors and also idiosyncrasies, and that in itself reduces the amount of contamination and endogeneity present in large samples of countries, Papaioannou and Siourounis (2008). In practical terms, given that we are interested in getting a better picture of what determines fertility (and economic development) in Africa, there is little to be gained in using a large sample including developed countries that have already experienced their own demographic transitions. Secondly, we construct a more thorough dataset which allows us to disaggregate the data in novel ways, say, not only by different trade openness categories but also by main trade partners. And although we do not claim causality here, but given how we conduct the whole empirical exercise,

we believe that our results are consistent and informative, so that a better picture of Africa is developed. [needs more beef here]

2 Data and Method

Our dataset covers 52 African countries during the 1962-2010 period. In order to study the effect of trade openness and of different trade categories, in this case agriculture and manufacturing, on fertility, we estimate the following two-way fixed-effects equation:

$$\begin{aligned} fertility_{it} &= \alpha_i + \upsilon_t + \beta 1 openness_{it} + \beta 2 mortality_{it} + \beta 3 income_{it} \\ &\quad + \beta 4 education_{it} + \beta 5 catX_{it} + \beta 6 catM_{it} + u_{it} \end{aligned} \tag{1}$$

where $fertility$ is the number of children that a woman gives birth to by the end of her childbearing years and the data are from the World Development Indicators at the World Bank. Our general trade *openness* variable is constructed by aggregating exports and imports relative to GDP from the World Integrated Trade Solution (WITS) reported at the five-digit Standard International Trade Classification level (SITC Version 1).[1] In addition to openness, for each of the 52 African countries we calculate the percentage of exports and imports in two aggregate categories, $catX$ and $catM$. More specifically, we aggregate the SITC to the one-digit level for primary products (SITC 0-4) and manufactured goods (SITC 5-8). The SITC categories are defined by the United Nations Statistics Division as: 0) food and live animals, 1) beverages and tobacco, 2) crude materials (inedible except fuels), 3) mineral fuels, lubricants and related materials, 4) animals and vegetable oils, fats and waxes, 5) chemicals and related products, 6) manufactured goods by material type, 7) machinery and transport equipment, and 8) miscellaneous manufactured articles.

Moreover, our choice of confounders follows the underlining theories of demographic transition, Galor (2011): infant *mortality*, defined as the number of deaths per 1000 live births under the age of one, real *income* per capita in 2005 US dollars and gross enrollment ratio in secondary *education* are all from the World Development Indicators at the World Bank as well.

To further study the effect of trade openness on fertility in Africa, we estimate the following two-way fixed-effects equation:

$$\begin{aligned} fertility_{it} &= \alpha_i + \upsilon_t + \beta 1 openOthers_{it} + \beta 2 mortality_{it} + \beta 3 income_{it} + \beta 4 education_{it} \\ &\quad + \beta 5 openChina_{it} + \beta 6 openEU_{it} + \beta 7 openUS_{it} + u_{it} \end{aligned} \tag{2}$$

where we disaggregate our trade openness variable so that it is specific to China ($openChina$), the European Union ($openEU$) and the United States ($openUS$)[2]. In addition, to avoid double

[1] WITS reports bilateral trade by Reporter (Importer) that includes CIF (cost insurance and freight).

[2] The European Union countries are essentially those countries which had colonies in Africa: Belgium, France, Germany, Italy, Portugal, Spain and the United Kingdom.

counting, we remove from our general openness variable trade with China, with the European Union and with the USA, so that we end up with *openOthers*.

Table 1 shows the descriptive statistics. A couple of notable features: although some countries already have low fertility rates, say, Mauritius and South Africa, overall the continent still has relatively high fertility (with a mean of 6 children per woman, Strulik and Vollmer 2013). Furthermore, the bulk of the manufactured-goods category is characterised by imports, or by all sorts of technologies and knowledge coming into Africa.

Table 1: **Summary Statistics 1962-2010**

variable	**Obs.**	**Mean**	**Std.Dev.**	**Min.**	**Max.**
Fertility	2619	6.032	1.314	1.57	8.449
Manufacture X	2428	.235	.262	0	1
Manufacture M	1392	.686	.111	.32	.94
gdppc	2193	1470.762	2048.878	123.724	23812.29
Infant Mort.	2402	96.766	41.206	12.2	223.6
Urban \%	2652	29.823	17.073	2.077	85.697
Sec. Gross Enroll	1419	28.068	23.037	1.004	115.971
Openness (Goods)	2175	33.064	24.214	0	163.658
Openness w/ CHN	2175	1.901	3.962	0	40.093
Openness w/o CHN	2175	42.763	28.388	0	192.767
Openness w/ EU	2175	20.031	15.427	0	156.937
Openness w/o EU	2175	24.633	21.978	0	198.543
Openness w/ USA	2175	4.649	7.174	0	77.576
Openness w/o USA	2175	40.015	27.09	0	200.678
Open. w/o UEC	2175	18.083	16.939	0	160.216

Note: The measure "Open. All Others" excludes USA, China, and European Union. Additionally, Liberia was excluded because it is an outlier.s

More about the method: given the dimension of our dataset, an unbalanced panel with $N = 52$ countries covering $T = 48$ years, we use panel-data analysis. Firstly, Phillips and Moon (1999) argue that the issue of spurious regressions—given the averaging that takes place in panel estimators, which reduces the noise coming from such regressions—is less of a problem in panels. Hence, we do not need to concern ourselves with issues such as nonstationarity and cointegration in panels.

Secondly, the issue of statistical endogeneity in panels is dealt with the fixed effects (FE) with robust standard errors estimator, which provides consistent estimates when $T \to \infty$, Smith and Fuertes (2010). The fixed effects purge the correlation between the unobserved heterogeneity and the regressors by demeaning the data. Intuitively, although those African countries shared economic and institutional transitions in their recent history (and some have common objectives as well), which makes the homogeneity of slopes plausible, the heterogeneous intercepts of the fixed effects estimator take into account that those countries also present different characteristics in terms of development, for instance, South Africa is relatively more developed than Zambia, and Mauritius relatively more developed than Ghana. [more here about time effects]

Thirdly, the issue of economic endogeneity. Well, we have fixed effects, which proxies for all sorts of omitted factors, in order to minimise omitted-variable bias. In addition, we use all confounders suggested by the demographic transition literature (mortality, income and education) on the right side of our regressions. Furthermore, our sample covers the whole of Africa—which reduces the amount of contamination and endogeneity present in large samples of countries—and which provides a perfect panel and ideal ground for studying the effects of trade openness on fertility. Altogether, we expect to reduce economic endogeneity concerns. Nevertheless, some will argue that economic endogeneity, or possible reverse causality running from fertility to trade openness, might still be a possibility, Galor and Mountford (2008). So, to be as thorough as possible, we attempt to deal with the issue of economic endogeneity as well.

Essentially, we augment our fixed effects regressions with instrumental variables. The fixed effects with instrumental variables (FE-IV) two-stage least squares estimator provides estimates that are asymptotically consistent and efficient as $T \to \infty$, Arellano (2003). Given that (truly external) instrumental variables do not come by easily and with the assumption that deeper lags of openness are uncorrelated with the error term ($E(openness_{it-n}u_{it} = 0)$) but correlated with contemporaneous openness, we use the lag of openness as a baseline internal identifying instrument for contemporaneous openness. We expect a positive effect of lagged openness on contemporaneous openness in the first-stage regressions.

3 Results and Discussion

In Table 2 we start by reporting our baseline fixed-effect regression with just general trade openness on the right side plus the confounders. We then include in the regressions the different trade-openness categories, in this case exports and imports of manufactured goods, on a step-wise fashion. We also report a regression with five-year lags to account for fertility dynamics. Furthermore, in Table 3 we report regressions which include the squared terms of income and education to account for nonlinearities, an extra confounder, urbanisation, and also interaction terms between education and all trade openness variables.

About the estimates: openness presents negative and statistically significant effects on fertility. Moreover, the results suggest that manufacture imports, and all sorts of technologies and knowledge embedded in those goods, have negative and significant effects on fertility. Furthermore, the interaction terms between education and our openness variables all have negative and significant estimates as well.

Table 2: Percentage 2 Categories

	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.+5
Openness (Goods)	-0.036***	-0.029***							-0.029***	
	(0.004)	(0.005)							(0.006)	
ln(Mortality)	0.459***	0.435***	0.559***	0.483***	0.548***	0.474***	0.552***	0.483***	0.479***	0.453***
	(0.011)	(0.020)	(0.020)	(0.027)	(0.020)	(0.027)	(0.020)	(0.027)	(0.027)	(0.025)
ln(GDPpc)	0.020***	-0.010	0.025**	-0.023*	0.029***	-0.015	0.031***	-0.013	-0.017	-0.006
	(0.006)	(0.008)	(0.010)	(0.012)	(0.009)	(0.012)	(0.009)	(0.012)	(0.012)	(0.011)
ln(Sec. Gross Enroll)			0.036***	0.036***	0.041***	0.045***	0.041***	0.043***	0.058***	-0.013
			(0.011)	(0.013)	(0.011)	(0.013)	(0.011)	(0.013)	(0.013)	(0.012)
ln(Manufacture X)			0.002	0.011**			0.005	0.012**	0.011**	0.007
			(0.005)	(0.005)			(0.005)	(0.005)	(0.005)	(0.005)
ln(Manufacture M)					-0.125***	-0.111***	-0.127***	-0.115***	-0.120***	-0.051*
					(0.027)	(0.030)	(0.028)	(0.030)	(0.028)	(0.027)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes
Adjusted R2	0.888	0.897	0.911	0.919	0.912	0.920	0.912	0.921	0.923	0.941
Obs	1853	1853	1140	1140	1140	1140	1140	1140	1140	1114

Robust standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3: Percentage 2 Categories Robustness

	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.
Openness (Goods)	-0.029***	-0.030***	-0.015***	-0.020***	0.090***	-0.022***	-0.029***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.018)	(0.006)	(0.006)
ln(Mortality)	0.478***	0.480***	0.325***	0.441***	0.456***	0.427***	0.470***
	(0.028)	(0.027)	(0.026)	(0.023)	(0.026)	(0.031)	(0.027)
ln(GDPpc)	-0.017	-0.277***	-0.003	-0.009	-0.007	-0.024*	-0.016
	(0.012)	(0.072)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
log(gdppc)2		0.019***					
		(0.005)					
ln(Sec. Gross Enroll)	0.057***	0.063***	0.341***	0.319***	0.182***	-0.024	0.026
	(0.013)	(0.013)	(0.024)	(0.022)	(0.021)	(0.020)	(0.018)
ln(Sec. Gross Enroll)2			-0.065***				
			(0.005)				
ln(Manufacture X)	0.011**	0.012**	0.000	0.009**	0.007	0.082***	0.010*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.016)	(0.005)
ln(Manufacture M)	-0.120***	-0.122***	-0.124***	-0.107***	-0.126***	-0.097***	0.076
	(0.028)	(0.028)	(0.024)	(0.026)	(0.029)	(0.027)	(0.087)
ln(Urban %)	0.005						
	(0.027)						
Inter EDU7 Urban %				-0.087***			
				(0.007)			
Inter EDU7 OPEN					-0.044***		
					(0.006)		
Inter EDU7 EXP %						-0.028***	
						(0.005)	
Inter EDU7 IMP %							-0.073**
							(0.030)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R2	0.923	0.924	0.937	0.935	0.926	0.926	0.923
Obs	1140	1140	1140	1140	1140	1140	1140

Robust standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

In Table 4 we report fixed-effects regressions where we disaggregate openness by countries, say, trade openness with China, European Union and USA. We also report a regression with five-year lags to account for any long-run effect of openness on fertility. For robustness, in Table 5 we report regressions which include the squared terms of income and education, urbanisation and interaction terms between education and openness as well.

About the estimates: interestingly enough, trade openness with the European Union is always negative and significant on fertility. On the other hand, trade openness with China and the US are much less clear cut. The interaction term between education and openness is yet again negative and significant on fertility.

Table 4: Openness by Country

	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.	lFert.+5
ln(Mortality)	0.556***	0.482***	0.575***	0.453***	0.564***	0.472***	0.555***	0.458***	0.448***
	(0.020)	(0.026)	(0.020)	(0.026)	(0.020)	(0.026)	(0.020)	(0.026)	(0.024)
ln(GDPpc)	0.011	-0.043***	0.014	-0.040***	0.012	-0.047***	0.012	-0.035***	-0.020*
	(0.009)	(0.013)	(0.009)	(0.012)	(0.009)	(0.013)	(0.008)	(0.012)	(0.012)
ln(Sec. Gross Enroll)	0.065***	0.065***	0.049***	0.056***	0.057***	0.065***	0.061***	0.066***	0.013
	(0.010)	(0.013)	(0.010)	(0.012)	(0.010)	(0.012)	(0.010)	(0.013)	(0.012)
Openness w/ CHN	-0.014***	-0.004					-0.015***	-0.002	-0.007*
	(0.003)	(0.004)					(0.003)	(0.004)	(0.004)
Openness w/ EU			-0.044***	-0.074***			-0.034***	-0.068***	-0.025***
			(0.007)	(0.008)			(0.008)	(0.009)	(0.008)
Openness w/ USA					-0.000	0.001	0.009**	0.008*	0.007
					(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Openness w/o CHN	-0.040***	-0.049***							
	(0.011)	(0.012)							
Openness w/o EU			-0.020**	0.021**					
			(0.008)	(0.009)					
Openness w/o USA					-0.068***	-0.069***			
					(0.011)	(0.011)			
Open. w/o UEC							-0.010	0.013	-0.002
							(0.008)	(0.009)	(0.008)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes	No	Yes	Yes
Adjusted R2	0.918	0.925	0.916	0.927	0.916	0.924	0.919	0.928	0.946
Obs	1127	1127	1139	1139	1135	1135	1123	1123	1097

Robust standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 5: Openness by Country Robustness

	lFert.	lFert.	lFert.	lFert.	lFert.+5
ln(Mortality)	0.457***	0.456***	0.318***	0.419***	0.454***
	(0.026)	(0.025)	(0.025)	(0.022)	(0.026)
ln(GDPpc)	-0.035***	-0.309***	-0.022*	-0.032***	-0.029**
	(0.012)	(0.072)	(0.012)	(0.011)	(0.012)
log(gdppc)2		0.020***			
		(0.005)			
ln(Sec. Gross Enroll)	0.065***	0.072***	0.327***	0.320***	0.094***
	(0.014)	(0.013)	(0.024)	(0.021)	(0.015)
ln(Sec. Gross Enroll)2			-0.061***		
			(0.005)		
Openness w/ CHN	-0.002	0.001	-0.002	0.003	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Openness w/ EU	-0.068***	-0.071***	-0.062***	-0.065***	-0.059***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.009)
Openness w/ USA	0.009*	0.008*	0.014***	0.009**	0.012**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Open. w/o UEC	0.013	0.008	0.013	0.008	0.026***
	(0.009)	(0.009)	(0.008)	(0.008)	(0.010)
ln(Urban %)	0.006				
	(0.029)				
Inter EDU7 Urban %				-0.086***	
				(0.007)	
Inter EDU7 OPEN					-0.009***
					(0.003)
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adjusted R2	0.928	0.929	0.941	0.939	0.929
Obs	1123	1123	1123	1123	1123

Robust standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

In Table 6 we report fixed-effects with instrumental variables regressions where we disaggregate openness by countries. Trade openness with the European Union has negative and significant effects on fertility. Trade openness with the USA and China are essentially zero. Moreover, in the first-stage regressions (reported in the Appendix) our instruments are always positive and significant, which minimises the issue of weak instruments.

Table 6: IV Openness by Country - Openness Lagged

	lIV_CHN	lIV_EU	lIV_USA	lIV_All1	lIV_All2
ln(Mortality)	0.489***	0.451***	0.476***	0.457***	0.457***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
ln(GDPpc)	-0.038***	-0.039***	-0.040***	-0.030***	-0.033***
	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)
ln(Sec. Gross Enroll)	0.071***	0.060***	0.075***	0.074***	0.076***
	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)
Openness w/ CHN	-0.009			-0.006	-0.005
	(0.007)			(0.006)	(0.006)
Openness w/ EU		-0.088***		-0.088***	-0.086***
		(0.010)		(0.015)	(0.014)
Openness w/ USA			-0.001	0.009	0.010
			(0.006)	(0.007)	(0.007)
Openness w/o CHN	-0.041***				
	(0.013)				
Openness w/o EU		0.028***			
		(0.009)			
Openness w/o USA			-0.070***		
			(0.010)		
Open. w/o UEC				0.023**	0.015
				(0.009)	(0.014)
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adjusted R2	0.926	0.928	0.925	0.929	0.929
F	175.88	222.50	390.16	.	.
Obs	1111	1127	1120	1106	1106

Robust standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 7: IV Openness by Country - Openness Lagged 1 and 2 Periods

	lIV_CHN	lIV_EU	lIV_USA	lIV_All1	lIV_All2
ln(Mortality)	0.489***	0.452***	0.478***	0.455***	0.454***
	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)
ln(GDPpc)	-0.039***	-0.037***	-0.039***	-0.034***	-0.041***
	(0.012)	(0.011)	(0.012)	(0.012)	(0.013)
ln(Sec. Gross Enroll)	0.074***	0.063***	0.078***	0.072***	0.075***
	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)
Openness w/ CHN	-0.012*			-0.012*	-0.010
	(0.007)			(0.007)	(0.007)
Openness w/ EU		-0.090***		-0.088***	-0.083***
		(0.010)		(0.017)	(0.015)
Openness w/ USA			-0.001	0.009	0.010
			(0.006)	(0.007)	(0.006)
Openness w/o CHN	-0.036***				
	(0.012)				
Openness w/o EU		0.030***			
		(0.009)			
Openness w/o USA			-0.072***		
			(0.010)		
Open. w/o UEC				0.025**	0.008
				(0.010)	(0.015)
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adjusted R2	0.927	0.928	0.926	0.929	0.929
F	88.74	116.45	195.63	.	.
Jtest	.073	.114	.459	.205	.325
Obs	1090	1113	1105	1087	1087

Robust standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Thus, by disaggregating the data by different trade-openness categories and by countries our results suggest that Africa, although still a major exporter of agricultural products and raw materials, is in fact benefiting (by learning) from the technologies and knowledge embodied in manufactured goods coming into the continent, particularly from the European Union. This diffusion of knowledge and learning altogether create incentives for lower fertility and the interaction terms between education and all trade openness variables further illustrate this negative effect of openness on fertility.

Furthermore, on one hand, given that Galor and Mountford (2008) do not consider the possibility of

knowledge diffusion and learning in their model, our results suggest that the role of trade openness in Africa is slightly more nuanced than what their prediction suggests. In addition, our results contrast with Gries and Grundmann (2014), who suggest that countries which export low-skilled products, for instance, agricultural products, tend to have higher fertility in their panel. These differences in results perhaps highlight the importance of having more data (Galor and Mountford use data for the 1985-1990 period and Gries and Grundmann for the 1980-2005 period), of the data disaggregation that we do (Galor and Mountford admittedly do not disaggregate the data and Gries and Grundmann do not disaggregate by country) and of using a more appropriate method (although Gries and Grundmann use GMM-type estimators, they do not report any dynamic panel regression).

On the other hand, our results are in line with Coe and Helpman (1993), who argue that more open economies tend to benefit from foreign technologies (in terms of having higher productivity), and with Keller (2001) and Acharya and Keller (2008), who argue about the importance of international diffusion of technology and the learning process associated with it, in creating, in this case, incentives for lower fertility. Our results are also in line with Baldwin, Martin and Ottaviano (2001), who argue about the importance of reducing transferring costs of ideas and technologies from the developed North to the developing South so that the South starts the process of convergence, and with Do, Levchenko and Raddatz (2016), who argue that countries with more female-intensive industries tend to have lower fertility.

Given the importance of our confounders, they deserve some comments as well: the mortality estimates are always positive and significant on fertility (the replacement effect), and these positive estimates are in line with Gries and Grundmann (2014), Angeles (2010), and Conley, McCord and Sachs (2007). Compared to mortality, the role of income on fertility is somehow less clear cut, with mostly negative, but not always significant estimates. If anything, as it is, there is no evidence that Africa is Malthusian, and our estimates are in line with Angeles (2010) who does not report conclusive income estimates in his panel either. The role of education on fertility is not clear cut either (with most estimates being positive, but not wholly significant). If anything, the (positive) relationship between education and fertility illustrates the well known fact that initially (in the process of development) some education tends to generate greater fecundity and lower natural contraceptives, but after a threshold education starts having a negative effect on fertility, and our results are in line with Lehr (2009).

Overall our results suggest that a process of modernisation is taking place in Africa, with technologies coming into the continent followed by knowledge diffusion, learning and lower fertility rates. The significance of our results can not be overlooked: lower fertility, caused by knowledge diffusion and learning, implies more capital per worker, higher productivity and higher growth rates. Moreover, our results do not suggest that Africa "remain mired in a Malthusian crisis of high mortality, high fertility, and rapid population growth", Conley, McCord and Sachs (2007), but that Africa is actually transitioning from the Malthusian epoch into sustained growth. In any event, our results,

although not entirely related, are not far-off from Young (2012), who argues that sub-Saharan Africa have witnessed since the 1990s an increase in consumption of vital durables such as schooling, health and housing, nor from Pinkovskiy and Sala-i-Martin (2014) who state that "Africa is on time" in terms of achieving the Millennium Development Goal of reducing poverty.

About future work: given the known shortcomings of GMM-type estimators, Roodman (2009), we avoided using them here. However, if properly implemented, that is an approach which, given the dimension of our data and the dynamics of fertility, can be used in future versions of this paper. Also, the use of an external instrumental variable picking up propensity to trade, such as genetic distance, Spolaore and Wacziarg (2009), is something doable and would enrich our results.

To conclude, Galor and Moav (2002) argue that for sustained growth to take place a higher proportion of educated "quality type" people combined with technological progress must be in place when a (positive) shock, for instance, trade openness, takes place, so that failed takeoffs do not happen. And Nelson and Phelps (1966) argue that educated people are innovators and also adaptable to technological change, which reinforces the role of trade openness, technologies, knowledge, diffusion and learning on fertility for sustained development in a globalised world.

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4 Appendix

Table 8: African Countries

Algeria	Eritrea	Namibia
Angola	Ethiopia	Niger
Benin	Gabon	Nigeria
Botswana	Gambia	Rwanda
Burkina Faso	Ghana	Sao Tome and Principe
Burundi	Guinea	Senegal
Cabo Verde	Guinea-Bissau	Seychelles
Cameroon	Kenya	Sierra Leone
Central African Republic	Lesotho	South Africa
Chad	Libya	Sudan
Comoros	Madagascar	Swaziland
Congo, Dem. Rep.	Malawi	Tanzania
Congo, Rep.	Mali	Togo
Cote d'Ivoire	Mauritania	Tunisia
Djibouti	Mauritius	Uganda
Egypt, Arab Rep.	Morocco	Zambia
Equatorial Guinea	Mozambique	Zimbabwe

Table 9: European Countries

Austria	Greece	Poland
Belgium	Ireland	Portugal
Denmark	Italy	Spain
Finland	Luxemburg	Sweden
France	Germany	United Kingdom
Germany	Netherlands	Norway

Table 10: Colonizers

Belgium	Italy	United Kingdom
France	Portugal	
Germany	Spain	