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Trade and fertility in the developing world: the impact of trade and trade structure

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Abstract In the literature on trade and development, fertility and trade have been widely discussed as two separate economic forces. However, an important recent contribution connects these two and suggests that international trade between developed and developing countries has an asymmetric effect on the demand for human capital. The asymmetry leads to a decline in fertility rates in developed countries and an increase in these rates in developing countries. We provide additional comprehensive empirical evidence in support of this novel hypothesis. Our findings suggest that countries that export skill-intensive manufacturing goods experience a decline in fertility rates, whereas in countries that export primary, low-skill-intensive goods, fertility rates are affected positively. Further, our findings indicate that the negative influence of manufacturing exports on fertility holds primarily and most strongly for middle-income countries where structural modernization and a growing manufacturing-intensive export sector is observed.

Keywords International trade · Fertility · Panel analysis · Export sectors

1 Introduction

Both trade and fertility are important issues in the development economics debate. How does international trade affect a country's development? What are the causes

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and effects of fertility in the development process? An important recent contribution by Galor and Mountford (2008, 2006) proposes that these two factors, trade and population development, are interrelated. The authors suggest that international trade between developed and developing countries asymmetrically affects the demand for human capital in these countries. High trade-induced human capital demand in developed countries contributes to a decrease in fertility rates, while the opposite, i.e., a lack of human capital demand, leads to an increase in fertility rates in developing countries. In the tradition of unified growth theory (e.g., Galor et al. 2009; Galor and Weil 2000; McDermott 2002; Doepke 2004 or Galor 2011), they analyze both developing and developed countries and argue that world trade intensification asymmetrically affects the pace of demographic transition across countries. Naturally, demographic transition is characterized by an initial decline in mortality rates, followed by a corresponding decline in fertility rates.[1] However, as its onset and evolvement is neither a simultaneous nor a uniform process and its implications for income distributions are great, understanding it is vital. Accordingly, especially in the light of ongoing vast trade intensification (WTO 2006, 2011) over the past decades, it appears to be an important theory that connects trade and demographic development and contributes to an understanding of the immense differences in per capita incomes across countries.

In a stylized two-economy model, Galor and Mountford (2008) propose a mechanism that explains the current distribution of the world population and the "Great Divergence" in income per capita across countries. While the controversy about the divergence in income levels and its explanations[2] include differences in institutions, geographic locations, human capital formation, and colonialism, their proposition rests on the role of international trade and increasing globalization patterns.[3] In brief, they propose that international trade affects economies differently due to their different trade composition. While in industrialized economies, the gains from trade will be directed toward investment in human capital formation, and in developing economies, they will be directed toward population growth. Specifically, they assume different levels of technology within an agrarian and a manufacturing sector. These sectors differ in relevance and size in industrialized and developing economies. While industrialized economies rely on strong technology-intensive sectors, developing countries rely on the opposite, which are less skill- but more labor-intensive sectors. Resting on the presumptions of comparative advantage, international trade

[1] For a detailed account of the demographic transition, theory, and trends, see recently, e.g., Galor (2012), or earlier, Bloom et al. (2003), or Lee (2003). See Strulik and Vollmer (2013) for an evolutinary account of cross-country fertility dispersion.

[2] Galor and Mountford (2008) provide a brief overview of the most important papers in the respective areas.

[3] Other theoretical contributions that connect world trade with fertility decisions are Lehmijoki and Palokangas (2009) and Sauré and Zoabi (2011). While the former focus on wage and income effects induced by international trade, the latter concentrate on the development of female labor force participation in connection with international trade and the resulting fertility and growth effects.

deepens developed countries' specialization in skill-intensive, industrial, and technologically advanced goods, while countries that focus on less skill-intensive and more labor-intensive goods specialize in those sectors. The result is that gains from trade are channeled into the demand for human capital in developed economies, while in developing economies, the demand for unskilled labor could rise. This leads to a gradual investment in the quality of the labor force in the former group of countries, while the latter group may invest more in increasing the size of the labor force. Now from a household's point of view, this means that in an industrialized, skill-intensive economy, there is an incentive to have smaller families and provide one's children with better education. Parents optimize their own consumption and the potential income of their offspring. Naturally, skilled workers have greater income potential. Assuming that it is more resource intensive for parents to raise skilled than unskilled offspring, they decide on the number of children and the amount of time they want to devote to raising them. This is essentially a decision on whether to raise skilled or unskilled children. As raising skilled children requires more time and money, they will restrict themselves to having fewer children. However, if there is demand for human capital, these children later have a greater potential income (a significant return on human capital) which is an incentive for parents to invest in their children's education. From the macro perspective, this is an aspect of demographic transition, namely a decline in fertility rates. According to theory, in an economy with intensive use of unskilled labor, this driver of demographic transition is absent, which leads first to a divergence in countries' fertility levels and eventually to a divergence of per capita income levels. All in all, we learn from the model that the structure of the export sector is significant in determining the impact of international trade on fertility (and income). If the theory holds, one could ask whether the development of advanced economies adversely affects the development of less-developed countries (Galor and Mountford 2008), the answer to which contributes a more nuanced aspect to the debate on whether trade encourages income growth.

Galor and Mountford (2008) also provide empirical evidence for the proposed relationship. In a conventional cross-country sample of 132 countries, fertility is regressed upon trade openness, while in another sample of 97 countries, the average years of schooling are regressed on openness. The chosen period is 1985 to 1990. Since theory requires a division of the sample according to the factor content of trade (human capital intensive vs. unskilled labor intensive), the sample is split into OECD and non-OECD countries, assuming that the former export on average more human capital intensive goods. The results support the hypothesis. The trade share in GDP affects the average fertility rate negatively in OECD countries, i.e., countries with an assumed high share of human capital intensive goods in their exports. The opposite holds true for non-OECD countries. The authors also find a negative effect of the trade share on education in non-OECD countries but a positive effect in OECD countries. Finally, the results are strengthened by the use of the Frankel-Romer instrumentation (Frankel and Romer 1999) for trade share in GDP.

While the empirical section nicely underlines the broad mechanism developed in the theory, the specification leaves room for a more in-depth analysis. The main point is whether the proposition holds in richer specified empirical fertility models. By incorporating additional regressors and employing opulent specifications, we strengthen the link between the theory and this strand of population literature and make the proposition comparable with existing fertility estimations. For instance, the inclusion of education as a determinant of fertility is particularly important (e.g., Becker et al. 2010 or Azarnert 2008), as is accounting for the relationship between fertility and female labor force participation (e.g., Bloom et al. 2009; Galor and Weil 1996 or Mishra and Smith 2010). Further, we expand the empirical knowledge by dividing the panel into subpanels of different income levels. This enables us to provide more evidence for the interaction channel that possibly varies in intensity. From an econometric point of view, we also expand the analysis along the following lines. First, instead of relying on one trade indicator (trade share in GDP) and to differentiate between factor contents by splitting the sample in OECD vs. non-OECD, we use two trade indicators in two sectors. Our assumption is that on average, the human capital content in manufactures is higher than in primary exports.[4] Also, we use this trade indicator in per capita terms in order to relate it more directly to fertility decisions. Second, and in line with the literature, we assume fertility decisions to be affected also by factors such as culture or religion. Thus, to control for such unobserved heterogeneity at the country level, we expand the analysis to include a panel setting. Third, the use of a system generalized method of moments (GMM) estimator enables us to account for potential endogeneity problems that are inherent in many conventional (cross-country) regressions. The use of the estimator is especially important as fertility regressions are reknown for complicated cause and effect situations, as noted by Schultz (2007), for example.

We are primarily interested in exploring whether international trade impacts on fertility decisions across countries. The implications of a positive finding would be a long run change in a country's comparative advantages, population development, and also growth patterns as predicted by GM. However, as we do not directly test the relationship between trade and growth, we do not elaborate on this vast literature.[5]

Our empirical findings generally support the theory. They show that (i) international trade affects fertility significantly, especially in less-developed countries, and (ii) the type of exports (i.e., their skill intensity) is particularly important for the direction of impact on fertility. In our analysis, we find evidence that while manufacturing exports affect fertility negatively, primary exports affect fertility positively.

[4] As Galor and Mountford (2008) note, there is little authoritative data on the factor content of trade. Even though there may be sections of the manufacturing sector that operate with very little human capital intensity and parts of the primary sector that operate with a high degree of human capital, we would expect our results to be further strengthened if we had more differentiated data.

[5] A good literature overview and a critical account of related problematic issues can be found in, e.g., Winters (2004).

The remainder of this paper is structured as follows. We introduce our data and methodology in detail in the next section and continue with the estimation results. The last section summarizes our major findings and concludes the paper.

2 Empirical analysis

The goal of this section is to determine the effects of different export sectors on fertility. Based on the theoretical model, we expect high-skill industrial exports to impact differently on fertility than low-skill industrial or primary exports. Our estimation strategy involves using a panel, today a common practice in cross-country empirical estimations. Further, we divide our sample into subsamples and use different estimators for a robustness analysis. The main part of our analysis circles around a panel estimation with the GMM system estimator which has several advantages but so far has not frequently been applied to fertility estimations.

We propose a straightforward panel regression model in which we regress a fertility proxy on trade measures with a capable GMM estimator. Because the estimator needs to be used with caution (Roodman 2009), we provide more details on its application and strength below. In the estimation, we control for other potential impacts on fertility as drawn from the existing fertility literature. Using five databases (World Development Indicators, Comtrade, Child Mortality Database, Penn World Tables, and Barro and Lee's dataset on educational attainment), we create a panel of around 100 countries (N) and 38 years (T) between 1970 and 2007. We limit our complete sample to this time frame and country choice since for many countries, there is not enough data for the period before 1970 to create a reliable dataset. Depending on the specification, we alter the panel and, as in our main analysis, create a balanced panel of five 5-year averages. However, we provide precise information about the number of countries and observations for each individual estimation in the tables and indicate a sample change to yearly data in the robustness analysis section.

Model and methodology The balanced panel that is analyzed in the main section consists of 68 countries and includes five nonoverlapping 5-year periods from 1980 to 2005. The limitation in observations stems from data availability. In the robustness section, we allow for unbalanced panels and estimate with more observations. According to our goal of estimating the effect of export sectors on fertility, we estimate the model:

$$F_{it} = \alpha + \beta T_{it} + \gamma X_{it} + \xi_t + \eta_i + \varepsilon_{it} \tag{1}$$

where the subscripts i and t denote country and time. F is our measure of fertility, T are two trade variables of interest, and X is a set of control variables. We include both time- and country-specific unobserved effects, ξ and η. For the time effect, we allow for a linear trend to pick up on the general trend of declining fertility and to retrieve results relative to this trend. α is a common intercept and ε is an i.i.d. error term. The inclusion of a country-specific effect guarantees that country-specific time-invariant characteristics are modeled properly. In the context of fertility, this seems relevant as, for example, cultural differences may affect fertility rates. However, the inclusion of η produces estimation problems for the conventional OLS cross section estimator. For consistency, the country-specific effects would have to be orthogonal to other regressors (Caselli et al. 1996). We cannot rule this out from a theoretical perspective. Consistent estimators thus start by eliminating the country-specific term by either taking deviations from period averages (fixed-effects estimator) or by using period averages right away (between estimators) (DeJong and Ripoll 2006). This strategy deals successfully with estimation inconsistencies resulting from non-orthogonality between regressors and country-specific effects, but as Caselli et al. (1996) note, inconsistencies remain unless all regressors are strictly exogenous. In our case this is especially important to note, as some of our control variables (e.g., female labor force participation) are a potential source of this endogeneity bias.

To cope with both problems, we use the system GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998). The system GMM estimator is similar to the difference GMM estimator proposed by Arellano and Bond (1991). Both estimators use a differenced version

$$F_{it} - F_{i(t-1)} = \beta(T_{it} - T_{i(t-1)}) + \gamma(X_{it} - X_{i(t-1)}) + (\xi_t - \xi_{(t-1)}) + (\eta_i - \eta_i) + (\varepsilon_{it} - \varepsilon_{i(t-1)}) \quad (2)$$

of Eq. (1) to eliminate the country fixed effect η_i. Endogeneity concerns are countered with within-instruments, i.e., the use of lagged level data as instruments in the differenced equation (Eq. 2) (the difference estimator) or the use of first differences as instruments in the level equation (Eq. 1), which is part of the system estimator. In the presentation of our main results, we focus on the system GMM estimator[6] since the difference estimator is said to have shortcomings. Easterly and Levine (2001) specifically note that the lagged levels of persistent regressors may prove to be weak instruments that could bias the estimation. Also, the use of differences alone leaves information about the level relationship unused (DeJong and Ripoll 2006) and further reduces the time dimension of the sample.

Even though the GMM system estimator appears to control for many caveats in panel data estimation, it rests on critical assumptions. Therefore, we follow Roodman (2006) and report among regression coefficients and sample-size important test statistics to validate the identifying assumptions. The first is the Hansen-J test for overidentification (Hansen 1982). The null hypothesis of instrument exogeneity should not be rejected. The Hansen-J test may be weakened by instrument proliferation (Roodman 2009), thus we limit the number of instruments and report their count. Further, we report the m_1- and m_2- tests for autocorrelation in the differenced errors $(\varepsilon_{it} - \varepsilon_{i(t-1)})$ after Arellano and Bond (1991). The presence of second-order serial correlation may mean that some lags are invalid instruments. Therefore, we should not reject the null of no serial correlation in the m_2- test. To deal with heteroscedasticity and arbitrary correlation patterns within countries, we use the two-step estimator and the finite-sample Windmeijer correction.

[6]Estimations with the difference estimator do not qualitatively alter our key findings.

To obtain generally valid results, we run several specifications with differing sets of control variables, ensuring that we proceed in accordance with the fertility literature. A core proposition of the theory by Galor and Mountford is the differential effect of trade on fertility. This effect is primarily modeled by using two different trade variables.

In an extension, we make robustness checks and exchange our estimator for an even more common fixed-effects estimator. Even though we cannot control for endogeneity (but can leave out the most critical variable, female labor force participation), we are still capable of controlling a bias resulting from unobserved heterogeneity (e.g., the abovementioned cultural differences across countries). Also, our chosen generalized least squares (GLS) estimator is capable of correcting serial correlation problems and groupwise heteroscedasticity.[7] However, most importantly, it performs well in an unbalanced panel so we can return to a yearly panel with more variation and more countries. The panel dimensions almost double in terms of the number of countries and increase seven times in terms of t. We estimate the same model as in Eq. (1). Increasing the sample size also allows us to split the panel and estimate the model in different income groups without reducing the subsamples to a small number of observations. This will provide an impression of how well behaved the proposition of impact is across income groups.[8]

Data and variables

Dependent Variable We estimate *fertility* with the total fertility rate (TFR). The TFR is a composite measure containing all age-specific fertility rates. Therefore, it comprises the number of children an imaginary woman would give birth to if she were to move fast-forward through her life (and her childbearing years). The great advantage of this is that the TFR is not influenced by age composition. The indicator is taken from the World Bank's development indicators (WDI) and lets us focus directly on reproductive behavior. Since the theory states that trade impacts on fertility levels, we use this indicator in levels. For a more detailed description and potential drawbacks of the TFR, see, e.g., Weil (2005).

Independent variable Trade variables are (a) *manufacturing exports per capita* and (b) *primary exports per capita.* Using exports per capita seem more appropriate than using trade shares or a structure-indicating ratio since exports per capita cover potential effects for an average person and hence point more directly toward the fertility decision of an household. We include both variables in one regression to identify an differential effect.[9] Primary exports per capita refers to the value of exports (to

[7] A test after Greene (2003) indicates heteroscedasticity within groups. Our test for serial correlation (after Wooldridge 2002) also rejects the null hypothesis of no serial correlation.

[8] We follow the World Bank's income groups classification: high-income countries, upper middle-income countries, lower middle-income countries, low-income countries with 2009 GNI per capita of more than US$12,195, US$3,946-US$12,195, US$996–US$3, 945 and less than US$996, respectively.

[9] Tests with separate estimations for both variables do not alter our findings.

the world) in categories 0–4 according to standard international trade classifications (SITC) divided by population. Manufacturing exports per capita refers to the values of exports (to the world) in SITC categories 5–8, also divided by total population. Data on trade statistics is drawn from the trade division of the United Nations (Comtrade 2011), while data on population figures is drawn from the Penn World Tables (Heston et al. 2011). The variable is used in levels to approximate the demand for human capital according to the theory. Exports per capita are stated in current US dollars.

Control variables *GDP per capita*, the first control variable, is our proxy for income. The role of income as a determinant of fertility is not straightforward and the subject of a long-standing debate.[10] The impact of income on fertility strongly rises and falls depending on whether children are perceived as a productive asset or a consumption good (Drèze and Murthi 2001). If children are regarded as a consumption good, the focus is on costs and the quality-quantity trade-off. This means that rising income makes children more affordable, hence we have a positive relationship. At the same time, one may observe that when parents' income increases, their opportunity costs rise as well, showing a possible negative effect. Alternatively, if parents substitute quality for quantity, the effect would also be negative. Particularly in developing countries, children are more likely to be regarded as a productive asset, i.e., an inexpensive source of additional labor and old-age security. What may further confuse the relationship is the type of (additional) income. While wage increases raise opportunity costs, an increase in productive assets, e.g., land, could raise demand for children (Drèze and Murthi 2001). Due to these complications, we do not expect a particular sign for this control variable. Our data source is the Penn World Tables Heston et al. (2011), while GDP per capita is used in levels to account for the mentioned possible interactions. It is stated in constant 2005 US dollars.

We also control for *infant mortality* as it directly affects fertility decisions.[11] To obtain a desired family size in the presence of rising child mortality, parents are forced to have more children. We therefore expect a strong positive relationship between infant mortality and fertility. It is suggested that especially in developing countries, infant mortality may not be exogenous to fertility. Due to hygiene and health issues, high fertility can lead to higher child mortality (Drèze and Murthi 2001). We will account for this by using instruments. The data is taken from the CME Info portal, a UN interagency group (Unicef, UN Population Division, World Bank, WHO) that produces child mortality estimates (CME 2010). Further, general mortality is also said to influence fertility decisions (e.g., Angeles 2010); however, general mortality correlates strongly with child mortality and is thus not included separately.

We also control for *female labor force participation* in our analysis. Especially, if women are mainly occupied with child rearing, their participation in the labor

[10] As early as 1798, Malthus proposed that income increases above subsistence levels are capable of spurring population growth (Malthus 1798).

[11] See, e.g., Doepke (2005) on the relationship between fertility and child mortality in the Becker-type quantity-quality model.

force affects the number of children they have. However, in less-developed agricultural economies, family duties and labor participation may be more easily combined than in middle-income, more industrialized societies. We therefore do not expect a uniform impact. Further, it is generally acknowledged that female labor force participation can lead to an endogeneity problem, as fertility can also be a determinant of labor force participation (Bloom et al. 2009). We use data from the World Development Indicators (World Bank 2011) that is stated as the ratio of economically active women to the total number of women aged 15 and older. "Economically active" means that they participate in the production of goods and services.

Female education The role of education is said to have different effects on fertility. Higher education can lead to higher income and thus increase the opportunity costs of having children. It may also be the case that more educated women, especially in developing countries, leave the agrarian sector and bear fewer children. Female education is also said to affect a woman's ability to have the desired number of children (see, e.g., Kim 2010). We also control for education since Galor and Mountford's conclusion that trade in industrial goods induces investments in human capital can be interpreted in two ways. The first is the modeled channel of induced investments in one's offspring's education, while the second is investment in one's own education. By including female education, we control for the second effect. The level of education is approximated by the average years of schooling, with data taken from Barro and Lee (2013). The original data is provided in the shape of 5-year averages. To obtain the yearly time series for the robustness estimations, we interpolate between the values because the series seem to follow strong trends and do not vary greatly.

Urbanization In the analysis, urbanization can impact fertility decisions because in urban settings children are less likely to be seen as a productive asset. Also, children are more difficult to supervise in urban environments (Drèze and Murthi 2001). Finally, a rapid spread of modern social norms is attributed to urban settings. We use data from the World Development Indicators on the share of population living in urban areas (World Bank 2011). We also interpolate the original 5-year averages to obtain yearly time series that we use in the robustness section for the same reasons as our education variable.

In the main analysis, we use half-decade averages data from 1980 to 2005. Even though it causes us to lose information, we create this balanced panel as it is preferably used by our estimator. Summary statistics are given in Table 3 (appendix) for both the main (averaged) panel and the robustness/extension panel with yearly data from 1970 to 2008. Detailed information on data and its source is given in the appendix (Table 4).

3 Estimation results

Table 1 shows the estimation results for the complete sample of all 68 countries in the balanced panel. The columns present the estimations of different model specifications. On the left-hand side, we start with less detailed specifications and increase the

Table 1 Trade and fertility (main sample — GMM estimates)

Dependent: TFR	(1)	(2)	(3)	(4)	(5)
All countries					
Man. exp. p.c.	−0.145***	−0.090***	−0.093***	−0.092***	−0.095**
	(0.022)	(0.027)	(0.024)	(0.036)	(0.040)
Prim. exp. p.c.	0.061***	0.070***	0.062***	0.067***	0.063*
	(0.022)	(0.019)	(0.020)	(0.033)	(0.033)
Infant mortality		0.168**	0.145**	0.288***	0.304***
		(0.072)	(0.067)	(0.080)	(0.097)
GDP per capita				0.101	0.129
				(0.121)	(0.145)
Female schooling	−0.359***	−0.344***	−0.324***	−0.250**	−0.248**
	(0.131)	(0.093)	(0.089)	(0.100)	(0.108)
Female labor force participation	−0.011	0.008	−0.014	−0.013	−0.006
	(0.196)	(0.144)	(0.130)	(0.150)	(0.155)
Urbanization				0.033	0.022
				(0.063)	(0.074)
Time trend	Yes	No	Yes	No	Yes
Observations	338	338	338	337	337
Countries	68	68	68	68	68
Hansen (*p* value)	0.72	0.25	0.32	0.15	0.13
Instrument count	10	40	41	43	44
AR(1) (*p* value)	0.01	0.00	0.00	0.00	0.00
AR(2) (*p* value)	0.40	0.21	0.20	0.14	0.15
High-income countries (groups 1 and 2)					
Man. exp. p.c.	−0.083**	−0.076	−0.086	−0.057*	−0.061*
	(0.035)	(0.072)	(0.056)	(0.030)	(0.033)
Prim. exp. p.c.	0.095***	0.098*	0.098**	0.041	0.038
	(0.035)	(0.053)	(0.041)	(0.033)	(0.026)
Infant mortality		−0.017	0.001	0.291**	0.264**
		(0.143)	(0.165)	(0.121)	(0.129)
GDP per capita				0.321*	0.372**
				(0.175)	(0.162)
Female schooling	−0.509	−0.895**	−0.415	−0.208	−0.082
	(0.333)	(0.410)	(0.439)	(0.520)	(0.573)
Female labor force participation	−0.024	−0.052	−0.120	0.010	−0.085
	(0.232)	(0.221)	(0.265)	(0.257)	(0.295)
Urbanization				0.123	0.092
				(0.085)	(0.122)
Time trend	Yes	No	Yes	No	Yes
Observations	164	164	164	163	163

Table 1 (continued)

Dependent: TFR	(1)	(2)	(3)	(4)	(5)
Countries	33	33	33	33	33
Hansen (*p* value)	0.23	0.44	0.12	0.22	0.17
Instrument count	22	24	25	30	30
AR(1) (*p* value)	0.18	0.47	0.28	0.03	0.03
AR(2) (*p* value)	0.42	0.41	0.48	0.12	0.14
Lower-income countries (groups 3, 4, and 5)					
Man. exp. p.c.	−0.066**	−0.059**	−0.046*	0.013	0.034
	(0.031)	(0.029)	(0.026)	(0.036)	(0.036)
Prim. exp. p.c.	0.039	0.113***	0.074**	0.178***	0.135***
	(0.033)	(0.039)	(0.031)	(0.038)	(0.038)
Infant mortality		0.445***	0.367***	0.496***	0.310**
		(0.117)	(0.118)	(0.119)	(0.121)
GDP per capita				−0.266**	−0.427***
				(0.135)	(0.162)
Female schooling	−0.317***	−0.053	0.025	−0.014	−0.105
	(0.103)	(0.173)	(0.168)	(0.227)	(0.166)
Female labor force participation	−0.188	−0.269**	0.017	−0.160	0.013
	(0.148)	(0.127)	(0.220)	(0.125)	(0.149)
Urbanization				0.005	0.174
				(0.130)	(0.115)
Time trend	Yes	No	Yes	No	Yes
Observations	174	174	174	174	174
Countries	35	35	35	35	35
Hansen (*p* value)	0.31	0.29	0.25	0.21	0.50
Instrument count	16	18	17	25	25
AR(1) (*p* value)	0.02	0.04	0.03	0.03	0.01
AR(2) (*p* value)	0.45	0.47	0.92	0.82	0.52

Notes: Dependent variable in all models is the total fertility rate (TFR). All variables are used in natural logarithms. Windmeijer corrected S.E.s in parentheses. All models are estimated with a constant. Sample range is 1980–2005 in 5-year averaged nonoverlapping periods

*$p = 0.10$; **$p = 0.05$; ***$p = 0.01$ (denote significance)

level of specification (in accordance with existing fertility studies) toward the right. Throughout all estimations, we control for country-specific effects (e.g., religion or culture) and in most cases also for a linear time trend. The latter is supposed to control for a general trend of declining fertility and to enable us to make statements about impacting factors relative to this trend. We are mainly interested in the behavior of the two export sector variables, manufacturing (man. exp. p.c.) and primary (prim. exp.

p.c.) exports per capita. Looking at the complete sample of all income groups, we find a negative and significant impact of manufacturing exports on fertility, while primary exports per capita exert a positive significant impact on fertility. This finding provides empirical evidence for a differential effect of different trade sectors on fertility. The hypothesis from Galor and Mountford (and their theoretical model) is supported. A growing manufacturing export sector seems to impact on the average household fertility decision. According to the theory, the availability of jobs in the manufacturing export sector increases demand for education and in turn, lowers fertility. Also, looking at the control variables, we find many of the expected signs, the majority of which are significant. We see a nonsignificant positive impact of income on fertility. Given the debate, we would have expected it to be at least negative. However, it may be the case that since the majority of countries are in the developing group, the theory favoring this direction of impact is supported. As acknowledged in the literature, child mortality appears to be positively (and throughout, significantly) related to fertility. Another strong negative relationship is established for female schooling, while female labor force participation is, as expected, negatively related to fertility, however not significantly.

The two panels in the middle and at the bottom divide the complete sample into high-income (middle) and middle- and low-income countries (bottom). Of the initial 68 countries, 33 are in the World Bank's income categories 1 (high income) and 2 (high-income non-OECD), while the remaining 35 are in categories 3 (upper middle income), 4 (lower middle income), and 5 (low income).

The two subsamples differ slightly in their similarity to the overall results. First, even though its still negative, the effect of manufacturing exports on fertility is losing magnitude and significance in the high-income sample. Further, the positive effect of primary exports is present and significant in three models ((1)–(3)). However, looking at the test statistics, we clearly see that we should not rely confidently on these results. None of the three models show the expected autocorrelation pattern. We thus conclude that the effect for high-income countries is far less pronounced. Using the model's terminology, the parents' assessment of the payoff associated with their children's education does not include a higher payoff if they find employment in the manufacturing export sector. A possible explanation for the missing effect on the average household fertility decision is that the manufacturing sector in high-income countries does not necessarily call for additional schooling over and above the already high educational attainment of workers. This seems plausible because the general level of education in developed countries is sufficient for producing large shares of their manufacturing exports. Further, the "quality versus quantity" decision with respect to children does not have as significant an impact on household's income as in less-developed economies. In high-income countries, social conditions and job opportunities for women may point more toward the trade-off between labor market participation of women and the number of children than toward the trade-off between the number of children and education quality.

Second, in middle- and low-income countries (bottom panel), the situation appears different. On the one hand, the impact of manufacturing exports on fertility is still (mostly) negative; however, it loses some significance. On the other hand, we obtain a fairly strong indication of a positive impact of primary exports on fertility. This supports Galor and Mountford's hypothesis[12] who predict that due to a limited incentive to invest in children's education in the primary sector, fertility levels are positively affected. The lack of skill intensity necessary for primary exports and consequently little human capital demand therefore does not induce a demographic change as the more skill-intensive manufacturing exports sector does. The finding that primary exports tend to positively affect fertility levels in lower-income countries is consistent with the conclusion of Weil and Wilde (2009), who argue that economic development in countries that depend heavily on agricultural production suffer from high population growth. Further, we observe that the direction of impact of our control variables does not change substantially over the subsamples, which lends credibility to the estimations.

Robustness and extension The two subsamples described above indicate that the mechanism is more valid in developing economies. Therefore, to obtain an even more differentiated view for developing countries, we proceed by running further sets of estimations for additional subsamples. Since dividing the sample used in the main analysis further would reduce the individual sample size to as few as 20 observations, we now use the complete sample with yearly data to obtain sufficient observations. In the now unbalanced panel, we use a GLS estimator and still control for time and country effects. Table 2 gives the estimation results. The panels from top to bottom are for income groups 3, 4, and 5, respectively.

Interestingly, we do not see the same negative impact of manufacturing exports across the subsamples. While in most higher and lower middle-income countries (top and middle panel) manufacturing exports negatively affect fertility, the subsample for low-income countries fails to show a single significant estimate. A possible explanation is that modern structures are too weakly developed and the role of manufacturing exports is marginal and unable to affect average fertility. Turning to the effect of primary exports on fertility, we find the strongest and positive impact in the group of least-developed countries and in four of our five models, even a significant impact. Even though the impact is positive in the panels for income groups 3 and 4, it is not significant in all cases. Besides these differentiated observations, our split into subsamples further establishes the existence of a differential effect of manufacturing and primary exports on fertility levels.

In addition to our findings on the impact of trade in manufacturing and primary products on fertility in high-, middle, and low-income countries, it is worth pointing out some of the results for the control variables. *Child mortality*, generally acknowledged as one of the main determinants of fertility, is — as expected — positively related to fertility, which is consistent with Doces (2011), Jeon and Shields (2005), Lehmijoki and Palokangas (2009), and Galor and Mountford (2008). In Table 2, we see that the impact is bigger in lower-income than in high-income countries. This result is further refined in Table 2 where the strength of impact varies

[12] In the empirical section of Galor and Mountford's paper, this impact is not explicitly tested. However, the authors detect a positive influence of the general indicator "trade/GDP" on fertility in non-OECD countries. Under the assumption that non-OECD countries trade mostly in little skill-intensive (primary) goods, this implicitly supports their theory.

Table 2 Trade and fertility (middle- and low-income countries - fixed-effects estimates)

Dependent: TFR	(1)	(2)	(3)	(4)	(5)
Higher middle income (group 3)					
Man. exp. p.c.	−0.004**	−0.005**	−0.004**	−0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Prim. exp. p.c.	0.005*	0.006*	0.007**	0.006**	0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Infant mortality		0.046***	0.035**	0.034**	0.042***
		(0.018)	(0.018)	(0.016)	(0.016)
GDP per capita		0.036***			0.040***
		(0.010)			(0.011)
Female schooling				−0.280***	−0.259***
				(0.021)	(0.023)
Urbanization					−0.084
					(0.057)
Time trend (t)	−0.023***	−0.022***	−0.022***	−0.015***	−0.015***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	657	654	654	603	603
Countries (n)	22	22	22	19	19
Years (t)	38	38	38	38	38
Lower middle income (group 4)					
Man. exp. p.c.	−0.002*	−0.002*	−0.002*	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Prim. exp. p.c.	0.003*	0.002	0.003	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Infant mortality		0.214***	0.214***	0.203***	0.186***
		(0.014)	(0.014)	(0.013)	(0.013)
GDP per capita		0.002			0.002
		(0.007)			(0.006)
Female schooling				0.092***	0.091***
				(0.012)	(0.011)
Urbanization					0.059**
					(0.024)
Time trend (t)	−0.019***	−0.013***	−0.013***	−0.017***	−0.018***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Observations	845	842	842	810	810
Countries (n)	28	28	28	26	26
Years (t)	38	38	38	38	38
Low income (group 5)					
Man. exp. p.c.	−0.001	−0.001	−0.001	0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)

Table 2 (continued)

Dependent: TFR	(1)	(2)	(3)	(4)	(5)
Prim. exp. p.c.	0.006**	0.005	0.006**	0.008**	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Infant mortality		0.279***	0.270***	0.180***	0.438***
		(0.032)	(0.031)	(0.033)	(0.050)
GDP per capita		0.024**			0.028**
		(0.011)			(0.014)
Female schooling				0.206***	0.147***
				(0.015)	(0.017)
Urbanization					0.322***
					(0.040)
Time trend (t)	−0.007***	−0.002***	−0.002***	−0.015***	−0.013***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Observations	354	354	354	272	272
Countries (n)	15	15	15	12	12
Years (t)	35	35	35	35	35

Notes: Dependent variable in all models is the total fertility rate (TFR). All variables are used in natural logarithms. Heteroscedasticity and serial correlation robust S.E.s in parentheses. Sample range is 1970 – 2007 with yearly intervals.

*$p = 0.10$; **$p = 0.05$; ***$p = 0.01$ (denote significance)

considerably. While in least-developed countries the effect is strong, it decreases as the development level rises, with a very small impact in income group 3 (top panel of Table 2). Intuitively, this is explained by lower child mortality in more developed countries. This robust relationship yields an important result for policy making. If birth rates are to be brought down in low-income countries, lowering child mortality is an important target. *Female education* also shows the expected sign across most estimations in Table 1. There is a clear negative relationship between female education and fertility, a finding consistent with Becker et al. (2010) and Osili and Long (2008), for example. The *labor force participation rate of women* also affects fertility negatively, a result in line with existing empirical evidence (Pampel 1993 or Jeon and Shields 2005). However, our estimations are not significant. We have left out this particular variable in our estimations for income groups 3 to 5 due to clear endogeneity problems that are not addressed by the GLS estimator, so no further statements can be retrieved. The presence of insignificant results makes sense because there are differences in opportunities for economically active women to raise children. A factory worker will find it more difficult to take care of children than a woman working on a rural family-owned field, even though both women would count as economically active. We also control for *per capita income*. The effect of income on fertility (or population growth) is discussed extensively in the literature.[13] However, there

[13] For a comprehensive review see, e.g., Kelley (1988).

are still supporters of a negative impact of income on fertility as well as supporters of the contrary, namely, a positive impact of income on population growth. Our coefficient estimates reflect this controversy. We find both positive and negative relationships which can, however, indicate opposing underlying effects. Interestingly, in the estimations for income groups 3 to 5, we see a positive relationship in the top and bottom income groups. That is, in higher-income and low-income countries, GDP per capita increases fertility levels, while in between (group 4), we witness a less strong relation (small insignificant coefficient). A commonly hypothesized u-shaped relationship may be present that possibly depends on the substitution and income effect of children (Weil 2005).

To validate our estimations further, we reestimate Table 1 using the extended yearly dataset and the GLS estimator. The reestimation results are given in the appendix in Table 5. The full sample consists of around 100 countries and 38 years. We have around 3,000 observations for the complete sample of all countries and 1,200 and 1,800 for the high-income and lower-income subsamples, respectively. All estimations support our main finding of the differential effect that manufacturing exports and primary exports exert on fertility. However, it is most visible in the lower-income sample (bottom panel). We find significant negative effects of manufacturing exports and significant positive effects of primary exports. The consistent positive impact of child mortality and its clear difference in magnitude between higher- and lower-income countries further strengthen the estimation.

4 Conclusion

Our contribution provides supporting empirical evidence for the hypothesis of Galor and Mountford (2008) that the international trade among developing and developed countries induces an asymmetry in their demand for human capital, to which fertility rates react. While they increase in developing countries, they decrease in developed countries. This is the case because skill intensity in the trading sectors differs and if it is beneficial to invest in human capital, fertility is driven down.

This contribution expands the existing empirical evidence given by Galor and Mountford in various ways. First, we directly address different export sectors as determinants of fertility and use exports per capita in two distinct sectors, primary exports and manufacturing exports. Second, we expand the analysis to include a panel setting and to control for unobserved characteristics that are certainly important for fertility estimations. Third, we include the most frequently suggested determinants of fertility as controls to make this study more comparable to existing fertility literature. Lastly, by using subsamples, we can also point out different effects at different development levels. Our panel regression contains half-decade averages over the period 1980 to 2005 and covers around 70 countries.

In support of the theory of Galor and Mountford (2008), we find that manufacturing exports lower fertility levels, while primary exports have either a positive impact or none at all. We find that this relation holds especially in developing countries, where education levels are generally lower. However, this effect is not present in the group of least-developed countries. Our findings support the general proposition of the work of Galor and Mountford (2008) that trade is a driver of demographic transition and a possible explanation for the great divergence in income levels across countries.

High fertility levels are often regarded as harmful to development. A recent survey by the United Nations (2011) World Fertility Policies 2011 has found that many governments regard their fertility levels with concern. Hence, besides lowering infant mortality as our estimates also show that global trade integration can support the goal of lowering fertility levels in countries which export primarily skill-intensive manufacturing goods. However, as this also works in the other direction, countries whose exports consist of little skill-intensive (primary) goods may face an aggregation of problems associated with high fertility levels. Further, a strategy of export-led growth via skill-intensive manufactures may provide additional benefits by lowering fertility rates and thus impacting on the demographic transition that can later pay off in the shape of a demographic dividend.

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Appendix

Table 3 Summary statistics

	Mean	Std. Dev.	Min.	Max.	*N*	*n*
Variable (main sample 1980–2005)						
Fertility	2.81	1.40	1.08	7.34	340	68
Manufacturing exports per capita (US$)	1, 841.63	3, 722.65	2.39	32, 676.04	340	68
Primary exports per capita (US$)	824.60	1, 491.52	3.00	11, 537.62	338	68
GDP per capita (US$)	13, 576.37	10, 446.71	878.83	43, 388.80	340	68
Infant mortality	28.71	27.99	2.36	142.68	340	68
Female labor force participation	44.85	14.59	11.82	84.52	340	68
Female schooling (years)	7.32	2.63	1.30	12.73	340	68
Urbanization	60.97	22.05	8.50	100.00	339	68
Variable (robustness/extension sample 1970–2007)						
Fertility	3.83	1.90	1.08	8.08	3, 958	104
Manufacturing exports per capita (US$)	1, 242.53	3, 324.64	0.03	50, 856.73	3, 429	104
Primary exports per capita (US$)	873.48	2, 393.12	1.64	46, 256.85	3, 255	103
GDP per capita (US$)	11, 438.89	12, 506.59	561.55	111, 730.40	3, 951	104
Infant mortality	46.59	40.89	1.90	193.00	3, 967	104
Female schooling (years)	5.99	3.05	0.12	12.73	3, 666	94
Urbanization	53.32	24.00	5.70	100.00	4, 056	104

Table 4 Data sources and description

Variable	Description	Time range	Source
Fertility	Fertility is measured as the total fertility rate (TFR). This is a composite measure containing all age-specific fertility rates. It comprises the number of children an imaginary woman would give birth to if she were to move fast-forward through her life (and her childbearing years)	1970–2007	World Development Indicators (WDI)
Manufacturing exports per capita	Exports classified in groups SITC 5, 6, 7, and 8 in current USD divided by total population numbers	1970–2007	United Nations Commodity Trade Database (2011)/Penn World Tables 7.0
Primary exports per capita	Exports classified in groups SITC 0, 1, 2, 3, and 4 in current USD divided by total population numbers	1970–2007	United Nations Commodity Trade Database (2011)/Penn World Tables 7.0
GDP per capita	Gross domestic product per capita in constant USD	1970–2007	Penn World Tables 7.0
Infant mortality	Mortality rate per 1,000 live births	1970–2007	Child Mortality Database (2011)
Female labor force participation	The ratio of economically active women to all women aged 15 and older	1980–2007	World Development Indicators (WDI)
Female schooling	Average years of schooling among women	1970–2007	Barro and Lee (2013)
Urbanization	Share of total population living in urban areas	1970–2007	World Development Indicators (WDI)

Table 5 Trade and fertility (fixed-effects estimates)

Dependent: TFR	(1)	(2)	(3)	(4)	(5)
All countries					
Man. exp. p.c.	−0.005***	−0.004***	−0.003***	-0.003***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Prim. exp. p.c.	0.000	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Infant mortality		0.211***	0.208***	0.183***	0.188***
		(0.009)	(0.009)	(0.010)	(0.010)
GDP per capita		0.007			0.009*
		(0.005)			(0.005)
Female schooling				0.058***	0.050***
				(0.010)	(0.011)
Urbanization					0.009
					(0.021)
Time trend (*t*)	−0.017***	−0.010***	−0.010***	−0.013***	−0.012***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3,150	3,115	3,116	2,906	2,905
Countries (*n*)	103	103	103	93	93
Years (*t*)	38	38	38	38	38
High-income countries					
Man. exp. p.c.	−0.007**	−0.003	−0.001	0.001	−0.001
	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)
Prim. exp. p.c.	0.000	−0.000	0.001	−0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Infant mortality		0.164***	0.179***	0.068***	0.064***
		(0.024)	(0.024)	(0.027)	(0.029)
GDP per capita		0.053***			0.027*
		(0.014)			(0.016)
Female schooling				−0.454***	−0.438***
				(0.043)	(0.048)
Urbanization					0.074
					(0.088)
Time trend (*t*)	−0.016***	−0.009***	−0.008***	−0.005***	−0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	1,294	1,265	1,266	1,221	1,220
Countries (*n*)	38	38	38	36	36
Years (*t*)	38	38	38	38	38
Low-income countries					
Man. exp. p.c.	−0.006***	−0.004***	−0.004***	−0.002**	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Table 5 (continued)

Dependent: TFR	(1)	(2)	(3)	(4)	(5)
Prim. exp. p.c.	0.000	0.004**	0.004**	0.002*	0.002
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Infant mortality		0.278***	0.271***	0.228***	0.226***
		(0.010)	(0.010)	(0.010)	(0.010)
GDP per capita		−0.003			0.001
		(0.006)			(0.006)
Female schooling				0.122***	0.111***
				(0.009)	(0.010)
Urbanization					0.074***
					(0.021)
Time trend (t)	−0.017***	−0.010***	−0.010***	−0.015***	−0.016***
	(0.00)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	1,856	1,850	1,850	1,685	1,685
Countries (n)	65	65	65	57	57
Years (t)	38	38	38	38	38

Notes: Dependent variable in all models is the total fertility rate (TFR). All variables are used in natural logarithms. Heteroscedasticity and serial correlation robust S.E.s in parentheses. Sample range is 1980 – 2007 with yearly intervals.

*$p = 0.10$; **$p = 0.05$; ***$p = 0.01$ (denote significance)

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