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Fertility choice and financial development

Valerio Filoso [a], Erasmo Papagni [b,*]

[a] Department of Law, University of Naples, Via Mezzocannone 16, 80138 Naples NA, Italy
[b] Department of Economics, Second University of Naples, Corso Gran Priorato di Malta, 81043 Capua CE, Italy

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ABSTRACT

We study the consequences of broader access to credit and capital markets on household decisions over the number of children. A model of the net reproduction rate is estimated on data from 78 countries over the period 1995–2010. Liquidity constraints are approximated by private credit and household credit, while opportunities for financial investment are measured by domestic public debt. We use the Index of Financial Liberalisation (Abiad et al., 2009) as one of the instruments for financial variables. We find that improved access to credit increases fertility with an elasticity of around 30%, while the effect of the development of capital markets is negative (−10%). The regression model takes the role of social security into account. Quantile regression shows that our results are robust to outliers and parameter heterogeneity.

1. Introduction

Fertility behaviour and financial development have seen dramatic changes in recent decades, both showing distinctive patterns: as financial development spreads worldwide, enhancing the possibility of credit and intertemporal trade for households and firms, fertility shows a clear downward trend which is a cause for concern, especially in developed countries which will be facing decreasing populations in the near future.

Do these two phenomena simply show a spurious temporal correlation or does one cause the other? Financial development may be one of the driving forces that change fertility behaviour. Raising children requires a significant transfer of parents' resources in the children's favour, which may be driven not only by altruism, but also by the expectation that some resources will be returned during the parents' old age: this exchange is not synchronous and requires coordination of individual actions that can be best achieved by means of specialised institutions. Since the basic function of financial markets is to facilitate intertemporal trade, making current consumption less dependent on current income, better organised and diversified financial markets would make such transfers easier and induce parents to have more children. Nevertheless, the development of financial markets reduces the demand for children for the purpose of receiving old age support. The impact of financial development on fertility is therefore undetermined and should be assessed empirically.

A glimpse at the figures involved can give an idea of the radical change that has taken place. At the world level, the fertility rate, i.e., the average number of children per woman over her lifetime, dropped from 4.91 in 1960–1965 to 2.56 in 2005–2008, with large differences between country groups. While more developed regions recorded a decrease from 2.67 to 1.64, the rate in less

* Corresponding author.
E-mail addresses: filoso@unina.it (V. Filoso), papagni@unina.it (E. Papagni).

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developed countries has declined from 6.73 to 4.39.[1] Unlike fertility, financial development is a multifaceted phenomenon; many of its indicators also reveal a similarly striking trend. For example, the ratio of private credit to GDP has risen from 0.39 to 1.14 in high income countries and from 0.13 to 0.31 in LDCs. Similar patterns are followed by other financial variables whose values measure the breadth of opportunities for financial investment.[2]

The transition from high to low fertility has been analysed in depth in the fields of economics and demography. In the literature, the onset of a demographic transition is often ascribed to the rise in income and education and to the reduction in mortality (Galor (2012) surveys the literature). Indeed, increasing income brings about both the rise in the opportunity cost of raising children and an income effect which implies greater investment in the education of fewer children. Since the demographic transition often occurred during periods of sustained economic growth, it is argued that technological progress increased the incentive for human capital investment, causing a decline in fertility. Another important phenomenon that accompanied the fertility transition was the significant reduction in infant mortality. Whatever is the reason for having children, lower mortality should allow a smaller number of births.

Although other causes of the demographic transition have been investigated, to date no comprehensive analysis of the role of financial development has been performed.[3] The objective of this paper is to produce general and reliable evidence on the effects of borrowing constraints and opportunities for financial investment on the choice of the number of children.

To elucidate the channels through which financial development affects fertility, we introduce a four-period life-cycle model of choice in which fertility is endogenous and the household cares for its children and for its parents too. In this setting young adults might choose to borrow some resources and, when older, to save and invest in the capital market. We assume two main types of imperfections of financial markets (Pollin, 1997; McKinnon, 1973): *borrowing constraints* – the difficulties encountered by individuals when trying to reach their optimal level of debt – and *saving constraints*, which pertain to the uneasiness encountered by individuals who wish to invest their savings in a private financial market. We show that in the context of fertility determination, this distinction has both theoretical relevance and a significant empirical counterpart. The model shows that the effect of relaxing the borrowing constraint on fertility depends on: (1) an investment effect, whose positive sign is due to the reduction of future resources and to a corresponding greater investment in children, and (2) an income effect. Hence, when children are normal goods in a household's preferences, fertility will unambiguously increase. Broader access to capital markets allows parents to rely less on children to fund their old age welfare. Nonetheless, larger savings imply lower debt in the early years of adulthood: in this case the household will command a smaller amount of resources for consumption and children. Both effects imply that fertility decreases with greater opportunities for financial investment.[4]

In the econometric analysis we use a panel of 78 countries over the period 1995–2010 built by merging the data on fertility, social and economic indicators with those that describe the level of financial development and structure. Household access to the credit market is approximated by two variables: the ratio of private credit to GDP and the ratio of household credit to GDP. To capture the opportunities for financial investment we use the ratio of domestic public debt to GDP. Government bonds are characterised by low risk and significant supply even in economies where more sophisticated forms of financial investment are scant. Confirmation of this picture comes from data produced by Beck et al. (2010) who shows that the market capitalization of public bonds has figures comparable with those of private bonds and stocks or life insurance premiums.

One of the main challenges we faced in the econometric analysis was the possible endogeneity of financial variables in the fertility equation. Demographic variables such as age are known to be important determinants of wealth allocation in the life cycle and of risk-taking attitudes. These effects would seriously undermine any attempt to estimate the causal effect of financial development on fertility. Here our approach is to apply instrumental variable methods. Indeed, we use the Index of Financial Liberalisation produced by Abiad et al. (2009) as instrumental variable for credit and saving availability. This index focuses on financial markets and measures the extent of liberalisation with respect to credit controls and reserve requirements, interest rate controls, entry barriers, state ownership, policies on securities markets and banking regulations. It records the evolution of the institutions that directly and indirectly affect the development of financial markets. Reasonably, since most of this change is due to policy interventions, it should be considered exogenous with respect to the dynamics of fertility.

Our empirical results indicate that both borrowing constraints and investment opportunities impact fertility, yet in opposite directions, as predicted by the theory. The estimate of the elasticity of net fertility to private credit is positive and its value is around 32%. The econometric results are confirmed when we use a better proxy of household borrowing constraints: the value of total claims of deposit money banks on households as ratio to GDP provided by Beck et al. (2012) for a cross-section of 44 countries over the period 1994–2005. Using this variable in error components 2SLS regressions we find that the elasticity of net fertility to household credit takes values in the interval 0.2–0.3. The effect of domestic public debt on fertility can be quantified with an elasticity that takes negative values close to 12%. These results were obtained with the estimation of a model that includes a proxy for the pension system, which is an alternative to the financial market in the allocation of saving. Robustness of the econometric results to the presence of outliers and to possible heterogeneity of the parameters across countries was checked by the estimation of a panel quantile regression.

[1] The figures on fertility rates are accessible at http://data.un.org/.

[2] The figures on financial structure are accessible at World Bank website and at Ross Levine's personal website.

[3] Cigno and Rosati (1992) investigate the effects of household access to capital markets on fertility in Italy, finding empirical support for a negative effect. Some evidence on this issue comes from the literature on microcredit programmes: these studies show some controversial effects of increased financial availability on fertility. Nonetheless, such financial empowerment programmes are generally aimed at very poor people living in LDCs; accordingly, the external validity of these studies is questionable.

[4] The model characterises the main relations between financial markets and fertility choice which guide the econometric analysis, but it does not provide a general equilibrium interpretation of the phenomenon which would deal with the endogeneity of the financial system. Such a model would greatly complicate the analysis and is beyond the scope of the paper. However, in the econometric model we take into account the possible endogeneity of the proxies for borrowing and saving constraints.

The results significantly confirm and reinforce the rest of our estimates. Quantile regression also highlights a stronger effect of borrowing in high fertility countries.

The full set of estimates highlights the importance of financial development for the explanation of fertility across the world. Indeed, the estimated elasticities take values comparable with those of other fundamental variables. The net effect of financial variables is positive since credit availability increases fertility much more than access to capital markets reduces it. Hence, our econometric analysis suggests financial development acted to curb the declining trend in reproduction which we observe in recent decades across the world.

The remainder of the paper is organised as follows: Section 2 surveys the theoretical and empirical literature on the impact of financial variables on fertility; Section 3 describes the model determining household intertemporal allocation of income and fertility determination; Section 4 describes the empirical implementation of the theoretical model, specification and identification issues, the data used for estimation and the corresponding results; Section 5 discusses policy implications and concludes.

2. Literature review

In the economic literature, fertility behaviour is driven by selfish or altruistic motivations: adults can invest in children as an alternative to financial investment and public pension, or derive pleasure from children as durable consumption goods; alternatively, parents can be altruistic and caring about their children's well-being.

The models of the first type date back to the pioneering contribution of Leibenstein (1957) in which children, rather than being net consumers of family resources, actually increase their families' lifetime wealth. Although infants are completely dependent upon their family for their personal consumption, as they grow up they become capable of working and transferring income back to their families. As long as the value of resources returned by grown-up children exceeds the value of resources consumed as infants, fertility is a financially profitable trade from the standpoints of parents and children.

Cigno (1993) analyses the model of an extended family where members are selfish and follow some self-enforcing family rules according to which the parents lend to the children and are paid back in old age. Hence, the family is a substitute for the financial market. When the demand for children depends on financial returns, the availability of alternative assets becomes crucial. As financial markets start providing assets which offer high returns, some families would drop fertility as an investment and turn to the market as the return on financial assets exceeds the return on children. This hypothesis of complete substitutability between children and financial assets may be found in the development economics literature (Willis, 1980; Schultz, 1974; Neher, 1971) and suggests that better access to financial markets and investment opportunities would invariably lead to a decrease in planned fertility. Nonetheless, Razin and Sadka (1995) have shown that in a general equilibrium analysis financial deepening does not necessarily carry a drop in fertility. Introducing heterogeneity in preferences and technologies, as well as the basic equilibrium identity between aggregate saving and aggregate borrowing, financial trade opportunities allow some families to invest more in market assets and less in fertility, but at the same time other families must do the opposite, thus increasing fertility. The net balance between these competing forces may result in higher overall fertility.

A different and complementary view of the relation between financial development and fertility choice arises from models where it is generally assumed that parents are interested in children per se (Hotz et al., 1997; Becker and Barro, 1988; Willis, 1973; Becker and Lewis, 1973; Becker, 1960) and may find it profitable to borrow against the future in order to finance their children's consumption and investment in human capital. In this case, financial deepening and credit consumption availability may induce an increase in fertility.

The empirical literature provides just a few inquiries into this topic. Cigno and Rosati (1996) develop a model of joint determination of fertility and saving in which fertility behaviour can be driven by two mutually exclusive reasons: altruism or selfishness. In the first case, altruism in the utility function runs either backwards, from parents to children, or forwards from children to parents. In the second case, the impossibility of intertemporal trade and the decreasing value of human capital across time make fertility the only available technology for saving for old age. Using cointegration analysis on time series data for Germany, Italy, UK and USA, the authors find evidence compatible with the selfish motivation for fertility.

Cigno and Rosati (1992), employing cointegration analysis on Italian data, document a negative effect of capital market accessibility on fertility in the long run. The variable selected to proxy for financial development is the inverse of the ratio of currency held by the non-bank public to bank deposits. Boldrin et al. (2005) calibrate a model of fertility with social security and financial market imperfections to reproduce the US economy in 2000. They find that the elasticity of fertility to better access to capital markets is negative and significant. An alternative model by Scotese Lehr (1999) finds that financial intermediation can influence fertility in an indirect fashion. In an economy with two sectors – a traditional one with low capitalization and a modern one with high capitalization – an increase in the level of financial intermediation lowers the cost of capital, driving up wages in the modern sector. Households then reduce fertility as their members shift labour supply from the labour-intensive sector to the capital-intensive sector. Employing a reduced-form VAR model with panel data on 87 countries from 1965 to 1980, Scotese Lehr finds that two measures of the extent of financial intermediation Granger-cause a drop in fertility. Specifically, the estimated elasticity of fertility with regard to the ratio of money to GDP is −7.7% and the elasticity with regard to the ratio of private credit to GDP is −5.7%.

The link between financial empowerment of women and fertility is also a subject of investigation in the literature on evaluation of microcredit programmes, although in this regard the empirical evidence is inconclusive. Since most of such programmes target women, the additional financial resources provided tend to shift individual effort from childbearing to income-generating activities. At the same time, the wealth effect can increase the demand for children when these are normal goods. For example, some econometric studies of the Grameen Bank programme in Bangladesh (Steele et al., 2001; Schuler and Hashemi, 1994) observe an increased use of contraceptives resulting in lower fertility, while others (Pitt et al., 1999; Schuler et al., 1997) find that the impact of the same programme on contraceptive use is in fact negligible.

The literature surveyed in this section, while offering several competing perspectives on households' fertility behaviour, so far has not provided a general framework for its analysis in the context of imperfect capital markets. More specifically, previous contributions failed to distinguish between *borrowing constraints* and *limited access to capital markets* (*saving constraints*). Though interlinked, these imperfections have distinctive features and differential effects on fertility. *Borrowing constraints* refer to the inability of households to receive their optimal level of loans from the financial sector: in this case, the observed level of households' debt is lower than optimal. Conversely, *saving constraints* refer to the insufficient ability of the financial sector to collect savings from households: in this case, it is the level of savings to be suboptimal, since its financial return is constrained to be too low. These two types of imperfections have different impacts along the life cycle, as typically young families are net borrowers, whereas mature families are net lenders: accordingly, rational forward-looking fertility decisions must account for both imperfections. In what follows we aim to show that this overlooked distinction is crucial to understand the complex link between financial markets and households' fertility behaviour.

3. Theory

The model represents the choices of a household over the life cycle as determined by altruistic relations in the family and by trading relations with financial markets. We model intergenerational altruism assuming that parents care about the well-being of their children and their parents. Adults care about consumption of their children and fund it with transfers; similarly, grown-up children make gifts to their parents to sustain their old age consumption. This theoretical approach to altruistic preferences (Becker, 1974; Andreoni, 1989) is fairly general and widely adopted in the literature on the demand for children (Boldrin and Jones, 2002; Wigger, 1999; Nishimura and Zhang, 1992; Ehrlich and Lui, 1991; Eckstein and Wolpin, 1985).

The time sequences of household expenditure and income over the life cycle imply the need to borrow resources in the first years of adulthood and the incentive to save and invest in the capital market later on. Capital markets can be perfect, meaning that households can borrow and save the optimal amounts consistent with their intertemporal budget constraint. Several forms of imperfections, nonetheless, may limit credit availability to households with significant consequences on their decisions. Similarly, opportunities for financial investment can be scarce in economies where property rights are not well enforced and informational asymmetries between lenders and borrowers are severe. This situation has been termed a *savings constraint* in the literature (Pollin, 1997) and refers to the adverse role on savings played by a low level of financial deepening (McKinnon, 1973; Shaw, 1973). In this case, investing in children is an alternative to poor financial market conditions.

In what follows, for expository convenience, we first present the model with perfect financial markets, and then we turn to the distinct cases of borrowing constraints and limited access to capital markets. Though real economies often present both types of market imperfections, this expository strategy affords a better understanding of the consequences of each kind of market failure on fertility choice.

3.1. Timing and budget constraints

A household lives for four periods: it is young in the first, young adult in the second, adult in the third, and old in the fourth. Children are born during their parents' young adulthood and neither work nor have resources; they live with their parents who spend some resources to rear them. Young adults work and take care of their n_t children during the first period of adulthood; they still work when adult and take care of their old parents; they retire when old. The choice problem starts in the second period of life and spans the three remaining periods. The life-cycle utility function of a household member who is a young adult at date t is:

$$U = v\left(c_t^1, n_t\right) + u\left(c_{t+1}^2, c_{t+1}^3\right) + g\left(c_{t+2}^3\right), \tag{1}$$

where superscript denotes the period of life (0, 1, 2, 3), c_t^1 is consumption during early adulthood, n_t is the number of children, c_{t+1}^2 is consumption during late adulthood, c_{t+2}^3 is consumption during old age, and c_{t+1}^3 is consumption of the parents during their own old age. The functions $v(\cdot), u(\cdot), g(\cdot)$ are strictly concave and satisfy Inada conditions. Assuming that household utility is increasing in each argument, two of them represent altruism in the family: children (n_t) and old parents' consumption (c_{t+1}^3), implying forward and backward altruism, respectively.[5]

During each period, choices are constrained by intertemporal and intratemporal requirements according to the following schedule:

- In the second period of their life ((Eq. (1)) agents become adult and start working, get married, become parents, and use debt to finance their consumption and the cost of their children which includes consumption and other expenditures (e.g., education, health); they may face borrowing constraints. The budget constraint is:

$$c_t^1 = (1 - \tau n_t) w_t^1 + D_t \tag{2}$$

where τ is the cost of raising one child as a share of the labour income, w_t^1, and D_t is the amount of debt.

[5] Altruistic parents take care of both the number and consumption of children. In what follows, we adopt the standard simplifying assumption that children consumption is given exogenously.

- In the third period (Eq. (2)) parents keep working, pay back their debt, and save for their own old age. In addition, they support their parents by transferring money to them. At the beginning of the same period, the children leave parental house and start working. The budget constraint is:

$$c^2_{t+1} = w^2_{t+1} - R_{t+1}D_t - q_{t+1} - s_{t+1} \tag{3}$$

where w^2_{t+1} is labour income, $R_{t+1} \equiv 1 + r_{t+1}$ and r_{t+1} is the interest rate, q_{t+1} is a money transfer towards parents, and s_{t+1} is the value of saving.

During the same time period the agent's parents face the following budget constraint:

$$c^3_{t+1} = R_{t+1}s_t + n_{t-1}q_{t+1} \tag{4}$$

where q_{t+1} is the amount of transfers received by the parents from each child.

- In the fourth period ((Eq. (3)) agents do not work because of their old age. They live on payments from previous financial investments and possibly from transfers from their children. The budget constraint is

$$c^3_{t+2} = R_{t+2}s_{t+1} + n_t q_{t+2} \tag{5}$$

where q_{t+2} is the amount of transfers received by parents from each child.

3.2. The optimal choice

The young adult optimisation programme consists in maximising the utility function ((Eq. (1)) with respect to life-cycle consumption, the number of children, and parents' consumption, subject to the budget constraints (Eqs. (2)–(5)). Following the literature (e.g., Lagerlöf (1997); Nishimura and Zhang (1992)), we assume that the household maximises its utility taking future decisions of the children as given. The optimality conditions characterise the trade-off between the household's consumption in different ages. The adult also chooses the gift for her/his parent by equating the marginal increase of utility she/he derives from greater parent's consumption to the marginal utility cost, which is equally shared with siblings. Similarly, the optimal choice of the number of children follows from the balance between the marginal cost of a child in terms of utility and two marginal benefits: the first derives from greater child consumption and the second from the increase in the parent's future consumption due to financial support.[6] By the same token, household optimal choices imply that the gross rate of return on children – the ratio between the value of the gift divided by the cost of a child net of the benefit in terms of current consumption – is equal to the rate of return on financial investment:

$$\frac{q_{t+2}}{\tau w^1_t - \dfrac{\partial v/\partial n_t}{\partial v/\partial c^1_t}} = R_{t+1}R_{t+2}. \tag{6}$$

The model accounts for some of the most important features of adult life and highlights how they are affected by financial markets. When these markets work perfectly, the optimal decisions of the parents can be fully realized. In this respect, further insights come from the comparative statics of n_t with respect to some of the most important parameters. Proofs of the results are in the appendix.

The comparative statics effect of wages on fertility can be split into two parts. The first represents the cost of children and is negative. The second part is a combination between the standard income effect (positive when children are normal goods) and the negative effect of income on the decision to invest in children. Greater support from the children to the parents has two effects on fertility: q_{t+2} increases n_t since it modifies the trade-off between marginal benefit and marginal cost of fertility by increasing the return from investing in children, while the same change in q_{t+2} has income effects which are similar to those already discussed.

An increase in the interest rate has several effects on n_t. As the financial alternative to investment in children yields a higher return, fertility becomes more costly. In addition, the household faces stronger incentives to shift expenditure from current items, c^1_t, n_t, to the future c^2_{t+1}, c^3_{t+1}, c^3_{t+2}. The income effect of the interest rate depends on the net financial position of the household, which can borrow more than the amount it saves, or just the opposite. The resulting effect depends on the balance between the two income effects we identified in the discussion of the effect of wages on fertility.

Now, suppose that households cannot borrow against the future the desired amount of resources, since they undergo rationing in financial markets. This additional constraint prevents expenditure on children and consumption of young adults from exceeding the total amount of resources available during the first period of adulthood:

$$c^1_t = (1 - \tau n_t)w^1_t + \overline{D}_t \tag{7}$$

where $\overline{D}_t$ is the highest amount of resources that can be borrowed, exogenously given. The first order conditions for this problem resemble those found in the case without borrowing constraint. As shown in appendix, the influence of w^1_t on n_t can be interpreted in

[6] With regard to the trade-off between private consumption and fertility at time t, we assume that $\tau w^1_t > q_{t+2}/(R_{t+1}R_{t+2})$, i.e., that child rearing costs are large enough to forbid annihilation of consumption. This condition obtains an internally significant solution for fertility ($n_t < \infty$).

terms of income and cost of children effects as in the case of perfect markets. The same can be said of the comparative statics effect of the gift q_{t+2} on n_t. If the gift from each child increases, then parents can obtain the desired old age consumption by raising fewer children.

Higher credit availability will impact on household fertility according to two causal effects. As the value of $\overline{D}$ grows – more credit is available to households – young parents command a greater amount of their future resources, and spend these resources on consumption and children. Since children are normal goods in household preferences then n_t will increase. Furthermore, the same increase in $\overline{D}$ means less income available for consumption during retirement. Hence, the household will react by increasing investment in children, i.e., raising the number of children n_t.[7] Both effects imply that the sign of $dn_t \ d\overline{D}_t$ is positive.

Since children can also provide support for their retired parents, fertility becomes crucial in determining the optimal amount of saving. We analyse the model of household choice by assuming that the optimal desired value of saving s_{t+1} is higher than the ceiling $\bar{s}_{t+1}$. Hence, adults face the following constraint:

$$c^3_{t+2} = R_{t+2}\bar{s}_{t+1} + n_t q_{t+2}, \tag{8}$$

which shows that both financial investment and children contribute to ensure old age consumption. When the savings constraint is binding while household borrowing is not restricted, the life-cycle utility maximisation programme highlights the consequences of greater access to financial investment.

Again, the analysis of the effects of labour income on fertility can follow the lines of the preceding cases. The same can be said of the effects of q_{t+2} and R on n_t. According to comparative statics, fertility decreases with $\bar{s}_{t+1}$. Indeed, there is a trade-off between the investment in children and that in financial activities since greater financial investment opportunities reduce the need to raise children for old age consumption. Furthermore, given the intertemporal budget constraint, when $\bar{s}_{t+1}$ increases, young adults reduce their debt. As a result, their resources will be lower and fertility will drop.

In summary, our model suggests that improved access to credit induces households to have more children, while fertility unambiguously decreases with easier access to capital markets.[8] In the following section, we search for econometric evidence consistent with these predictions of the model.

4. Empirical analysis

The econometric exercise is carried out to find evidence for an economically significant impact of financial markets on fertility behaviour. In our estimates we use an unbalanced panel of five-year time series covering the period 1995–2010 for a maximum number of countries equal to 78. We first introduce our empirical specification, then turn to data description, and finally show various estimates along with some robustness checks.

4.1. Model specification

Our theoretical model predicts that desired fertility should be responsive, in opposite directions, both to borrowing constraints and to opportunities to access the capital markets. This feature is peculiar to our approach, since the literature does not distinguish between different sources of imperfections in financial markets.

The focus of our analysis is the number of surviving children, and the dependent variable of the econometric model should correctly approximate for *desired* fertility. In many countries infant/child mortality is not negligible, and may cause a significant difference between the number of births and the number of surviving children. In this respect, the use of the total fertility rate should be accompanied by the inclusion of child mortality among the explanatory variables. However, mortality variables are generally considered endogenous to fertility. The literature on the effect of child mortality on fertility deals with endogeneity with the selection of instrumental variables useful to reduce the bias in parameter estimates. However, the search is arduous and there is no broad agreement on the proposed instrumental variables. Furthermore, the role of child mortality in the demographic transition has been questioned in the recent debate (Galor, 2012). Indeed, theory clearly states that if parents appreciate surviving children, when mortality declines they reduce the number of births, leaving desired fertility unchanged. This could not be the case if survival were uncertain and parents had a precautionary demand for children. The evidence on the relevance of this theoretical hypothesis seems quite scant (Doepke (2005); Galor (2012)). In the context of this paper, the endogeneity of mortality would add to those of financial variables and per capita GDP, making the econometric analysis really hard. This is the main reason why we choose to approximate net fertility with the net reproduction rate (NRR). According to the definition of the United Nations, NRR is: "The average number of daughters a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates and the mortality rates of a given period. It is expressed as number of daughters per woman." The use

[7] If the model allowed for the quantity/quality trade-off, the parent could react to less resources during old age reducing fertility and investing more in the education of her children. This extension of the model would greatly complicate the derivation of comparative statics results; nonetheless, in the literature there is no evidence of the relevance of old age security hypothesis for the increase in education occurring in developing countries.

[8] Our model does not consider the case for bequests from parents to children. This extension of the model would not change the sign of the effect of released credit constraints on the young adult resources, hence on fertility. However, it would imply that the old age security hypothesis does not hold for obvious reasons. The resulting model would miss an important part of the explanation of fertility trends in the world.

of NRR as an alternative to the total fertility rate is common in the literature and is the choice of Scotese Lehr (2009) and Angeles (2010) among others.[9]

In what follows, we assume that the parameters q_{t+2} and τ differ across countries, but stay constant across time for each country. From the empirical point of view, fertility choice is deeply intertwined with a large number of economic and social variables. Many of these variables are unobservable in the publicly available data collections while others are intrinsically non-dimensional, like those related to deeply rooted mental habits, cultural influences, religious traditions, and the like. Given that these variables change only slowly, the fixed-effect panel estimator is the elective method of estimation. Accordingly, we formulate the empirical model:

$$\mathrm{NRR}_{i,t} = \beta_0 + \mathrm{BOR}'_{i,t}\beta_1 + \mathrm{FIN}'_{i,t}\beta_2 + \mathrm{X}'_{i,t}\beta_3 + u_i + \phi_t + \varepsilon_{i,t} \tag{9}$$

where BOR is a vector of variables used to approximate the ease of access to borrowing, FIN is a vector of variables describing the development of investment opportunities in capital markets, X is a set of variables which account for the main determinants of fertility, u is a country-specific, time-unvarying, random variable potentially correlated with the explanatory variables, ϕ is a time effect, and ε is a scalar disturbance term with $E[\varepsilon] = 0$. The subscript i is for countries, while t is for time periods. Each time observation is the average of the value of a given variable over a non-overlapping five-year period. The set of controls X includes per capita GDP, female and male education, and the rate of urbanisation.[10] This set also includes a proxy of the availability of public pension programmes. Indeed, in many countries, governments provide elders with publicly funded pensions financed through a pay-as-you-go system. This intergenerational transfer is made up by taxation on youths and a corresponding transfer to elders. Public pension systems diminish the need to access private financial markets for old age support, resulting at least in a partial offset of freely-chosen savings. In this context, the inclusion of some measure of public pensions in Eq. (9) could bring about a lower or negligible coefficient for private financial markets. Hence, the observed correlation between financial opportunities and fertility would simply mask a genuine causal relation running from public pensions to fertility. In our econometric analysis of cross-country fertility, other important control variables are the public expenditure on children (CHILDRENEXP) (see, e.g., Borck and Wrohlich (2011)) and the share of people who adhere to Catholic (CATHOLICS) and Islamic (MUSLIMS) religions. Data on these variables refer to one time period only, and we use them in random effects IV estimates.

The hypothesis that financial variables are endogenous to the NRR is of paramount importance in model estimation. Indeed, the rate of population change modifies the age structure which is one of the determinants of the allocation of assets in the life cycle. Age affects household portfolio choice through influence on the degree of risk aversion. If household preferences change over time then the birth year could have similar consequences on financial decisions.

Instrumental variable methods allow unbiased parameter estimates when variables strongly correlated with the endogenous variables and uncorrelated with the model error are used as instruments. We instrument the variables approximating for credit and financial investment with the Index of Financial Liberalisation (FINREFORM) produced at IMF (Abiad et al., 2009). The recent history of the financial sector in developed and developing countries highlights the importance of state intervention until a diffused process of liberalisation and deregulation took place starting from the early 1980s. Previously, the state had an important role in the ownership of banks and the allocation of credit was strongly regulated. Entry barriers restricted the supply of financial services and limited competition. Liberalisation of financial markets was the outcome of policy reforms implemented by governments in many countries. Often, those reforms were caused by events like economic crises, the formation of a new government, and the intervention of international financial institutions (Abiad and Mody, 2005). Hence, financial liberalisation can be considered exogenous to the choice of fertility.

The process of financial liberalisation can be interpreted in a political economy framework where a policy reform can be favoured by some interest groups, which face the opposition of other groups who gain more in the status quo (Burgoon et al., 2012). In this context, the quality of political institutions affects the likelihood of reforms in financial markets. In the same framework, Rajan and Zingales (2003) show that the opposition to financial liberalisation can be weakened by openness to trade and to capital flows. We agree with Rajan and Zingales and use the ratio between foreign trade and GDP (TRADE) as an instrumental variable for credit constraints and access to financial investment.

The econometric model allows for the likely endogeneity of per capita GDP as a consequence of reverse causality from the dynamics of population to economic growth. Hence, we add to the set of IVs the inflation rate (INFLATION), the index of investment freedom (INVESTFREEDOM) of the Heritage Foundation and the ratio of foreign trade to GDP. The first variable captures the impact of monetary policy on the economy, while openness is one of the main determinants of economic growth, as well as the constraints to private investment. We also expect significant effects of FINREFORM on GDP per capita because they are well documented in the literature.

4.2. Data description

The dependent variable in our regressions is the net reproduction rate which we take from the United Nations, World Population Prospects 2010.

[9] Though our theoretical model is developed under the assumption that planned and actual fertility coincide, to allow for discrepancies between them would be a straightforward mathematical extension. For an example see Azarnert (2006).

[10] In preliminary estimates the set of controls included the real interest rate, but its parameter was always not significant. Hence, in the following, we present regression results from models excluding the interest rate.

Table 1
Description of variables.

Variable	Description/source	Availability	
		From	Until
NRR	Log of net reproduction rate: number of children born to an average woman over her reproductive years United Nations (2010)	1995	2010
GDP	Log of per capita gross domestic product (2005's PPP units)	1995	2010
URBAN	Log of urbanisation rate	1995	2010
INFLATION	Inflation rate, consumer prices (annual percent change)	1995	2010
TRADE	Foreign trade (percentage of GDP) The World Bank (2010), World Development Indicators	1995	2010
SCHOOLINGFEM	Log of average years of schooling of women aged 15 and over	1995	2010
SCHOOLINGMAL	Log of average years of schooling of men aged 15 and over Barro and Lee (2010)	1995	2010
CATHOLICS	Percentage of catholics in the population	2000	2000
MUSLIMS	Percentage of Muslims in the population Barro (2003)	2000	2000
PRIVCRED	Log of total private credit by deposit money banks to GDP, deflated Beck et al. (2000)	1995	2010
DEBT	Log of public sector's domestic debt to GDP Panizza (2008)	1995	2007
SSECURITY	Social security payments to GDP	1995	2010
CHILDRENEXP	Children expenditure to GDP ILO, *The Social Security Expenditure Database*	1995	2010
SHAREGOVCONS	Log of share of government consumption at current PPPsc Penn World Table, version 8.0	1995	2005
FINREFORM	Index of financial reforms Abiad et al. (2009)	1995	2005
HOUSECRED	Log of total outstanding claims of deposit money banks on households as ratio to GDP Beck et al. (2012)	Average 1994–2005	
INVESTFREEDOM	Freedom of investment Heritage Foundation (2012)	1995	2010

The econometric model includes the main determinants of fertility (e.g., Ehrlich and Kim (2007); Schultz (1997)). Five variables approximate for the system of incentives faced by households in the choice of fertility. Data on the GDP per capita in 2005 purchasing parity units (GDP) come from the World Bank, World Development Indicators 2010 (WDI). The average years of schooling of women (SCHOOLINGFEM) and the average years of schooling of men (SCHOOLINGMAL), both aged 15 and over, are from the dataset of Barro and Lee (2010). As a proxy of public pensions we consider the ratio of public social protection (excluding health) expenditure to GDP (SSECURITY).[11] The source of these data is the IMF and they are available at the site of the International Labour Office for the years 1995–2007. We also include in some specifications the variable CHILDRENEXP. This variable accounts for the public social protection expenditure on benefits for children as a percentage of GDP. Data are released by the ILO for the years from 2008 to 2011. Given the sparse nature of this variable, in the estimates we consider this variable time unvarying and apply random effects panel methods. The social and economic characteristics of the environment relevant to reproduction are approximated by the rate of urbanisation (URBAN), drawn from the World Bank, WDI 2010, and by the variables CATHOLICS and MUSLIMS that refer to the year 2000 and are from Barro (2003).

Access to financial markets is approximated by three variables. Following the literature on other household choices (e.g., savings and education, Loayza et al. (2000); De Gregorio (1996)), we use the ratio of private credit by deposit money banks to GDP (PRIVCRED) as a proxy for borrowing constraints. Data on this variable come from the Financial Development and Structure Database of the World Bank Research Department (Beck et al. (2000)). While private credit includes credit to the business sector, Beck et al. (2012) provide the ratio of household credit (HOUSECRED) to GDP for 45 countries averaged over the years 1994–2005. We use this better proxy for access to credit as a robustness check of our regression results.

To capture the degree of development of the other side of capital markets, namely financial investment, we use data on one of the most popular forms of investment: public bonds. Indeed, often countries where financial markets find the minimal conditions for their existence see the significant presence of assets issued by the public administration, as shown by Beck et al. (2010). Actually, the supply of public bonds is favoured by the considerable size of state assets in every modern economy and the consequent low risk of default which attracts a wide public of risk-averse savers. The sustained and widespread growth of public expenditure worldwide after World War II was another major reason for the increase in the share of public bonds on financial markets. However, public bonds can also be sold to foreign institutions. Hence, external public debt cannot be used to approximate the range of financial investment opportunities available to domestic households. We use the data from Panizza (2008) to obtain the ratio of domestic public debt held by residents to GDP (DEBT) for more than 100 countries in the years from 1990 to 2007.

[11] For a comprehensive survey on the economic and political factors shaping modern social security systems see Galasso and Profeta (2002).

Table 2
Descriptive statistics.

Variable	N	Mean	σ	Min	Max	Quartiles 25%	50%	75%
NRR	574	0.19	0.43	−0.90	1.04	−0.16	0.18	0.59
GDP	529	8.60	1.27	5.62	11.26	7.57	8.65	9.61
URBAN	606	3.89	0.53	2.03	4.61	3.55	4.03	4.30
INFLATION	494	0.08	0.11	−0.37	0.99	0.03	0.05	0.08
TRADE	539	90.24	49.96	0.67	422.02	56.68	80.05	112.27
SCHOOLINGFEM	432	2.05	0.44	0.51	2.62	1.82	2.19	2.36
SCHOOLINGMAL	432	1.97	0.43	0.05	2.55	1.77	2.09	2.27
CATHOLICS	342	0.30	0.33	0.00	0.94	0.01	0.11	0.58
MUSLIMS	342	0.25	0.36	0.00	0.99	0.00	0.04	0.39
PRIVCRED	459	0.33	0.25	0.02	1.31	0.13	0.27	0.48
DEBT	337	2.80	1.02	0.00	4.80	2.18	2.95	3.56
SSECURITY	217	9.54	6.85	0.01	24.32	3.20	9.26	15.58
CHILDRENEXP	264	0.97	1.07	0.00	4.15	0.13	0.54	1.46
SHAREGOVCONS	501	0.20	0.11	−0.00	0.78	0.13	0.17	0.25
FINREFORM	270	13.74	4.77	0.81	21.00	10.40	14.10	17.60
HOUSECRED	135	0.28	0.24	0.03	0.99	0.08	0.18	0.42
INVESTFREEDOM	496	51.33	18.91	10.00	90.00	35.00	50.00	70.00

The following variables are used as instruments. The Index of Financial Liberalisation (FINREFORM) is constructed by Abiad et al. (2009) as the sum of seven components measuring reforms in credit controls and reserve requirements, interest rate controls, entry barriers, state ownership, policies on securities markets, banking regulations and restrictions on the capital account. Data refer to 91 countries over the period 1973–2005. INVESTFREEDOM is one of the components of the Index of Economic Freedom produced by The Heritage Foundation. The set of IV is completed by two variables drawn from WDI: the inflation rate, and the ratio of foreign trade to GDP.

The dependent variable NRR and all the explanatory variables but SSECURITY, are expressed in logarithms.

The sources and description of the data of each variable are reported in Table 1, while basic statistics and a correlation matrix are reported respectively in Table 2 and in Table 3. The reported figures are for the complete sample, while the various subsamples used for estimation are made up of observations for which the whole set of variables – dependent and independent – are non-missing. Accordingly, each estimation table reports the number of countries and the number of observations included in the calculation.

Table 3
Cross-correlations.
Time-varying variables net of fixed effects.

NRR	1.000												
SCHOOLINGFEM	−0.438	1.000											
	(0.000)												
SCHOOLINGMAL	−0.407	0.993	1.000										
	(0.000)	(0.000)											
URBAN	−0.437	0.632	0.623	1.000									
	(0.000)	(0.000)	(0.000)										
SSECURITY	−0.329	0.184	0.154	0.028	1.000								
	(0.000)	(0.046)	(0.096)	(0.761)									
GDP	−0.025	0.549	0.548	0.364	−0.134	1.000							
	(0.788)	(0.000)	(0.000)	(0.000)	(0.148)								
PRIVCRED	0.252	0.198	0.191	0.107	−0.244	0.698	1.000						
	(0.006)	(0.031)	(0.039)	(0.247)	(0.008)	(0.000)							
DEBT	−0.411	0.188	0.200	0.117	0.169	−0.173	−0.302	1.000					
	(0.000)	(0.042)	(0.030)	(0.208)	(0.068)	(0.061)	(0.001)						
INFLATION	−0.003	−0.170	−0.174	−0.208	0.004	−0.481	−0.246	0.256	1.000				
	(0.970)	(0.066)	(0.059)	(0.024)	(0.963)	(0.000)	(0.007)	(0.005)					
TRADE	−0.196	0.393	0.384	0.270	0.110	0.578	0.271	0.206	−0.141	1.000			
	(0.033)	(0.000)	(0.000)	(0.003)	(0.236)	(0.000)	(0.003)	(0.025)	(0.128)				
INVESTFREEDOM	0.337	−0.506	−0.502	−0.334	−0.011	−0.195	0.188	−0.118	0.161	−0.185	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.910)	(0.035)	(0.042)	(0.205)	(0.081)	(0.045)			
FINREFORM	−0.276	0.616	0.614	0.409	0.013	0.834	0.557	0.037	−0.471	0.544	−0.281	1.000	
	(0.002)	(0.000)	(0.000)	(0.000)	(0.892)	(0.000)	(0.000)	(0.687)	(0.000)	(0.000)	(0.002)		
SHAREGOVCONS	−0.057	−0.254	−0.243	−0.196	0.244	−0.549	−0.364	0.085	0.428	−0.291	0.270	−0.538	1.000
	(0.543)	(0.006)	(0.008)	(0.034)	(0.008)	(0.000)	(0.000)	(0.359)	(0.000)	(0.001)	(0.003)	(0.000)	

Notes — The table reports the unconditional correlation coefficients between the variables. Probability values in parentheses.

Table 4
Fixed effects estimation.

	(1)	(2)	(3)	(4)
GDP	0.075	0.003	0.114	0.019
	(1.142)	(0.035)	(1.547)	(0.210)
SCHOOLINGFEM	−0.703	−0.546	−1.044	−0.837
	(−0.809)	(−0.633)	(−1.124)	(−0.935)
SCHOOLINGMAL	0.454	0.379	0.917	0.774
	(0.490)	(0.416)	(0.914)	(0.802)
URBAN	−0.464**	−0.512**	−0.260	−0.255
	(−2.370)	(−2.275)	(−1.219)	(−1.057)
SSECURITY	−0.007	−0.008	−0.010**	−0.012***
	(−1.373)	(−1.453)	(−2.298)	(−2.831)
PRIVCRED		0.146**		0.148**
		(2.435)		(2.007)
DEBT			−0.051**	−0.044
			(−2.233)	(−1.578)
Statistics				
Observations	201	195	158	152
Countries	78	76	70	68
R^2 within	0.319	0.381	0.433	0.497
F test prob. for time dummies	0.000	0.000	0.001	0.001

Notes — Dependent variable: Log of net reproduction rate. Temporal dummies are included. Country-clustered Student's *t* in parentheses. Statistical significance asterisks: * = 10%, ** = 5%, *** = 1%.

Table 5
Instrumental variables estimation.

	MODELS								
	A		B		C		D		E
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	GMM	LIML	GMM	LIML	GMM	LIML	GMM	LIML	EC2SLS
GDP	−0.079	−0.074	−0.173*	−0.186	−0.098	−0.127	−0.270**	−0.268**	−0.316**
	(−0.894)	(−0.794)	(−1.647)	(−1.616)	(−1.132)	(−1.299)	(−2.217)	(−1.961)	(−2.278)
SCHOOLINGMAL	1.885**	2.223**	2.033**	2.136**	3.066**	3.119**	2.966**	3.253**	0.906
	(1.996)	(2.266)	(2.054)	(2.096)	(2.062)	(2.085)	(2.083)	(2.210)	(0.734)
SCHOOLINGFEM	−2.029**	−2.327**	−1.990**	−2.082**	−3.109**	−3.167**	−2.831**	−3.062**	−1.165
	(−2.314)	(−2.558)	(−2.146)	(−2.173)	(−2.328)	(−2.353)	(−2.187)	(−2.294)	(−1.023)
URBAN	−0.447*	−0.524**	−0.860***	−0.821***	−0.224	−0.108	−0.519*	−0.506*	−0.158
	(−1.766)	(−1.983)	(−3.169)	(−2.947)	(−0.660)	(−0.296)	(−1.721)	(−1.689)	(−0.665)
SSECURITY	−0.002	−0.002	−0.002	−0.002	−0.005	−0.005	−0.004	−0.006	0.006
	(−0.493)	(−0.506)	(−0.496)	(−0.328)	(−1.010)	(−0.925)	(−0.813)	(−1.070)	(0.936)
PRIVCRED			0.300***	0.326**			0.323**	0.288	0.337*
			(2.759)	(2.539)			(2.354)	(1.604)	(1.949)
DEBT					−0.124***	−0.118***	−0.137***	−0.115***	−0.140***
					(−3.902)	(−3.069)	(−4.222)	(−2.632)	(−4.353)
CHILDRENEXP									0.049
									(0.840)
CATHOLICS									0.107
									(0.670)
MUSLIMS									−0.252
									(−0.852)
Dummy for years 2005–2010	0.067***	0.068***	0.038***	0.036**	0.054***	0.060***	0.045**	0.049***	0.034
	(5.051)	(5.006)	(2.818)	(2.353)	(3.078)	(3.096)	(2.575)	(2.614)	(1.625)
Dummy for OECD high income country									0.031
									(0.129)
Statistics									
Observations	155	155	149	149	117	117	111	111	77
Countries	57	57	55	55	47	47	45	45	36

Notes — Dependent variable: Log of net reproduction rate. Models A–D are estimated with GMM and LIML with country-clustered Student's *t* in parentheses. Model E is estimated with Error Components 2SLS with bootstrapped Student's *t* in parentheses. Model A includes as instruments for GDP: INFLATION, TRADE, and FINREFORM. Model B includes as instruments for GDP and PRIVCRED: INFLATION, TRADE, FINREFORM, and INVESTFREEDOM. Model C includes as instruments for GDP and DEBT: INFLATION, INFLATION^2, TRADE, and FINREFORM. Model D includes as instruments for GDP, PRIVCRED, and DEBT: INFLATION, INFLATION^2, TRADE, FINREFORM, and INVESTFREEDOM. Model E includes as instruments for GDP, PRIVCRED, and DEBT: INFLATION, INFLATION^2, TRADE, log of TRADE, FINREFORM, log of FINREFORM, and INVESTFREEDOM. Model E also includes as additional controls the percentage of catholics and the percentage of muslims. Statistical significance asterisks: * = 10%, ** = 5%, *** = 1%.

Table 6
Instrumental variables estimation.
Diagnostic tests.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	GMM	LIML	GMM	LIML	GMM	LIML	GMM	LIML	RNDM
Observations	155	155	149	149	117	117	111	111	77
Countries	57	57	55	55	47	47	45	45	36
R^2 within	0.306	0.313	0.388	0.371	0.322	0.316	0.304	0.388	
A. Hansen's J									
Statistic	2.688	2.619	2.570	2.425	0.742	0.739	1.183	1.136	15.609
p-Value	0.261	0.270	0.277	0.298	0.690	0.691	0.554	0.567	0.552
C. Anderson–Rubin Wald test									
χ^2 statistic	4.933	4.933	17.707	17.707	23.031	23.031	34.837	34.837	
p-Value	0.177	0.177	0.001	0.001	0.000	0.000	0.000	0.000	
D. Angrist–Pischke test for GDP									
F statistic	38.577	38.577	33.214	33.214	28.550	28.550	9.766	9.766	
p-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
χ^2 statistic	123.406	123.406	107.288	107.288	93.996	93.996	32.634	32.634	
p-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
E. Angrist–Pischke test for log of private credit/GDP									
F statistic			12.230	12.230			9.438	9.438	
p-Value			0.000	0.000			0.000	0.000	
χ^2 statistic			39.506	39.506			31.538	31.538	
p-Value			0.000	0.000			0.000	0.000	
F. Angrist–Pischke test for log of debt/GDP									
F statistic					18.152	18.152	15.574	15.574	
p-Value					0.000	0.000	0.000	0.000	
χ^2 statistic					59.762	59.762	52.042	52.042	
p-Value					0.000	0.000	0.000	0.000	

Notes — The statistical tests in each column refer to the corresponding columns in Table 5. Stock–Yogo's critical values for Angrist–Pischke F test of weak identification: Models 2, 4, 6, and 8 at 10% maximal LIML size 6.46; Model 1 at 5% maximal IV relative bias 13.91; Models 3 and 7 at 10% maximal IV relative bias 9.08; Model 5 at 5% maximal IV relative bias 16.85.

4.3. Econometric methods and results

The model is estimated under different specifications and with different methods. Specifications start from the basic equation, to which we add PRIVCRED and DEBT. We estimate a panel fixed effects model using OLS and two IV methods: two-step Generalized Method of Moments (GMM) and Limited Information Maximum Likelihood (LIML). OLS, GMM and LIML adopt clustered by country robust estimators of the standard errors of the model.[12]

Table 4 presents the OLS fixed effects estimates of several models. Among the most important determinants of the net reproduction rate we find the ratio of private credit to GDP that shows a significant positive effect with an elasticity of 15%. The variables DEBT and SSECURITY have significant parameter estimates with a negative sign as expected. The estimate of the elasticity of NRR to DEBT is −5.1%.

The endogeneity of per capita GDP and the financial variables is addressed with IV estimates presented in Table 5. GMM provides efficient parameter estimates – i.e., with minimum asymptotic variance – under general heteroskedasticity. The LIML estimator is a useful alternative because it is more robust to the presence of weak instruments (Stock and Yogo, 2005), although it assumes i.i.d. errors. Table 5 shows the results of the estimation of the same specifications of Table 4 with GMM and LIML. Table 6 provides a large set of statistics useful for the evaluation of IV estimates. The results of the first-stage regression for the model with PRIVCRED and the model with DEBT are in Table 7.

In the IV regression results, the basic model of fertility is confirmed and reinforced. Indeed, almost in every specification the schooling variables and the rate of urbanisation show significant and sizeable parameters. Per capita GDP confirms the minor role it displays in OLS estimates, which is not peculiar to this paper. The model which includes PRIVCRED among regressors is estimated with GMM and LIML using INFLATION, TRADE, FINREFORM, and INVESTFREEDOM as instruments for the endogenous variables per capita GDP and PRIVCRED. It is worth noting the small difference of GMM with respect to LIML parameter estimates, notwithstanding the lack of robustness to heteroskedasticity of the latter estimation method. The parameter of PRIVCRED is still significant and positive, showing a value around 0.32, greater than the OLS estimate. The positive effect of instrumenting PRIVCRED on its parameter estimate can be explained as the effect of measurement error due to the statistical content of the variable that includes not just credit to households, but credit to the business sector too. Instrumental variables may correct the attenuation effect in OLS estimates. In the following we will present the estimation results of a model that includes a measure of credit to households.

The results of the IV estimation of the effect of access to financial investment on net fertility are presented in Table 5. The set of instruments for GDP and DEBT includes the variables: INFLATION, INFLATION squared, TRADE, and FINREFORM. The addition of the ratio of domestic public debt to GDP to the basic model provides a test of the theory in Section 3. Indeed, IV estimates confirm the

[12] The computation was conducted using the STATA command xtivreg2 (Baum et al., 2003).

Table 7
Instrumental variable estimation.
First stage estimates.

	Models							
Correspondence to Tables 5 and 6	Columns 3–4				Columns 5–6			
Estimation technique →	GMM		LIML		GMM		LIML	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Endogenous variables →	GDP	PRIVCRED	GDP	PRIVCRED	GDP	DEBT	GDP	DEBT
SCHOOLINGFEM	0.592	1.330	0.592	1.330	1.045	−8.149	1.045	−8.149
	(0.409)	(0.889)	(0.409)	(0.889)	(0.523)	(−1.212)	(0.523)	(−1.212)
SCHOOLINGMAL	−0.076	−1.181	−0.076	−1.181	−0.500	10.667	−0.500	10.667
	(−0.050)	(−0.771)	(−0.050)	(−0.771)	(−0.244)	(1.494)	(−0.244)	(1.494)
URBAN	−0.388	−0.112	−0.388	−0.112	−0.378	−0.319	−0.378	−0.319
	(−1.356)	(−0.317)	(−1.356)	(−0.317)	(−1.220)	(−0.232)	(−1.220)	(−0.232)
SSECURITY	−0.017***	−0.021**	−0.017***	−0.021**	−0.026***	0.045	−0.026***	0.045
	(−3.074)	(−2.655)	(−3.074)	(−2.655)	(−2.965)	(1.598)	(−2.965)	(1.598)
TRADE	0.002**	−0.002	0.002**	−0.002				
	(2.028)	(−1.483)	(2.028)	(−1.483)				
FINREFORM	0.026***	0.017***	0.026***	0.017***	0.023***	−0.041*	0.023***	−0.041*
	(5.632)	(3.478)	(5.632)	(3.478)	(3.825)	(−1.930)	(3.825)	(−1.930)
INFLATION	−0.444***	−0.108	−0.444***	−0.108	−0.807**	−2.849	−0.807**	−2.849
	(−4.047)	(−1.388)	(−4.047)	(−1.388)	(−2.275)	(−1.634)	(−2.275)	(−1.634)
$INFLATION^2$					0.555	5.870***	0.555	5.870***
					(1.318)	(2.726)	(1.318)	(2.726)
INVESTFREE	0.002**	0.007***	0.002**	0.007***	0.004***	−0.001	0.004***	−0.001
	(2.316)	(5.469)	(2.316)	(5.469)	(3.086)	(−0.173)	(3.086)	(−0.173)
Log of TRADE					0.046	1.492***	0.046	1.492***
					(0.441)	(3.242)	(0.441)	(3.242)
Dummy for years 2005−2010	0.101***	0.125***	0.101***	0.125***	0.167***	−0.205**	0.167***	−0.205**
	(5.628)	(5.700)	(5.628)	(5.700)	(5.745)	(−2.312)	(5.745)	(−2.312)
Statistics								
Observations	149	149	149	149	111	111	111	111
Countries	55	55	55	55	45	45	45	45

Notes — Dependent variable: Log of net reproduction rate. Standard error in parentheses. Statistical significance asterisks: * = 10%, ** = 5%, *** = 1%.

results of OLS regressions which maintain that greater opportunities of financial investment reduce the desired number of children. The joint significance of the parameters of PRIVCRED and DEBT provides support to one of the main results of the theory that maintains borrowing constraints and access to financial investment have quite distinct effects on household behaviour and fertility. When the model includes both DEBT and PRIVCRED, the estimated elasticity of DEBT amounts to around −13%, while the same elasticity remains close to 30% for PRIVCRED. The model in the last column of Table 5 displays the results of the estimates with the inclusion of the controls CHILDRENEXP, CATHOLICS, MUSLIMS and a dummy variable for high-income OECD countries to the set of explanatory variables. Because these variables do not vary over time, we apply the two-stage least-squares error-components model (EC2SLS) proposed by Baltagi (1981). The main results of model estimation remain robust after the enlargement of the set of explanatory variables.

The reliability of the results of IV estimation depends on several hypotheses which underlie the use of GMM and LIML methods. Table 6 presents the statistics of some tests of the general specification and the quality of instrumental variables. The Sargan–Hansen J statistic is a general test of specification that under the null maintains the validity of the overidentifying restrictions. In the case of EC2SLS, this statistic also tests the hypothesis of random effects. The values of the J statistic in Table 6 show that the specifications cannot be rejected. Furthermore, a recent strand of the econometric literature highlights the risks involved in the use of excluded instrument which are not strongly correlated with the endogenous variables. Underidentification of an endogenous variable can be tested by the Angrist–Pischke chi-squared statistic (Angrist and Pischke, 2009). The values of the statistic we obtain are clearly against the null of underidentification of each of the three endogenous variables.

The Angrist–Pischke F statistic allows a test of weak identification. This phenomenon arises when the correlation between the endogenous variable and its instruments is not zero but small. Critical values for this test are not available. One possibility is the use of the Stock–Yogo (Stock and Yogo, 2005) critical values for the Cragg–Donald F statistic with one endogenous regressor. The null hypothesis is that a given group of instruments is weak against the alternative that it is strong, under two definitions of weak instruments: instruments are weak if the bias of the IV estimator, relative to the bias of OLS, could exceed a certain threshold b; instruments are weak if the conventional α-level Wald test based on IV statistics has an actual size that could exceed a certain threshold r. Interestingly, Stock–Yogo critical values for LIML estimates are lower than those for GMM, reflecting greater robustness of the former method to the presence of weak instruments. Applying the test to the endogenous variables in Table 6, we find strong rejection of the null with respect to GDP, while PRIVCRED and DEBT often lead to the rejection of the weak IV hypothesis. In this respect, Table 6 displays the estimates of the Anderson–Rubin (Anderson and Rubin, 1949) test statistic that is robust to the use of weak instruments. The null hypothesis maintains the coefficients of the endogenous regressors are jointly equal to zero. The estimated values in Table 6 show that

in most of the specifications the null cannot be accepted. The relevance of the instruments we use in estimates can be further appreciated with a glance at Table 7 that presents the first stage estimation results. In particular, FINREFORM and other IVs enter the equations with significant parameters, as expected.

One question which arises from the use of PRIVCRED as a proxy for household borrowing constraints is the inclusion of credit channelled to the business sector. Although both components of private credit probably display similar temporal trends and high cross-country correlation, the robustness of the results we obtained should be assessed through the use of data specific to household credit. In this regard, we consider data on household credit (HOUSECRED) available for a cross-section of 44 countries over the period 1994–2005. Here, we apply again EC2SLS methods. The results are in Table 8. We estimate four models which include HOUSECRED among regressors. The differences depend on the inclusion of DEBT and CHILDRENEXP among explanatory variables with effects on the number of countries in the sample. When the endogenous variables are GDP and HOUSECRED the instruments are: INFLATION, TRADE, FINREFORM, and INVESTFREEDOM. To estimate models that assume GDP, HOUSECREDIT, and DEBT are endogenous variables we use INFLATION, INFLATION squared, TRADE, FINREFORM, and INVESTFREEDOM as IVs. The parameter of HOUSECRED is again positive and precisely estimated, displaying an elasticity with respect to NRR in the range 20–30%. Hence, the use of a better proxy for household credit provides a more realistic estimate of the effect of borrowing constraints on fertility. We also provide a further test of the robustness of our results to model specification with the estimation of an equation that includes the share of government consumption in GDP (SHAREGOVCONS). Indeed, although our estimates take several forms of government intervention into account, some could be missing and they could be approximated by SHAREGOVCONS. Data on SHAREGOVCONS are from Penn World Tables 8.0. The results of GMM and LIML within panel estimates are shown in the last two columns of Table 8. The inclusion of SHAREGOVCONS is justified and the overall results are significantly confirmed. More in general, Table 8 shows how DEBT enters all the specifications with significant parameter estimates close to −0.10.

The complete econometric exercise not only highlights the importance of financial development for the choice of the number of children, but it also clarifies that the positive effect of released borrowing constraints exceeds the negative one due to more extensive access to capital markets. Hence, financial development does seem responsible for a check on the declining trend of fertility worldwide.

4.4. Quantile regression

The picture obtained by the preceding set of estimations provides evidence that financial development, proxied by PRIVCRED and DEBT, does play a role in the determination of fertility. Nonetheless, it may be of interest to check the robustness of our estimates to outliers and whether the size of the estimated effects carries over the whole distribution of fertility; this is also motivated by the prior

Table 8
Robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.034	−0.023	0.046	−0.008	−0.384**	−0.451**
	(0.371)	(−0.252)	(0.491)	(−0.080)	(−2.342)	(−2.330)
HOUSECREDIT	0.266***	0.198**	0.305***	0.226*		
	(3.133)	(2.089)	(3.269)	(1.764)		
SCHOOLINGFEM	−1.095	−1.293	−1.279	−0.884	−3.490***	−3.644***
	(−1.221)	(−1.248)	(−0.850)	(−0.509)	(−3.249)	(−3.165)
SCHOOLINGMAL	0.812	0.931	1.095	0.450	3.731***	3.946***
	(0.911)	(0.834)	(0.728)	(0.254)	(3.201)	(3.138)
URBAN	−0.369*	−0.258	−0.569**	−0.420*	−0.490*	−0.467
	(−1.760)	(−1.211)	(−2.325)	(−1.680)	(−1.717)	(−1.536)
SSECURITY	−0.004	−0.007*	−0.001	−0.006	−0.003	−0.003
	(−0.824)	(−1.737)	(−0.176)	(−0.809)	(−0.534)	(−0.374)
DEBT		−0.067**		−0.096**	−0.105***	−0.108***
		(−2.029)		(−2.075)	(−2.839)	(−2.612)
CHILDRENEXP			0.008	0.012		
			(0.164)	(0.218)		
PRIVCRED					0.368*	0.445*
					(1.909)	(1.924)
SHAREGOVCONS					−0.384*	−0.426*
					(−1.857)	(−1.886)
Statistics						
Observations	106	81	94	69	108	108
Countries	41	37	35	31	44	44
R^2	0.445	0.475	0.446	0.543	0.373	0.296
Hansen *J*						
Statistic	12.697	7.153	14.878	13.928	3.040	2.885
p-Value	0.391	0.894	0.248	0.379	0.219	0.236

Notes — Dependent variable: Log of net reproduction rate. Bootstrapped Student's *t* in parentheses. Models 1–4 are estimated with EC2SLS, Model 5 with GMM, Model 6 with LIML. Models 1 and 3 include as instruments for GDP and HOUSECREDIT: INFLATION, TRADE, FINREFORM, and INVESTFREEDOM. Models 2 and 4 include as instruments for GDP, HOUSECREDIT, and DEBT: INFLATION, INFLATION^2, TRADE, FINREFORM, and INVESTFREEDOM. Models 5 and 6 include as instruments for GDP, PRIVCRED, and DEBT: INFLATION, INFLATION^2, Log of TRADE, FINREFORM, and INVESTFREEDOM. Temporal and regional dummies included. Statistical significance asterisks: * = 10%, ** = 5%, *** = 1%.

Table 9
Quantile regressions.

	Quantiles of the distribution				
	(1)	(2)	(3)	(4)	(5)
	10%	25%	50%	75%	90%
SCHOOLINGFEM	−0.914***	−0.795***	−0.839***	−0.841***	−0.698***
	(−6.323)	(−7.603)	(−8.002)	(−5.889)	(−4.106)
SCHOOLINGMAL	0.765***	0.695***	0.775***	0.812***	0.664***
	(5.014)	(6.303)	(7.006)	(5.394)	(3.704)
URBAN	−0.259***	−0.261***	−0.255***	−0.249***	−0.261***
	(−16.351)	(−22.791)	(−22.253)	(−15.938)	(−14.026)
SSECURITY	−0.011***	−0.012***	−0.012***	−0.012***	−0.011***
	(−11.382)	(−17.010)	(−16.497)	(−11.773)	(−9.263)
GDP	0.041***	0.031***	0.019**	0.006	−0.004
	(3.684)	(3.888)	(2.400)	(0.533)	(−0.321)
DEBT	−0.047***	−0.044***	−0.044***	−0.040***	−0.043***
	(−7.488)	(−9.703)	(−9.676)	(−6.427)	(−5.832)
PRIVCRED	0.111***	0.137***	0.148***	0.150***	0.217***
	(3.783)	(6.410)	(6.937)	(5.172)	(6.278)

Notes — Dependent variable: Log of net reproduction rate. Bootstrapped Student's *t* in parentheses. Temporal dummies included country-specific fixed effects partialled out. Each column reports regression coefficients for the given percentile of the dependent variable's distribution. Statistical significance asterisks: * = 10%, ** = 5%, *** = 1%.

that countries with high levels of fertility (typically those of the Sub-Saharan area) may react differently than those which already have transitioned to permanently low fertility because of unobserved variables. To address this issue, we employ a quantile regression estimator (Koenker, 2005) on our panel of countries and account for the fixed effect component using the two-step method suggested by Fitzenberger (2012):

1. we regress the net reproduction rate on the standard set of regressors, including two dummies for temporal effects, using a FE-OLS estimator; next, we subtract from the net reproduction rate the estimated fixed effect;
2. we perform quantile regressions of the resulting variable on the standard set of regressors.

Finally, we bootstrap standard errors. The results for this exercise are displayed in Table 9 and substantially corroborate the previous econometric analysis based on conditional mean functions. The evidence suggests that, with the exception of URBAN, SSECURITY, and DEBT, all regressors show a substantial degree of heterogeneity across the fertility spectrum. More specifically, women's and men's schooling vary across quantiles without following any definite trend, while PRIVCRED and GDP follow a detectable pattern. The positive effect of PRIVCRED on fertility is relatively low (0.111) for the first percentiles – the countries with low fertility – whereas it doubles (0.217) at top fertility percentile. This result shows a very peculiar type of unintended consequences of financial development: interestingly, high fertility countries may see their fertility problems affected by financial opportunities more than low fertility countries.

More generally, we find that the gradient of the effect of GDP is increasing across quantiles, going from 0.041 to a negligible −0.004 ($p = 0.749$): this suggests that the negative role of income on fertility is larger in countries with very low fertility, whereas this effect is very small in countries with very high fertility, probably because of the low degree of substitution between home- and market-produced goods and opportunities. In sum, the quantile regression approach suggests that the commonly observed negative relation between fertility and income is highly nonlinear and mediated by financial markets.

5. Final remarks

The objective of this paper was to investigate the role of financial market imperfections in determining fertility using international panel data. Our results appear useful to interpret the main trends observed in fertility in the world in recent years: the declining number of children per woman is fundamentally caused by growing income and human capital and wider female participation in the labour force. During this period, households' indebtedness is known (Harvey, 2004) to have sharply increased while financial markets further developed with a burst of innovation. According to our estimates, the development of financial markets has positively influenced the fertility rate. Indeed, household behaviour has led to a significant shift of resources in the life cycle from the later stages of adulthood to the earlier ones. Greater debt has brought about an incentive to invest in children to compensate for the negative effects on old-age consumption. Broader access to financial investment has had an important income effect (negative) on fertility choice of young adults. Hence, financial development exercised significant influence on the fertility choice of households but in two opposite directions. In this respect, our paper highlights the powerful connections between financial markets and fertility choices, substantially overlooked in the existing literature, with an aggregate cross-country perspective.

Appendix A. Comparative statics results

The case of no frictions

Let us consider the young adult optimization programme under the assumption of perfect financial markets:

$$\max_{c_t^1, n_t, c_{t+1}^2, c_{t+1}^3, c_{t+2}^3} \quad v\left(c_t^1, n_t\right) + u\left(c_{t+1}^2, c_{t+1}^3\right) + g\left(c_{t+2}^3\right)$$
$$\text{sub} \quad (1-\tau n_t)w_t^1 + \frac{w_{t+1}^2}{R_{t+1}} + \frac{n_t q_{t+2}}{R_{t+1}R_{t+2}} + \frac{s_t}{n_{t-1}} + -\left[c_t^1 + \frac{c_{t+1}^2}{R_{t+1}} + \frac{c_{t+2}^3}{R_{t+1}R_{t+2}} + \frac{c_{t+1}^3}{n_{t-1}R_{t+1}}\right] = 0.$$

Optimization provides the first-order conditions:

$$\frac{\partial L_u}{\partial c_t^1} = \frac{\partial v}{\partial c_t^1} - \lambda_u = 0 \tag{10}$$

$$\frac{\partial L_u}{\partial n_t} = -\tau w_t^1 \lambda_u + \frac{\partial v}{\partial n_t} + \lambda_u \frac{q_{t+2}}{R_{t+1}R_{t+2}} = 0 \tag{11}$$

$$\frac{\partial L_u}{\partial c_{t+1}^2} = \frac{\partial u}{\partial c_{t+1}^2} - \frac{\lambda_u}{R_{t+1}} = 0 \tag{12}$$

$$\frac{\partial L_u}{\partial c_{t+1}^3} = \frac{\partial u}{\partial c_{t+1}^3} - \frac{\lambda_u}{R_{t+1}n_{t-1}} = 0 \tag{13}$$

$$\frac{\partial L_u}{\partial c_{t+2}^3} = \frac{\partial g}{c_{t+2}^3} - \frac{\lambda_u}{R_{t+1}R_{t+2}} = 0 \tag{14}$$

$$\frac{\partial L_u}{\partial \lambda_u} = (1-\tau n_t)w_t^1 + \frac{w_{t+1}^2}{R_{t+1}} + \frac{n_t q_{t+2}}{R_{t+1}R_{t+2}} + \frac{s_t}{n_{t-1}} + -\left[c_t^1 + \frac{c_{t+1}^2}{R_{t+1}} + \frac{c_{t+2}^3}{R_{t+1}R_{t+2}} + \frac{c_{t+1}^3}{n_{t-1}R_{t+1}}\right] = 0, \tag{15}$$

where λ_u is the Lagrange multiplier. Let us consider the comparative statics effect of life-cycle wages on fertility, ((Eq. (16)):

$$dn_t = \frac{1}{\Delta}\left\{\underbrace{\left[\frac{\partial v}{\partial c_t^1}\tau\Delta_{22}dw_t^1\right]}_{\text{Cost of children}} - \underbrace{\left[\Delta_{62}(1-n_t\tau)dw_t^1 + \frac{\Delta_{62}}{R_{t+1}}dw_{t+1}^2\right]}_{\text{Income effect}}\right\} \tag{16}$$

where Δ and Δ_{ij} denote the determinant and the (i,j)-th cofactor of the bordered Hessian matrix of the problem, obtained deriving the first order conditions with regard to c_t^1, n_t, c_{t+1}^2, c_{t+1}^3, c_{t+2}^3, and λ_u. The second-order conditions for utility maximisation imply that $\Delta < 0$ and $\Delta_{22} > 0$. Hence, the sign of the income effect depends on Δ_{62}, whose expression is:

$$\Delta_{62} = -\frac{\partial^2 g}{\partial(c_{t+2}^3)^2}\left[\frac{\partial^2 u}{\partial(c_{t+1}^2)^2}\frac{\partial^2 u}{\partial(c_{t+1}^3)^2} - \left(\frac{\partial u}{\partial c_{t+1}^2 \partial c_{t+1}^3}\right)^2\right] \times \times \left[\left(\frac{\partial v}{\partial c_t^1 \partial n_t} - \tau w_t^1 \frac{\partial^2 v}{\partial(c_t^1)^2}\right) - \frac{q_{t+2}}{R_{t+1}R_{t+2}}\right]. \tag{17}$$

The strict concavity of the utility functions $u(\cdot)$ and $g(\cdot)$ implies that the sign of Δ_{62} depends on the sign of the expression in brackets on the second line of ((Eq. (17)), which is made of the difference of two terms. The one in parentheses is positive when children are normal goods in the maximisation of $v(c_t^1, n_t)$. The term $q_{t+2}(R_{t+1}R_{t+2})^{-1}$ refers to the negative effect on fertility of larger

wealth because parents have more resources to fund their old-age consumption. Hence, we detect three channels of influence of income upon fertility: two are negative, one is positive. The comparative-statics effect of the gift q_{t+2} on n_t is given by:

$$\frac{dn_t}{dq_{t+2}} = -\frac{\Delta^{-1}}{R_{t+1}R_{t+2}}\left[\frac{\partial v}{\partial c_t^1}\Delta_{22} + n_t\Delta_{62}\right]. \tag{18}$$

The change in the number of children due to a change in the interest rate, assuming that $R_t = R_{t+1} = R$, is given by

$$\frac{dn_t}{dR} = \frac{1}{\Delta R}\left\{\underbrace{\frac{\lambda_u}{R}\left[\frac{2q_{t+2}\Delta_{22}}{R} - \Delta_{32} - \frac{\Delta_{42}}{n_{t-1}} - \frac{2\Delta_{52}}{R}\right]}_{\text{Substitution effect}} + \underbrace{\Delta_{62}\left(D_t - \frac{s_{t+1}}{R}\right)}_{\text{Financial position}}\right\}.$$

Given the sign of the cofactor Δ_{62}, the discussion of the effects of q_{t+2} and R on n_t follows along the lines of Section 3.2.

The model with borrowing constraints

Under the assumption of binding borrowing constraints the utility maximisation programme becomes:

$$\begin{aligned}
&\max_{c_t^1, n_t, c_{t+1}^2, c_{t+1}^3, c_{t+2}^3} \quad v\left(c_t^1, n_t\right) + u\left(c_{t+1}^2, c_{t+1}^3\right) + g\left(c_{t+2}^3\right)\\
&\text{sub} \quad (a) \quad (1-\tau n_t)w_t^1 + \frac{w_{t+1}^2}{R_{t+1}} + \frac{n_t q_{t+2}}{R_{t+1}R_{t+2}} + \frac{s_t}{n_{t-1}} +\\
&\qquad\qquad -\left[c_t^1 + \frac{c_{t+1}^2}{R_{t+1}} + \frac{c_{t+2}^3}{R_{t+1}R_{t+2}} + \frac{c_{t+1}^3}{n_{t-1}R_{t+1}}\right] = 0\\
&\qquad\quad (b) \quad c_t^1 = (1-\tau n_t)w_t^1 + \overline{D}_t.
\end{aligned}$$

By differencing the first order conditions, we obtain the comparative statics effects of the exogenous variables on n_t. Higher credit availability will impact on household fertility according to the following expression:

$$\frac{dn_t}{d\overline{D}_t} = \frac{\Gamma_{11}}{\Gamma}\left(\tau w_t^1 \frac{\partial^2 v}{\partial (c_t^1)^2} - \frac{\partial v}{\partial c_t^1 n_t}\right) + \frac{\Gamma_{51}}{\Gamma}, \tag{19}$$

where Γ and Γ_{ij} denote the determinant and the (i,j)-th cofactor of the bordered Hessian matrix of the problem. In this case, $\Gamma > 0$ and $\Gamma_{11} < 0$ are required for the maximisation problem to reach an optimal solution, while it can be easily verified that $\Gamma_{51} > 0$:

$$\Gamma_{51} = -\frac{q_{t+2}}{R_{t+1}R_{t+2}}\left[\frac{\partial^2 u}{\partial (c_{t+1}^2)^2}\frac{\partial^2 u}{\partial (c_{t+1}^3)^2} - \left(\frac{\partial u}{\partial c_{t+1}^2 \partial c_{t+1}^3}\right)^2\right]\frac{\partial^2 g}{\partial (c_{t+2}^3)^2} > 0. \tag{20}$$

The model with saving constraints

Now we analyse the model of household choice by assuming that the optimal desired value of saving s_{t+1} is higher than the ceiling $\overline{s}_{t+1}$. Accordingly, the maximisation programme becomes:

$$\begin{aligned}
&\max_{c_t^1, n_t, c_{t+1}^2, c_{t+1}^3, c_{t+2}^3} \quad v\left(c_t^1, n_t\right) + u\left(c_{t+1}^2, c_{t+1}^3\right) + g\left(c_{t+2}^3\right)\\
&\text{sub} \quad (a) \quad (1-\tau n_t)w_t^1 + \frac{w_{t+1}^2}{R_{t+1}} + \frac{n_t q_{t+2}}{R_{t+1}R_{t+2}} + \frac{s_t}{n_{t-1}}\\
&\qquad\qquad -\left[c_t^1 + \frac{c_{t+1}^2}{R_{t+1}} + \frac{c_{t+2}^3}{R_{t+1}R_{t+2}} + \frac{c_{t+1}^3}{n_{t-1}R_{t+1}}\right] = 0\\
&\qquad\quad (b) \quad c_{t+2}^3 = R_{t+2}\overline{s}_t + n_t q_{t+2}.
\end{aligned}$$

The reaction of a household's fertility to greater investment opportunities is given by:

$$\frac{dn_t}{d\overline{s}_{t+1}} = \frac{1}{\Phi}\left(\frac{\Phi_{52}}{R_{t+1}} - q_{t+2}R_{t+2}\frac{\partial^2 g}{\partial (c_{t+2}^3)^2}\Phi_{22}\right). \tag{21}$$

where Φ and Φ_{ij} denote the determinant and the (i,j)-th cofactor of the bordered Hessian matrix of the problem. Among the second order conditions for a maximum of the problem we have $\Phi > 0$ and $\Phi_{22} < 0$. In this expression, the term

$$-q_{t+2}R_{t+2}\frac{\partial^2 g}{\partial\left(c_{t+2}^3\right)^2}\Phi_{22} < 0$$

refers to the trade-off between the investment in children and that in financial activities. The sign of the term is negative because greater financial investment opportunities reduce the need to raise children for old age consumption. The other component of the effect of $\bar{s}_{t+1}$ on n_t has the opposite sign of the income effect of wages, determined by the sign of Φ_{52}. Below we show that Φ_{52} is negative:

$$\Phi_{52} = -\left[\frac{\partial^2 u}{\partial\left(c_{t+1}^2\right)^2}\frac{\partial^2 u}{\partial\left(c_{t+1}^3\right)^2} - \left(\frac{\partial u}{\partial c_{t+1}^2 \partial c_{t+1}^3}\right)^2\right]\left(\frac{\partial v}{\partial c_t^1 \partial n_t} - \tau w_t^1 \frac{\partial^2 v}{\partial\left(c_t^1\right)^2}\right) < 0. \tag{22}$$

Hence, fertility will decrease with $\bar{s}_{t+1}$.

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