Fertility rebound and economic growth. New evidence for 18 countries over the period 1970-2011.

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Abstract

Long-run impact of economic growth on fertility trends is ambiguous and sensitive for in-time variations. Over last decades, economic growth has led in many countries to significant falls in total fertility rates. However, recently, in high-income economies a kind of "fertility rebound" is revealed [Goldstein 2009; Luci and Thevenon, 2011; Day 2012]. The concept of fertility rebound supports the hypothesis that reversal trends in total fertility rates are mainly attributed to economic growth.

Our paper unveils the relationship between total fertility rate changes and economic growth in 18 selected countries with fertility rebound observed, over the period 1970-2011. We anticipate uncovering U-shaped impact of economic growth on total fertility rate. To report on the relationship we deploy longitudinal data analysis assuming non-linearity between examined variables. Data applied are exclusive derived from World Development Indicators 2013. Our main findings support the hypothesis on U-shaped relationship between total fertility rate and economic growth in analyzed countries in 1970-2011. Along with the previous we project the minimum level of GDP *per capita* when the fertility rebound takes place.

Keywords: *fertility rate, fertility rebound, economic growth, panel data analysis.*

JEL classification:*J11, O10, C23.*

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1. Introduction

In 1994 Hirschman [1994] concluded that the picture arising from empirical evidence on changing fertility is ambiguous and not does not provide clear justification about its determinants. After twenty years of further studies, our knowledge about factors influencing fertility is much broader however, we still lack hegemonic theory on that field, and the picture of modern society emerging from multitude of studies is highly heterogeneous.

The negative relationship between fertility and socio-economic development, previously considered as one of the most established and consolidated regularities in social sciences, has undergone numerous analyses in recent years [i.e. Lee, 2003; Myrskylä et al., 2009; Luci and Thévenon, 2011]. The evidence, which is reported in cited study reveals detectable regularities between fertility rate and economic development, especially when high-income economies are considered [i.e. Varvarigos, 2013]. Although in many works [i.e.Galor&Weil, 1996 and 1999; Kohler et al., 2002a and 2002b; Deopke 2004, Caldwell& Schindlmayr, 2003; Butler, 2004; Morgan andTaylor, 2006; Klasen&Lamanna 2009; Mills et al., 2011] it is reported that fertility changes are negatively attributed to economic development, it is highly possible that the two are rather linked by two-way relationship. The hypothesis on potential positive relationship between fertility trends and economic development is supported by evidence on growing total fertility rates mainly in high-income economies. The changing trends in fertility rates are recognized as fertility rebound, which is defined as reversal of fertility decline accompanied by economic development.

The aim of the paper is to provide new evidence on relationship between fertility and economic development. We re-examine the hypothesis on a U-shaped relationship between total fertility rate [TFR] and GDP per capita. Our study covers 18 high-income countries over the period 1970-2011. Our study consists of six parts, whereby the introductory part is followed by section two explaining theoretical background and literature review. Section three presents data rationale, whereas section four sets forth the main goals of the paper and adopted empirical strategy. The subsequent section five illustrates empirical analysis results and the final part refers to substantial conclusions in this respect.

2. Literature review

Recent empirical studies provide broad evidence on relationship between TFR and GDP *per capita* or overall socio-economic development approximated by Human Development Index. Although the evidence is relatively broad, main conclusions reported in empirical studies vary significantly showing complexity of the problem and multitude of factors, which potentially affect the two-way relationship between fertility and broadly defined socio-economic development.

Both in theoretical and empirical works in which main emphasis is put on aspects combining fertility trends and economic development, three seminal research streams are easily distinguishable, each one offering different perspectives for the analysis. The first stream combines issues of changing fertility with economic development, the second - changing fertility trends with economic growth exclusively, while the third one confronts changing fertility trends with business cycles. The first and second one perspective are mostly long-term in nature, while the third one combined shot-, and long-run approach.

In seminal study of Myrskylä *et al.* [2009] they apply panel data for 37 high developed countries over the period 1975 to 2005, to examine the relation between the Human Development Index [HDI] and the total fertility rates. They suggest that HDI-TFR relationship tends to reveres from negative to positive, as countries pass critical level of HDI. Their findings show that, at low and medium level of human development index [HDI], decrease in fertility rate coincides with continuously progressing economic growth. The situation changes diametrically at higher HDI levels. Further development, upon reaching a particular threshold, may lead to a reversal in fertility declining trend. The level of HDI, which turns the correlation between human development and fertility from negative to positive, is at about 0.9. Following the above, they predict that, in long-run perspective, advanced in human development shall impact positively fertility rates, however changes in fertility are not exclusively attributed to economic effect solely. Changing relationship – from negative to positive – between two covariates like total fertility rates and economic development, can be graphically approximated by U-shaped pattern.

Luci and Thévenon [2010] also report on U-shaped relationship between TFR and GDP *per capita*. Unlike Myrskylä *et al.* [2009] do, they analyse the impact of GDP *per capita* on fertility rate, to isolate the pure economic impact on total fertility rates. To test the hypothesis of a convex impact of GDP per capita on TFR, Luci and Thévenon [2010] use a panel data set of 30 OECD countries over the time span 1960-2007. Applying on step-estimator, they designate turning point in the relationship between economic development and fertility, at which further development may lead to a reversal of fertility decline trend. The minimum of the curve is located at specific GDP per capita that corresponds to approximately 32,600 [in PPP constant 2005] and total fertility rate at 1.51 children *per* woman. Separately they identify country-specific factors, which intend to explain why countries at comparable level of GDP *per capita* levels experience different fertility rates. A general conclusion of the study is that economic development is likely to induce the fertility rebound; however, the evidence is not robust and case-sensitive.

The evidence provided by Myrskylä *et al.* [2009] clearly claims that advances in development path, in some cases are accompanies by reverses of declining fertility rate, but, by contrast, such conclusion is questioned by Furuoka [2009]. Furuoka applies a threshold regression to examine the existence of the U-shaped fertility-development curve proposed by Myrskylä *et al*. [2009]. He uses threshold HDI [indicated as 0.777] to divide the sample into two subsamples - countries with HDI level equal to or lower than the threshold value and those that exceed the threshold. Thus, the negative relationship between HDI and fertility rate was revealed both in the countries with HDI below and above the threshold, although in countries with high HDI, the negative relationship between covariates was relatively weak. It supports the supposition that countries placed in earlier phases on economic development are more likely to experience declining fertility rates, likewise, in high-developed countries it is just the opposite. The aforementioned evidence provided by Myrskylä *et. al*. [2009] is additionally supported by Goldstein *et al.* [2010]. They verify the importance of economic conditions for fertility trends, using data on unemployment rates and GDP growth in 27 OECD countries [regardless total fertility rates levels], over the period 1995 to 2008. However, they do not claim direct influence of unemployment on fertility, rather emphasising importance of current economic conditions on individual decisions on childbearing. Goldstein *et al.* [2009] find both unemployment and economic growth rates to be statistically significant predictors of prospected TFR.

Another stream, both in theoretical and empirical research highlights the importance of distinguishing between short and long-run perspectives when analyzing TFR and GDP per capita relationship. Long-term analysis mainly focuses on macro-factors [on aggregate level] that determine observed changes in fertility, and such approach was presented in aforementioned studies.

While short-term analysis – concentrate on examining the impact of business cycles [especially recession] on the period TFR, and refer to individual decisions that may influence changes in TFR [Sobotka *et al*., 2011].

The majority of short-term analysis shows pro-cyclical relationship between fertility and GDP *per capita*. During recessions [approximated by GDP per capita declines, growth of unemployment rates etc.] fertility tends to decrease. Such evidence in presented *inter alias* in works of Lee [1990], Bengtsson et al. [2004], Martin [2004] or Adsera&Menendez [2009]. Sobotka, *et al.* [2011] confirmed the pro-cyclical relationship between GDP *per capita* and fertility. They used changes in GDP *per capita* as a proxy explaining recession and the period TFR as an indicator of fertility [they imposed 1-year lag in GDP *per capita* impact on TFR changes] . Their study [Sobotka *et al*., 2011] covered 26 low fertility developed countries over the period 1980-2008, and results obtained seem to support the hypothesis that fertility and economic growth are positively correlated along business cycles, which was already concluded from previous works [see i.e. Lee, 1990; Bengtsson *et al*. 2004]. However, detecting rigid regularities in behavior of TFR *versus* GDP *per capita* if business cycles are considered, huge uncertainties emerge which makes the relationship even fuzzier. The previous was clearly stated in works of i.e. Kohler et al. [2002a, 2002b], Santow and Bracher [2001], Mills and Blossfeld [2005], Kreynfeld [2010], Neels [2010] or Sobotka [2010].

Circumstance that today`s recessions [i.e. that which started in 2008] take place under, differ significantly from those in the past. This is mainly due to huge increases in women`s active participation in labor market, which is partly determined by their growing access to education, contraceptives, and changing social norms. In effect, the previous may precondition the strength of influence of short-term recessions on changing fertility trends.

The counter-cyclical relationship was only mentioned in few studies – i.e. Butz and Ward [1979a, 1979b] or Macukovich [1996]. Recent decades are featured by relatively short recessions, thus their real impact on fertility was temporary. The fall of fertility during recessions was followed by its rise [or slower decline] during recoveries.

When analyzing trends in fertility in short time perspective, there might arise, some difficulties with clear distinguish between fertility changes and fertility timing [postponement of the birth]. Only in few studies, we observe a trial to tackle the problem just mentioned. Formal analysis trying to combine short and long run perspective in detecting relationships between economic development and fertility, are found i.e. in works of i.e. Ogawa [2003] or Rindfuss *et al.* [1988]. Empirical evidence linking fertility changes with GDP *per capita* is even rarer than the previous.

Our empirical analysis, presented in following sections of the paper, predominantly concentrates on detecting long-term relationships between changing total fertility rates and GDP per capita.

3. Data

Our analysis covers two different variables. Firstly, we account for Total Fertility Rate [TFR_{it}] which refers to number of children that a woman would give birth to, in accordance with current age-specific fertility rates [see WDI 2013]. Secondly, to approximate level of economic development of countries, we consider gross domestic product *per capita* [$GDPpc_{it}$] We take natural logarithms of purchasing-power-parity adjusted national GDP *per capita* in constant 2005 US$. All data are exclusively derived from World Development Indicators database 2013. To complete our empirical analysis we construct strongly balanced cross-country long panel including 18 high-income economies that satisfy two prerequisites: over the period 1970-2011 Total Fertility Rate has dropped below 2.1 [replacement rate] which was followed by “fertility rebound”, and – according to World

Bank – are classified[4] as high-income countries. Finally, our sample covers Australia, Belgium, Barbados, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Japan, Italy, Netherlands, Norway, Sweden and United States.

4. Empirical targets and methodological approach

The aim of the paper is twofold. Preliminary, using panel data of 18 countries over the period 1970-2011 we are to confirm the hypothesis on U-shaped relationship between Total Fertility Rate and economic growth approximated by GDP *per capita*. Following the above, we estimate threshold level of GDP *per capita* when the fertility rebound effect is revealed.

To test the hypothesized relationship, we perform panel regressions analysis, which allow capturing variation in behavior across time and entities [countries], if countries tend to be highly heterogeneous. Firstly we confirm the U-shaped relationship between variables: Total Fertility Rate $[TFR_{it}]$ – response variable; and economic growth $[LnGDPpc_{it}]$ – explanatory variable. For this, adopting pooled OLS, we examine linear model *versus* 2-degree polynomial [quadratic equation] and 3-degree polynomial [cubic equation]. To formalize the above, we specify:

$$TFR_{it} = \beta_0 + \beta_1 LnGDPpc_{it} + \varepsilon_{it} \quad [1]$$

$$TFR_{it} = \beta_0 + \beta_1 LnGDPpc_{it} + \beta 2[LnGDPpc_{it}]^2 + \varepsilon_{it} \quad [2]$$

$$TFR_{it} = \beta_0 + \beta_1 LnGDPpc_{it} + \beta_2[LnGDPpc_{it}]^2 + \beta_3[LnGDPpc_{it}]^3 + \varepsilon_{it} \quad [3]$$

where *i* denotes country, *t* – period [year] and ε_{it} - an error term.

If U-shaped relationship between TFR_{it} and $LnGDPpc_{it}$ is confirmed, afterwards we exclusively concentrate on quadratic longitudinal models. Using yearly observations, we test convex shape of the curve explaining cross-country relationship between TFR_i and $LnGDPpc_{it}$ and its square term.

To capture time-invariant countries` specific effects, we propose country-fixed effects regression, defined as:

$$TFR_{it} = \alpha_i + \delta_1 LnGDPpc_{it} + \delta_2 [LnGDPpc_{it}]^2 + \varepsilon_{it} \quad [4],$$

which can be rewritten [if country-dummies included]:

$$TFR_{it} = \delta_0 + \delta_1 LnGDPpc_{it} + \delta_2 [LnGDPpc_{it}]^2 + \gamma_2 C_2 + \ldots + \gamma_n C_n + \varepsilon_{it} \quad [5].$$

In [4] and [5], α_i denotes unobserved, time-invariant fixed effect, γ_2 is coefficient for binary-country regressors, *C* – is country-dummy, *n* accounts for number of countries in the sample, and α_i and $LnGDPpc_{it}$ are arbitrary correlated. For [4] and [5], to satisfy the exogeneity assumption, we assume that $E[\varepsilon_{it} | X_i, \alpha_i]=0$, if X_i represents $LnGDPpc_{it}$. In specified model, the TFR_i concisely expresses the vector of country`s individual results determined by changes in *per capita* income, across all periods.

To examine time-fixed effects we additionally estimate:

$$TFR_{it} = \delta_0 + \delta_1 LnGDPpc_{it} + \delta_2 [LnGDPpc_{it}]^2 + \gamma_2 C_2 + \ldots + \gamma_n C_n + \lambda_2 Y_2 + \ldots + \lambda_t Y_t + \varepsilon_{it} \quad [6],$$

where *Y* is year-dummy and λ stands for its coefficient. Hence regression [6] is estimated for *n-1* countries and *t-1* years. In [6] we relax the assumption on unobserved effects which vary across countries but are constant over time. Thus we control for time effects supposing that unexpected variation potentially influence explanatory variable.

[4] According to formal World Bank country classification [see: http://data.worldbank.org/about/country-classifications, acceded: Feb 2014]

To confirm results generated from [5] and [6], along with within estimator we introduce instrumental variables [IV] estimator, which cuts potential correlation between error term and explanatory variables.

To formalize the above, let us give: $y_i=\beta x_i+\varepsilon_i$, but $E[x_i,\varepsilon_i]\neq 0$, despite the exogeneity assumption requires $E[x_i,\varepsilon_i]=0$. Hence, to "omit" the endogeneity, we define z_i as instrument which satisfies $E[z_i,x_i]\neq 0$ and $E[z_i,\varepsilon_i]=0$. To obtain unbiased β, we adopt 2SLS method where: $y_i=\beta x_i+\varepsilon_i$ and $x_i=\varphi z_i+\mu_i$, if $\varphi\neq 0$ [$\leftrightarrow E[z_i,x_i]\neq 0$]. In our case we deploy lagged $LnGDPpc_{it}$ and $LnGDPpc_{it}^2$ *[[LnGDPpc*$_{it}$ *– 1-year lag], [LnGDPpc*$_{it}^2$ *– 1-year lag]]* as instruments, which are sufficiently correlated with $LnGDPpc_{it}$ and $LnGDPpc_{it}^2$ respectively, but uncorrelated with ε_{it}, which allows producing unbiased δ_1 and δ_2.

To get rid of the unobserved heterogeneity in models, first differences estimators [FDE] are often applied. However, we decide not to follow this approach. First differencing of data implies that all estimates are generated for relative changes instead of levels, which brings risk of obtaining misleading results due to convergence process that characterizes analyzed countries. Convergence hypothesis support the logic that relatively poor economies experience higher rates of i.e. GDP *per capita* growth, if compared to rich ones. In our case, as total fertility rate are expected to decrease along with economic growth, which results in positive correlation between variables expressed as relative changes of both $LnGDPpc_{it}$ and TFR_{it}. If we assume the previous, concluding on the role economic growth in total fertility rate in-time variability might be confusing and leading to incorrect conclusions. Luci and Thévenon [2011], they also refer to the problem and indicate that using FD estimator in this case might not allow for clear statement about the "role of economic development for the fertility rebound in highly developed countries" [see Luci and Thévenon, 2011].

To accomplish second goal of the paper we calculate the vertex [turning point] of the parabola defined as $TFR_{it} = \alpha_i + \beta_1 LnGDPpc_{it} + \beta_2 [LnGDPpc_{it}]^2$ [2], which corresponds to averaged level of GDP *per capita* at which the fertility rebound takes place. If we assume that [2] is a 2-degree polynomial, then its general form follows:

$$f(x) = ax^2 + bx + c \qquad [7],$$

where $x\in[-\infty;+\infty]$, and at least $a\neq 0$.

Thus the vertex [turning point] of the [7] is defined as:

$$\left(-\frac{b}{2a}, f\left(-\frac{b}{2a}\right)\right) \qquad [8].$$

Alternatively the [8] can be calculated by use of first derivative of [7]:

$$f`(x) = 2ax + b \qquad [9],$$

and solving the equation:

$$f`(x) = 2ax + b = 0 \qquad [10].$$

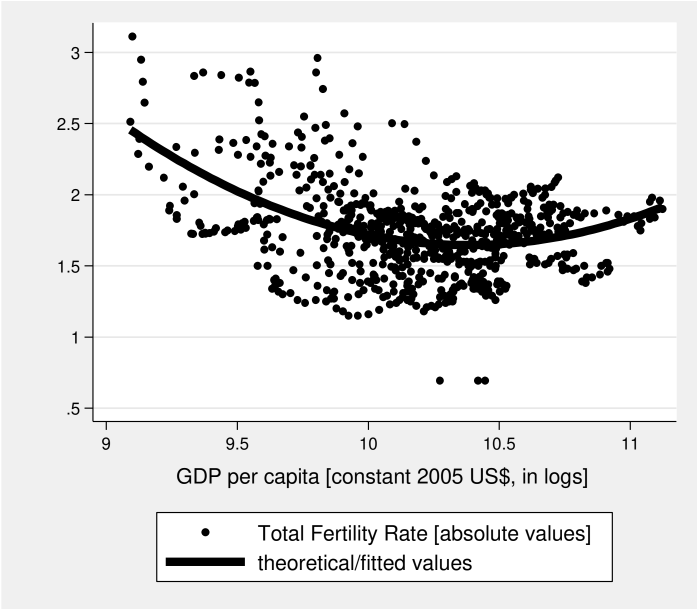
5. Results

As it was explained, our empirical analysis is limited to countries where the fertility rebound was detected over the period 1970-2011. Finally have concentrated on 18 high-income economies, where total fertility rate fell below 2.1 – replacement rate, and after reaching the low point it was steadily increasing. Although growing trends in total fertility rates were to a point disrupted by short "ups" and "downs", the positive direction was maintained. Looking backwards, the reversal trends in TFR were preceded by long run and substantial falls in fertility rates. In 1970 the average total fertility rate was approximately 2.36[5], then in 1980 – 1.77, 1990 – 1.69, 2000 – 1.60 and finally in 2011 – 1.70. Then the absolute change in average TFR between 1970 and 2000 was 0.76. Basing on the previous, we conclude that sharpest declines in total fertility rate were noted in decade 1970-1980, when the TFR fell below the threshold [2.1] required to replace country`s population. Countries that experienced most significant declines in TFR over the period 1970-1980 were Barbados [-1.1], Netherlands [-.98], Australia [-.96], Italy and Norway [-.78 for both]. Reversely, we note that in 2011, the average TFR was slightly higher than in 2000 [+0.1], thus over this decade the fertility rebound is revealed. Countries with greatest intensity of growing TFR over the period 2000-20111, were Sweden [+.36], United Kingdom [+.34], Belgium and Greece [+.13 for both] and Italy [+.15]. Observed, over last decade, positive changes in fertility rates probably are becoming a permanent feature rather than mere cyclical change. However, the 41-year changes in total fertility rate do not resemble a smooth trend, but they are rather often interrupted by temporarily upward and downward trends [for detailed statistics see Appendices].

Furthermore, we confront total fertility rates *versus* economic growth. Our panel encompasses 18 countries covering long period, which constitutes a promise for accurate estimates. Adopted empirical procedures allow controlling for both unobserved country and time specific effects. Relying on pooled OLS we detect the best-fitting curve demonstrating changes of TFR_{it} *versus* $GDPpc_{it}$. Additionally we plot our panel to control for graphical specification of examined relationship. Charts 1 and 2, preliminarily confirm that analyzed countries follow the U pattern over the period 1970-2011, if TFR_{it} *versus* $GDPpc_{it}$ relationship is examined. Solid black line [Chart 1 and 2] approximates theoretical pattern between TFR_{it} and $GDPpc_{it}$. For relatively low $GDPpc_{it}$ the TFR_{it} is high, but along with the process of economic growth it continuously declines, finally reaching the low point of the U-shaped curve [the parabola opens downward]. Then having passed the vertex, moderate increases in TFR_{it} are revealed and the parabola opens upward. It supports the idea that the fertility rebound is accompanied by certain threshold level of $GDPpc_{it}$.

[5] Own estimates for the 18 selected countries.

Chart 1. Total Fertility Rate *versus* GDP per capita. 18 countries. Period 1970-2011.



Source: own elaboration based on data derived from World Development Indicators 2013. Note: solid line presents quadratic prediction for $GDPpc_{it}$ versus TFR_{it}. On X axis – logs of $GDPpc_{it}$ in constant 2005 US$; on Y axis – Total Fertility Rate absolute values.

Table 1 presents results of linear, quadratic and cubic predictions for TFR_{it} *versus* $GDPpc_{it}$. Quadratic model reveals the best fit to empirical data, as R^2=.196 and all coefficients are statistically significant. Thus we conclude that quadratic model, better than linear or cubic, predicts relationship between TFR_{it} and $LnGDPpc_{it}$.

Table 1. Total Fertility Rate *versus* GDP per capita. Linear, quadratic and cubic predictions. 18 countries. Period 1970-2011.

	Lineal prediction	Quadratic prediction	Cubic prediction
	Pooled OLS		
Explanatory variable			
$LnGDPpc_{it}$	-.25 [-8.85]	-10.09 [-9.87]	-18.33 [-.66]
$[LnGDPpc_{it}]^2$		0.48 [9.65]	1.30 [.47]
$[LnGDPpc_{it}]^3$			-.02 [-.30]
_cons	4.2 [14.88]	54.06 [10.47]	81.79 [.87]
R^2 of the model adjusted – R^2	.095 .094	.196 .193	.196 .192
# of countries # of observations	18 746	18 746	18 746

Source: own estimates based on data derived from World Development Indicators 2013. Note: in parenthesis *t-statistics* at 5% significance level.

Table 2 summarizes full specification of estimation results based on multiple periods in 18 selected countries. The analysis is based on panel data; hence the evidence demonstrates evolution of changing total fertility rates which are attributed to economic growth.

Table 2. Total Fertility Rate *versus* GDP per capita. Quadratic estimates. 18 countries. Period 1970-2011.

	Pooled OLS		**FE [I]**		**FE [II]**		**FE [III]**	**FE [IV]**
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
$LnGDPpc_{it}$	-10.09 [1.01]	-9.19 [.88]	-21.54 [5.15]	-18.30 [5.26]	-14.56 [5.79]	-14.61 [5.88]	-21.48 [6.02][a]	-14.65 [7.09][a]
$[LnGDPpc_{it}]^2$	0.48 [.049]	.422 [.044]	1.02 [.25]	.862 [.26]	.724 [.28]	.721 [.28]	1.02 [.29][a]	.727 [.35][a]
$LnGDPpc_{it}$ *- 2-year lag*		.434 [.061]		.267 [.09]		.064 [.13]		
_cons	54.06 [5.1]	46.99 [4.6]	114.22 [26.1]	95.78 [27.3]	75.46 [29.9]	75.49 [30.6]	113.87 [30.55][a]	75.9 [35.9][a]
R^2 of the model	.196	.259	.466 [within]	.487 [within]	.590 [within]	.582 [within]	.466 [within]	.586 [within]
Year-fixed Country-fixed Instruments	No No No	No No No	No Yes No	No Yes No	Yes Yes No	Yes Yes No	No Yes Yes	Yes Yes Yes
# of countries # of observation	18 746	18 744	18 746	18 744	18 746	18 744	18 744	18 744

Source: own estimates based on data derived from World Development Indicators 2013. Note: below coefficients – robust SE. Also tested for [$LnGDPpc_{it}$ - 1-year lag] – results less significant than for [$LnGDPpc_{it}$] - 2-year lag. All estimates for significance level at 5%. [a] – bootstrap SE [1000 replications]. Lagged explanatory variable used as instruments. [I] – country-fixed effect. [II] – time-fixed effects. [III] – instrumented country-fixed effects regression. [IV] – instrumented time-fixed effects regression.

Displayed outcomes suggest that TRF_{it} and $GDPpc_{it}$ are negatively correlated for lower *per capita* income [*ante* vertex of the curve], and the relationship turns to be positive for higher $GDPpc_{it}$, thus the U-shaped trajectory is generated. Estimates obtained from quadratic panel regressions of total fertility rates against economic growth; show that regressor [$LnGDPpc_{it}$] always holds negative sign, and [$LnGDPpc_{it}^2$] – positive. In all cases estimated coefficients are statistically significant at 5% level. In columns [1] and [2] results of simple OLS are reported. Model with $LnGDPpc_{it}$ *- 2-year lag* variable added, shows slightly higher *R-square*, which might suggest that level of total fertility rate in period [t] is to some extend pre-conditioned by GDP *per capita* in period [t-2]. Estimates were also performed with $LnGDPpc_{it}$ *- 1-year lag* included, they were significantly weaker that for 2-year lag. This also supports the hypothesis that positive effects of economic growth on total fertility rates are revealed with significant time lags. Estimates of coefficients δ_1 and δ_2 resulted from within-estimator [FE[I]], explaining mediated effects of $LnGDPpc_{it}$ on TFR_{it} due to cross-country differences, are statistically significant however – in each case – δ_1 tends to be higher than δ_2. It suggests that, over the period 1970-2011, the "negative" relationship between TFR_{it} and $GDPpc_{it}$ was strongly dominant. As in case of OLS estimates, inclusion of lagged $GDPpc_{it}$, resulted on slightly higher R^2 of the model [.487], which again confirms lagged impact of economic growth on changes in total fertility rates.

Analyzing relationship between total fertility rate and economic growth, we suppose that the impact of $GDPpc_{it}$ on TFR_{it} may be additionally determined by factors varying across time. Hence, to check for unexpected in-time variation, which potentially affects influence of GDP *per capita* on [TFR_{it}], we control for time-fixed effects. Results obtained from FE[II] suggest that, after "absorbing" the unobserved effects that vary across time and potentially determines the impact of $GDPpc_{it}$ on TFR_{it}, the strength and direction of the relationship remains at comparable level to estimates generated by FE[I]. The *R-square* [within] of the model FE[II] is at 0.59, thus we may conclude that the FE[II] regression – with time-fixed effects included – relatively better explains relationship between total fertility rate and economic growth, than the FE[I] model. In FE[II] with lagged $GDPpc_{it}$ included, estimated coefficients, also confirm previous results and proof that relationship between total fertility changes and economic growth in examined panel, is *not* specifically featured by country and/or time fixed effects, but rather is *inter-temporal* in its nature. However, to confirm the previous, we additionally run random-effects regression [results not reported in Table 2] and perform Hausman test, which resulted in obtaining Prob>chi^2=.000, however the V_b-V_B matrix is not positive definite. It suggests that relationship between total fertility rate and economic growth, to some extent, might be additionally affected by omitted variables relatively constant over time, but varying across countries, and – some other variable relatively constant [fixed] for countries but varying over time.

To control for potential endogeneity in models, in columns [7] and [8] we present results of instrumental variables estimator. All coefficients are reported under assumption that lagged $LnGDPpc_{it}$ and $LnGDPpc_{it}^2$ are treated as instruments, and IV-regression was performed using 2SLS. Obtained outcome are highly similar to those resulted from estimates with no instruments used, thus are not discussed in particular.

Presence of time-invariant country specific effects, like i.e. culture, institutions etc., surely influence relationship between TFR_{it} and economic growth, but their impact is not strength enough to eliminate average response of TFR_{it} if GDP *per capita* changes in analyzed countries over the period 1970-2011. Hence the "panel effect" is not interrupted by occasional incidents.

However to some extent, our results seem to be, additionally conditioned by unobserved effects that tend to vary in-time [not only across countries]. The later justifies why variations in GDP *per capita* influence differently total fertility rate [determined by people`s behavior] at different points of time; and explains changes in patterns of total fertility rate over the period 1970-2011, as its significant falls are followed by moderate increases. Similar conclusions are presented in works of Luci and Thévenon [2011], Myrskylä *et al.* [2009] and Furuoka [2009].

As the demonstrated in Chart 1, the relationship between total fertility rate and economic growth follows the U-shaped pattern which is well described by quadratic models [confirmed by results presented in Table 2 above]. We assume existence of specific threshold level of GDP *per capita*, determined by the convex of the parabola, at which total fertility rate starts to rise and the downward trend is halted. Following previous estimates, the low peak of the curve [using OLS] corresponds to approximately $LnGDPpc_{it}$=10.38 which is equivalent to 32 208 of GDP *per capita* [in 2005 constant US$]. Thus, when considering total fertility rate that changes as countries advance in level economic development, rising fertility trends tend to be revealed once a country achieves the threshold level of GDP *per capita* 32 208 [in 2005 constant US$]. However, it shall be clearly stated that estimated effect of economic growth on changing total fertility rates explains only the *averaged* response of falling/rising TFR_{it} as $GDPpc_{it}$ grows in *hypothetical* country. It shows that economic growth may be of the channel inducing growth in total fertility rates. However, one should be aware that country`s specific effects and patterns explaining behavior of total fertility rate *versus* economic growth may differ significantly across economies, as being affected by state policies or social norms.

6. Conclusions

The paper was designed to uncover the relationship between changing total fertility rates and economic growth in 18 high-income economies over the period 1970-2011. We have examined the relationship adopting longitudinal analysis, which allowed obtaining averaged response of total fertility rates as countries advance in economic development pattern. Additionally, it was hypothesized the U-shaped trajectory explains changes in long-run total fertility trends determined by economic growth, and the supposition was confirmed. Our estimates lead to general conclusion that TFR_{it} and $GDPpc_{it}$ are closely interrelated, and uncovered quantitative relationship that supports the hypothesis on inter-temporal nature of the links. Hence, the relationship between total fertility rate and economic growth is relatively robust to time and country specific effects. We have also discovered that the fertility rebound is especially to be revealed as countries achieve the threshold level of economic development approximated by GDP *per capita* 32 208 [in 2005 constant US$]. Designating the turning point at U-shaped curve would imply that economic growth to a certain point constitutes a channel of reversing paths with regard to total fertility rates in high-income countries. The last supports more general idea that countries at higher stages of development tend to experience fertility rebound as *per capita* income is sufficient to provide decent life and education for more children [Varvarigos, 2013]. It may also suggest that some of developed countries are now entering new phase of development significantly marked by demographic change determined by reversals in fertility rates, which starts to recover and grow slightly above pure replacement rate. Although discovering such quantitative links between TFR and GDP *per capita*, we do not claim that achieving the threshold GDP *per capita* shall automatically induce increases in total fertility rates. Surely, not all countries will follow analogous paths of growing fertility, regardless they perform well or not in terms of economic growth. Additionally, the positive impact on growing income on fertility may finally be to be temporal and short-term. Still many developed countries do not experience the fertility rebound, which suggests that economic growth does not drive exclusively demographic changes, and fertility rebounds across countries are only partly explained by growth in living standards, while the rest of it is hugely attributed to institutional, social and state policy context.

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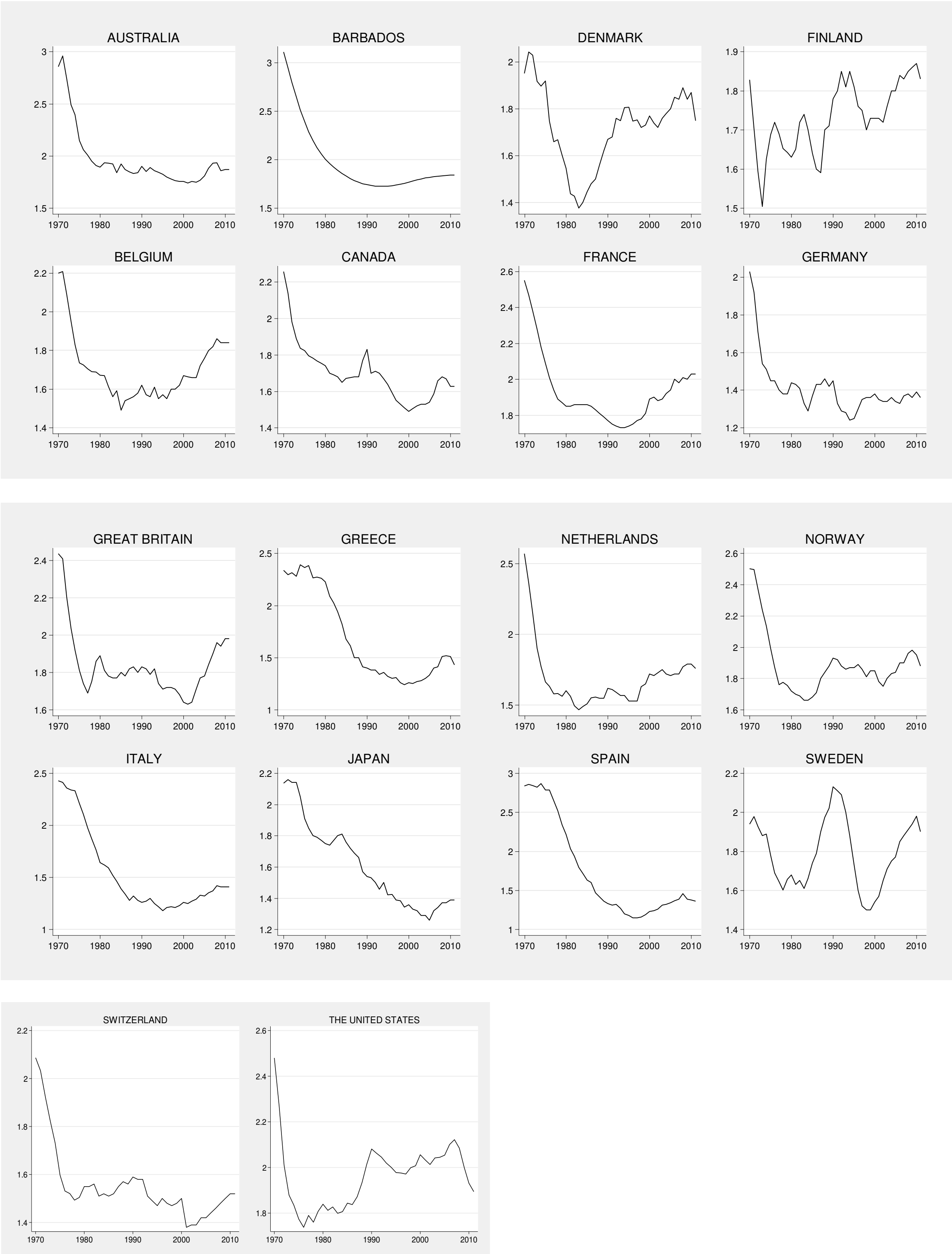
APPENDICES

Country-specific total fertility rate patterns. 18 countries. Period 1970-2011.



Source: own elaboration based on data derived from World Development Indicators 2013. Note: on vertical axis – Total Fertility Rates [raw data].

Total fertility rate. 18 countries. Period 1970-2011.

	Australia	Belgium	Barbados	Canada	Switzerland	Germany	Denmark	Spain	Finland	France	United Kingdom	Greece	Japan	Italy	Netherlands	Norway	Sweden	United States	Spain
1970	2,86	2,20	3,11	2,26	2,09	2,03	1,95	2,84	1,83	2,55	2,44	2,34	2,14	2,43	2,57	2,50	1,94	2,48	2,84
1971	2,96	2,21	2,95	2,14	2,03	1,92	2,04	2,86	1,70	2,47	2,41	2,30	2,16	2,41	2,36	2,50	1,98	2,27	2,86
1972	2,74	2,09	2,79	1,98	1,92	1,71	2,03	2,84	1,59	2,38	2,20	2,32	2,14	2,36	2,15	2,37	1,93	2,01	2,84
1973	2,49	1,95	2,65	1,89	1,82	1,54	1,92	2,82	1,50	2,28	2,04	2,28	2,14	2,34	1,90	2,24	1,88	1,88	2,82
1974	2,40	1,83	2,51	1,84	1,73	1,51	1,90	2,87	1,63	2,18	1,92	2,39	2,05	2,33	1,77	2,14	1,89	1,84	2,87
1975	2,15	1,74	2,39	1,82	1,60	1,45	1,92	2,79	1,69	2,09	1,81	2,37	1,91	2,21	1,66	1,99	1,78	1,77	2,79
1976	2,06	1,73	2,29	1,80	1,53	1,45	1,75	2,79	1,72	2,01	1,74	2,39	1,85	2,11	1,63	1,87	1,69	1,74	2,79
1977	2,01	1,71	2,20	1,78	1,52	1,40	1,66	2,65	1,69	1,94	1,69	2,27	1,80	1,98	1,58	1,76	1,64	1,79	2,65
1978	1,95	1,69	2,12	1,77	1,49	1,38	1,67	2,52	1,65	1,89	1,75	2,27	1,79	1,87	1,58	1,78	1,60	1,76	2,52
1979	1,91	1,69	2,06	1,75	1,51	1,38	1,60	2,34	1,64	1,87	1,86	2,26	1,77	1,76	1,56	1,76	1,66	1,81	2,34
1980	1,89	1,67	2,00	1,74	1,55	1,44	1,55	2,22	1,63	1,85	1,89	2,23	1,75	1,64	1,60	1,72	1,68	1,84	2,22
1981	1,94	1,67	1,96	1,70	1,55	1,43	1,44	2,03	1,65	1,85	1,81	2,09	1,74	1,62	1,56	1,70	1,63	1,81	2,03
1982	1,93	1,61	1,92	1,69	1,56	1,41	1,43	1,94	1,72	1,86	1,78	2,02	1,77	1,59	1,50	1,69	1,65	1,83	1,94
1983	1,92	1,56	1,89	1,68	1,51	1,33	1,38	1,79	1,74	1,86	1,77	1,94	1,80	1,52	1,47	1,66	1,61	1,80	1,79
1984	1,84	1,59	1,86	1,65	1,52	1,29	1,40	1,72	1,70	1,86	1,77	1,82	1,81	1,46	1,49	1,66	1,66	1,81	1,72
1985	1,92	1,49	1,83	1,67	1,51	1,37	1,45	1,63	1,64	1,86	1,80	1,68	1,76	1,39	1,51	1,68	1,74	1,84	1,63
1986	1,87	1,54	1,81	1,68	1,52	1,43	1,48	1,60	1,60	1,85	1,78	1,62	1,72	1,34	1,55	1,71	1,79	1,84	1,60
1987	1,85	1,55	1,78	1,68	1,55	1,43	1,50	1,47	1,59	1,83	1,82	1,50	1,69	1,28	1,56	1,80	1,90	1,87	1,47
1988	1,83	1,56	1,77	1,68	1,57	1,46	1,56	1,42	1,70	1,81	1,83	1,50	1,66	1,32	1,55	1,84	1,98	1,93	1,42
1989	1,84	1,58	1,75	1,77	1,56	1,42	1,62	1,36	1,71	1,79	1,80	1,41	1,57	1,28	1,55	1,88	2,02	2,01	1,36
1990	1,90	1,62	1,74	1,83	1,59	1,45	1,67	1,33	1,78	1,77	1,83	1,40	1,54	1,26	1,62	1,93	2,13	2,08	1,33
1991	1,85	1,57	1,73	1,70	1,58	1,33	1,68	1,31	1,80	1,75	1,82	1,38	1,53	1,27	1,61	1,92	2,11	2,06	1,31
1992	1,89	1,56	1,73	1,71	1,58	1,29	1,76	1,32	1,85	1,74	1,79	1,38	1,50	1,30	1,59	1,88	2,09	2,05	1,32
1993	1,86	1,61	1,73	1,70	1,51	1,28	1,75	1,27	1,81	1,73	1,82	1,34	1,46	1,25	1,57	1,86	2,00	2,02	1,27
1994	1,84	1,55	1,72	1,67	1,49	1,24	1,81	1,20	1,85	1,73	1,74	1,36	1,50	1,22	1,57	1,87	1,88	2,00	1,20
1995	1,82	1,57	1,73	1,64	1,47	1,25	1,81	1,18	1,81	1,74	1,71	1,32	1,42	1,18	1,53	1,87	1,73	1,98	1,18
1996	1,80	1,55	1,73	1,59	1,50	1,30	1,75	1,15	1,76	1,75	1,72	1,30	1,43	1,21	1,53	1,89	1,60	1,98	1,15
1997	1,78	1,60	1,74	1,55	1,48	1,35	1,75	1,15	1,75	1,77	1,72	1,31	1,39	1,22	1,53	1,86	1,52	1,97	1,15
1998	1,76	1,60	1,75	1,53	1,47	1,36	1,72	1,16	1,70	1,78	1,71	1,26	1,38	1,21	1,63	1,81	1,50	2,00	1,16
1999	1,76	1,62	1,76	1,51	1,48	1,36	1,73	1,19	1,73	1,81	1,68	1,24	1,34	1,23	1,65	1,85	1,50	2,01	1,19
2000	1,76	1,67	1,77	1,49	1,50	1,38	1,77	1,23	1,73	1,89	1,64	1,26	1,36	1,26	1,72	1,85	1,54	2,06	1,23
2001	1,74	1,66	1,78	1,51	1,38	1,35	1,74	1,24	1,73	1,90	1,63	1,25	1,33	1,25	1,71	1,78	1,57	2,03	1,24
2002	1,76	1,66	1,79	1,52	1,39	1,34	1,72	1,26	1,72	1,88	1,64	1,27	1,32	1,27	1,73	1,75	1,65	2,01	1,26
2003	1,75	1,66	1,80	1,53	1,39	1,34	1,76	1,31	1,76	1,89	1,71	1,28	1,29	1,29	1,75	1,80	1,71	2,04	1,31
2004	1,77	1,72	1,81	1,53	1,42	1,36	1,78	1,32	1,80	1,92	1,77	1,30	1,29	1,33	1,72	1,83	1,75	2,05	1,32
2005	1,81	1,76	1,82	1,54	1,42	1,34	1,80	1,34	1,80	1,94	1,78	1,33	1,26	1,32	1,71	1,84	1,77	2,05	1,34
2006	1,88	1,80	1,82	1,59	1,44	1,33	1,85	1,37	1,84	2,00	1,84	1,40	1,32	1,35	1,72	1,90	1,85	2,10	1,37
2007	1,93	1,82	1,83	1,66	1,46	1,37	1,84	1,39	1,83	1,98	1,90	1,41	1,34	1,37	1,72	1,90	1,88	2,12	1,39
2008	1,93	1,86	1,83	1,68	1,48	1,38	1,89	1,46	1,85	2,01	1,96	1,51	1,37	1,42	1,77	1,96	1,91	2,08	1,46
2009	1,86	1,84	1,84	1,67	1,50	1,36	1,84	1,39	1,86	2,00	1,94	1,52	1,37	1,41	1,79	1,98	1,94	2,00	1,39
2010	1,87	1,84	1,84	1,63	1,52	1,39	1,87	1,38	1,87	2,03	1,98	1,51	1,39	1,41	1,79	1,95	1,98	1,93	1,38
2011	1,87	1,84	1,84	1,63	1,52	1,36	1,75	1,36	1,83	2,03	1,98	1,43	1,39	1,41	1,76	1,88	1,90	1,89	1,36

Source: own compilation based on data derived from World Development Indicators 2013.