Do stock market booms anticipate baby booms? A VAR and DSGE Perspective.

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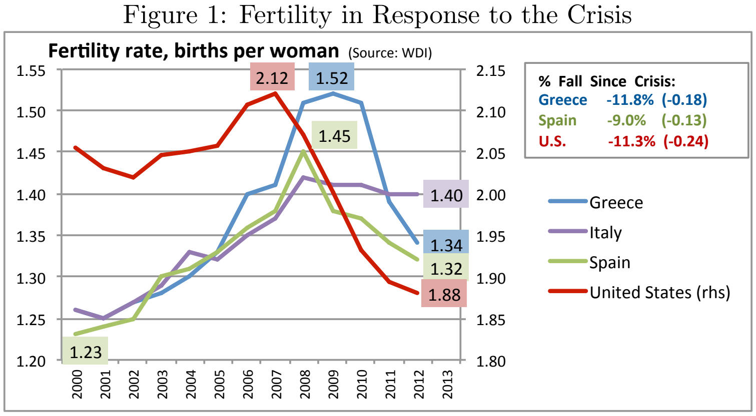
Abstract

This paper studies the procyclical nature of fertility in the U.S. employing a VAR and DSGE perspective. I find that fertility responds positively to: (i) current economic conditions - TFP shocks and (negative) unemployment shocks, as well as to (ii) expectations about future economic conditions - consumer condifence expectations and stock price news shocks. I complement these results with a DSGE model that incorporates fertility into a simple RBC model. Fertility is irriversible, children provide households with utility, and are associated with costs of two types: consumption - entering the budget constraint, and time - away from leisure and work. The model proposes two channels causing fertility to be procyclical. Fertility turns out to be procyclical when the consumption cost of children is high, but becomes countercyclical when their cost is low.[1] Finally, I aim to extend this model by introducing credit frictions and analyzing a role for policy in attaining optimally countercyclical fertility, in the spirit of the education literature. If agents had access to perfect credit markets they would choose to forgo working during recessions when childbearing costs are lower (substitution effects would dominate income effects) but under credit constraints childbearing becomes procyclical.

1 Introduction

Fertility rates have recently shown to embody a strong cyclical component, evidenced by declining birth rates in countries severely hit by the 2008 global financial crisis. Birth rates per woman fell respectively by 11.3% in the U.S., 9.0% in Spain, and 11.8% in Greece as of 2013, since their pre-crisis peaks. Italy saw fertility rates stabilize, when they were previously rising. In fact, pre-crisis trends in fertility rates were positive in these four countries, turning negative thereafter. While fertility has traditionally been seen as pimarily a trend phenomenon, there is evidence of its strong procyclicality. This raises scope to study fertility as a business cycle phenomenon using VAR and DSGE methods.

Figure 1: Fertility in Response to the Crisis



The aim of the empirical part of this paper is to investigate the effects of current economic conditions and expectations about the future on fertility decisions in the United States. More precisely, how does fertility respond to shocks to current TFP and unemployment? Can consumer confidence expectations about the future state of the economy predict fertility rates? And can stock prices, by reflecting expectations of future developments in the

[1]These results are preliminary and might hindge on my calibration.

economy, predict fertility rates? This paper contributes to the empirical literature that studies the relationship between fertility and the business cycle. It is the first (to my knowledge) to look at how news, or expectations about the future, affect fertility decisions employing VAR methods.

Structural VAR estimation based on Choleski identification of shocks suggests that fertility is procyclical, with fertility rates rising in response to current economic conditions such as a (positive) shock to TFP, to consumer confidence about the current economic situation, and (negative) shock to unemployment. Fertility also responds positively to expectations about the future: such as a shock to confidence about the future economy and to stock prices, which carry information about future TFP.

I complement these results with a DSGE model that incorporates fertility into a simple RBC model for married couples with a joint utility function. Children provide households with direct and durable utility, but also entail two types of costs. First, children have a consumption cost that enters the household budget constraint. Second, children have a time cost for women in terms of time away from work and leisure (for simplicitly, I assume men's labor supply is inelastic). Finally, the decision to have children is irriversible, i.e. fertility is non-negative. My model is similar to the general equilibrium model of Doepke et al (2007), differing in that I do not consider a life-cycle set up nor the accumulation of work experience. According to my calibration of the model, fertility turns out to be procyclical when the consumption cost of children is high, but becomes countercyclical when their cost is low.[2] Given empirical evidence that households shift from 'quantity' towards 'quality' of children as their education rises, there is scope for endogenizing the cost of children to depend on education. As a result, higher education would increase the procyclicality of childbearing, a testable hypothesis.

Finally, I aim to extend this model by introducing credit frictions and analyzing a role for policy in attaining optimally countercyclical fertility, in the spirit of the education literature. If agents had access to perfect credit markets they would choose to forgo working during recessions when childbearing costs are lower (substitution effects would dominate income effects), but under credit constraints childbearing becomes procyclical.

2 Literature

The empirical part of this paper combines two main strands of literature. The first strand of literature looks at how fertility rates are affected by current economic conditions. Early studies found fertility rates to be countercyclical. This was the famous finding by Butz and Ward (1979) [5], with fertility falling in good times as the opportunity costs of childbearing rose in the U.S. over 1948-1975. Ermisch (1988) [7] found a similar result for the U.K. over 1950s-1985. However, more recent analyses point to procyclical patterns in fertility. For example, Adsera (2004) [2] found a reduction in fertility due to high unemployment for 23 OECD countries spanning 1960-1997. McNown (2003) [9] provided similar results for the post World War II United States. Finally, Orsal and Goldstein (2010) [8] find that fertility has become positively associated with economic conditions using panel methods for OECD countries over 1976-2008. These studies usually employ panel or time series econometric regressions. A vast literature studies similar questions using microeconomic methods, examining labor market determinants of fertility such as unemployment, wages, and wealth.

A smaller body of empirical literature studies how fertility responds to current economic conditions, such as unemployment, using VAR methods. Mocan (1990) suggested that both female and male unemployment rates have a negative effect on fertility, and that the behavior of fertility is pro-cyclical in bivariate VAR models but turn counter-cyclical once divorce rates are included in the VAR. Huang (2003) finds that unemployment has a negative effect on conception rates in Taiwan (and a positive effect on divorce as well as marriage rates), contrasting findings by Shieh (1994). Another paper estimates savings and fertility simultaneously employing a VAR and finds that social security has a negative effect on fertility and positive effect on household saving in Germany (Cigno et al, 2001 [6]) .

The second strand of empirical literature relates to recent studies of news shocks. Beaudry and Portier (2006) [4] show that innovations in stock prices reflect TFP growth that is anticipated by economic agents and constitute a significant force driving business cycle fluctuations in the US. Their paper sparked renewed interest in the idea of news and expectation shocks as important factors driving macroeconomic fluctuations (Barsky and Sims, 2010 [3]). I use their identification of news shocks as revealing information about future productivity, and analyze its impact on fertility decisions. Abel (2003) [1] is related in that it looks at the reverse effect of baby booms on economic outcomes such as stock prices and productivity, using an overlapping generations model in which baby booms increase national savings and investment and leads to an initial rise and subsequent fall in the price of capital (measured as stock prices). This paper, in a sense, looks at the effect running in the opposite direction, asking the question whether stock price rises anticipate baby booms.

[2]These results are preliminary and might hindge on my calibration.

The theoretical part of this paper contributes to the literature termed New Home Economics of Becker (1981) and Willis (1973). This literature stresses the role of female wages, representing the opportunity cost of childbearing, as a determinant of fertility. The female wage, and hence TFP, is seen to have both positive (income) and negative (substitution) effects on fertility, with opposite effects on labor force participation.[3] The majority of this labor literature focuses on partial equilibrium choice models and are therefore not suitable for our purposes.

Fewer papers examine fertility decisions in a general equilibrium framework. Several such papers explain the baby boom following World War II. Greenwood et al (2005) explain the boom as generated by a decline in the direct cost of having children. Doepke et al (2007) explain the boom and subsequent bust by focusing on the decline and then rise in (time) opportunity cost of having children. Much of this literature uses lifecycle models (where aggregation versions of standard neoclassical growth models) and have a role for endogenous experience. We contribute to this literature by studying the business cycle properties of these theoretical models, by building a simple DSGE model that incorporates fertility and can be used to study reponses to aggregate technology shocks.[4]

3 Evidence from VARs

3.1 Data

I use quarterly data for the U.S.[5] spanning the period 1974Q1-2012Q3 for fertility, unemployment and consumer confidence indicators, and spanning 1980Q1-2012Q3 for fertility, TFP, and stock prices.

I define the fertility rate as quarterly 9-month lead[6] births per female between the ages of 15 and 54[7]. I construct data on monthly births from microdata publibly provided by the U.S. Centers for Disease Control and Prevention, constructed from microdata, while data on female population is obtained from the OECD Main Economic Indicators.

The unemployment rate is obtained from the U.S. Bureau of Labor Statistics (BLS).

I construct a capacity-utilization adjusted measure of TFP by assuming a Cobb-Douglas production function and using data on real GDP (U.S. Bureau of Economic Analysis), real capital stock (Oxford Economics), industry capacity utilization rates (Federal Reserve), total hours worked in the economy (BLS), and the labor share of non-farm business (BLS).

The consumer confidence indices regarding expectations and the present situation are constructed by the Conference Board Consumer Surveys. The stock price index considered is the S&P 500 composite index deflated by the GDP implicit price deflator and divided by the population. The consumer confidence and stock price indices are expressed in natural logarithms.

All variables are seasonally adjusted and detrended using a linear trend. We include 2 quarterly lags in the VAR, suggested optimal by the Bayesian Information Criterion. The raw data, before trend and logarithmic adjustments, are displayed below.

[3] Higher TFP would also increase the male wage resulting in a higher demand for child services. Because of the dual quality-quantity dimensions of child services, rising incomes need not necessarily result in higher fertility rates.

[4] Literature review on theretical papers relating to fertility in macro models to be expanded. Surveys of empirical studies of the NHE model are provided by Macunovich (1996a) and Hotz, Klerman, and Willis (1997). Critical surveys and reviews of models of fertility based on economic theories of behavior have been conducted by Olsen (1994), Macunovich (1996a), Murphy (1992), and Smith (1981). This paper also relates to the literature on education and the business cycle.

[5] The choice of focusing on the U.S. stems from its hands-off government policy which implies limited unemployment and maternity benefits. Thus, we would expect economic conditions to affect fertility decisions more than in countries where the state offers many benefits for having children.

[6] This assumes conception take place 9 months prior to child births.

[7] Prefered data on females between the ages of 15 and 44 was not available.

Figure 2: Data on Fertility and Unemployment

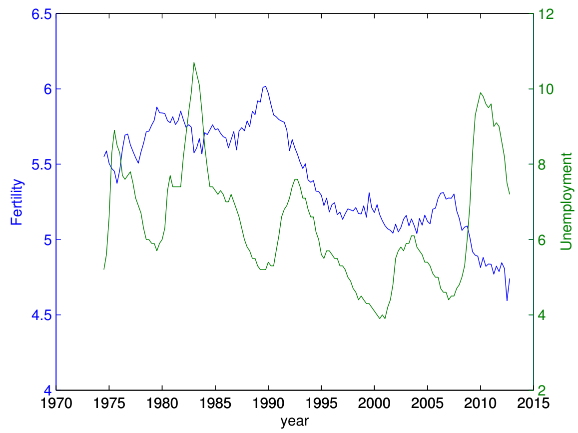
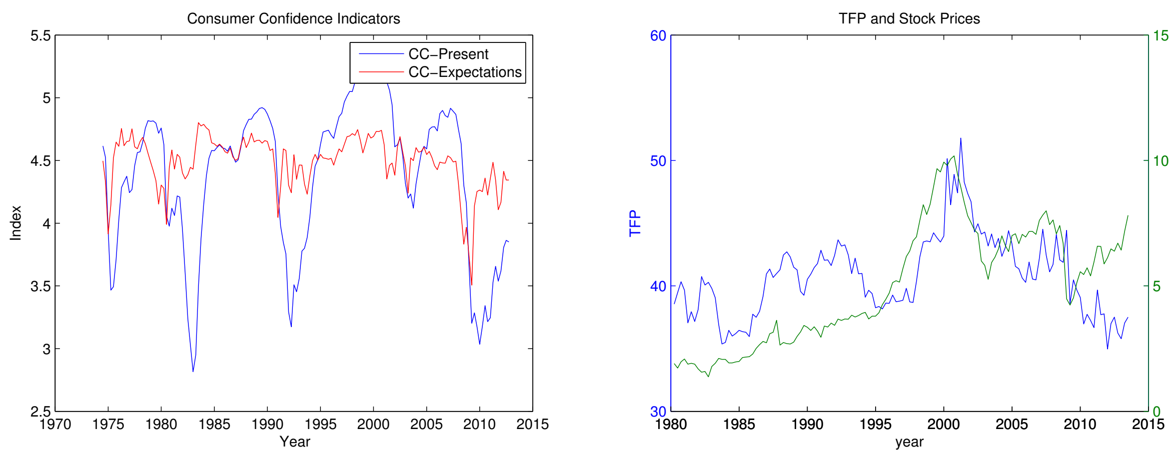


Figure 3: Data on Consumer Confidence, TFP, and Stock Prices



3.2 Structural VAR Estimations and Impulse Responses

3.2.1 Unemployment and Consumer Confidence Shocks

I employ a VAR model composed of fertility rates (f_t), unemployment (u_t), and consumer confidence (cc_t), in this order. I consider two consumer confidence indicators regarding expectations about the future (cc_t^F) and regarding the present state of the economy (cc_t^P). I employ Choleski identification for structural shocks to confidence, which assumes that expecations can affect unemployment and fertility decisions only with a lag but not contemporaneouly.

I present the impulse responses for my shocks to expectations using the Choleski identification, defined as shocks that do not impact unemployment nor fertility contemporaneously.[8] As fertility rates are measured per 1,000 females, we can interpret the fertility rate as multiplied by 1,000 in the impulse response functions. From the impulse response functions, we observe that fertility reacts negatively to a rise in unemployment (positive unemployment shock), for a period of approximately 10 quarters, suggesting that agents respond to current economic conditions with procyclical fertility. Moreover, positive consumer confidence shocks about the economy's current and future state also affect the fertility rate (positively). Confidence regarding the present situation has a stronger and longer effect on fertility than expectations about the future, with the former lasting approximately 20 quarters and the latter 15 quarters.[9]

[8]Monthly data spanning 1975M1-2013M7 gives very similar results in magnitude and significance, albeit "bumpier" IRFs.
[9]Results are robust to a reordering of the fertility variable.

Figure 4: Positive Unemployment Shock

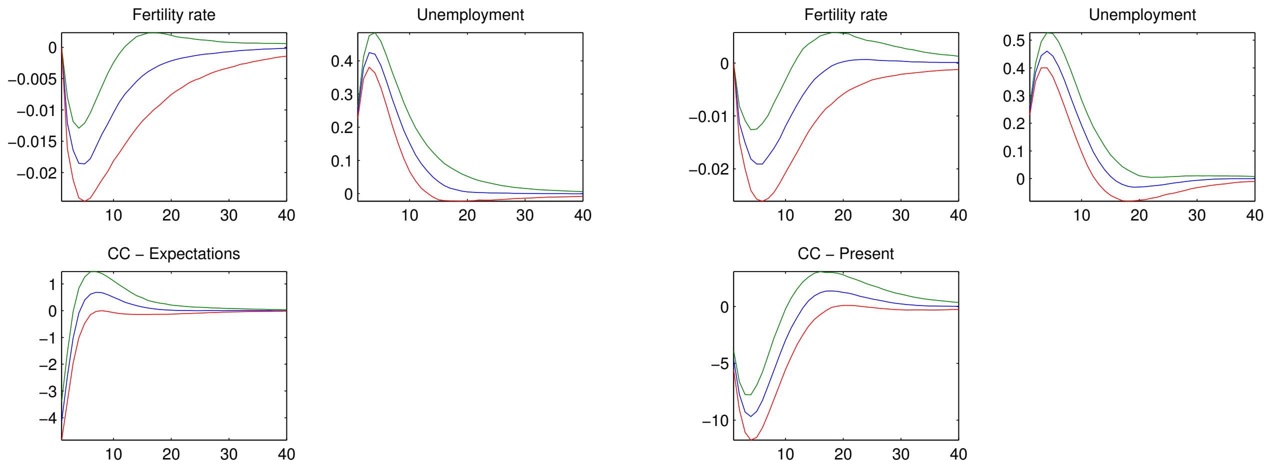
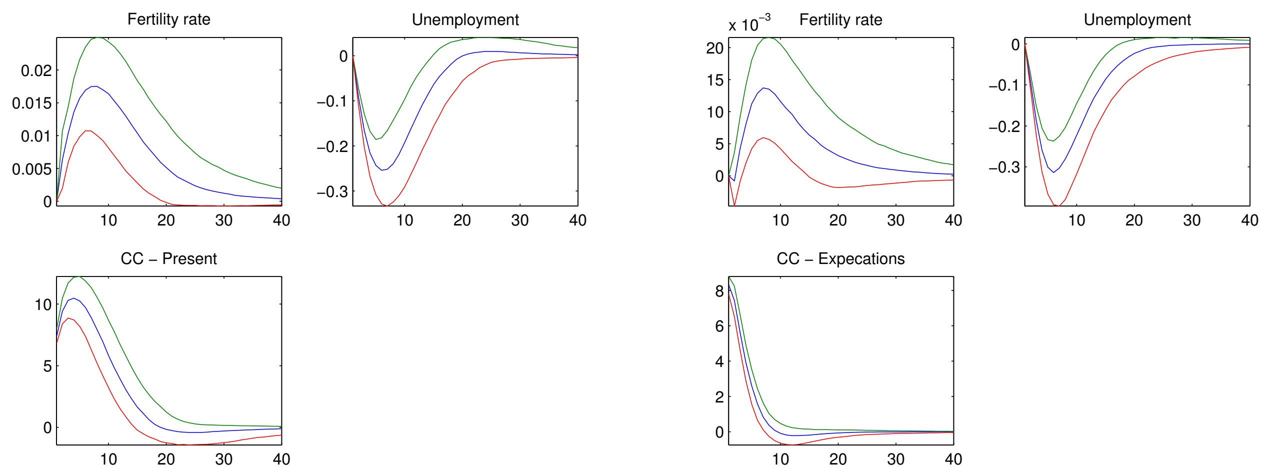


Figure 5: Positive Consumer Confidence Shock: Present Situation (left panel) Expectations (right panel)



3.2.2 TFP and Stock Price News Shocks

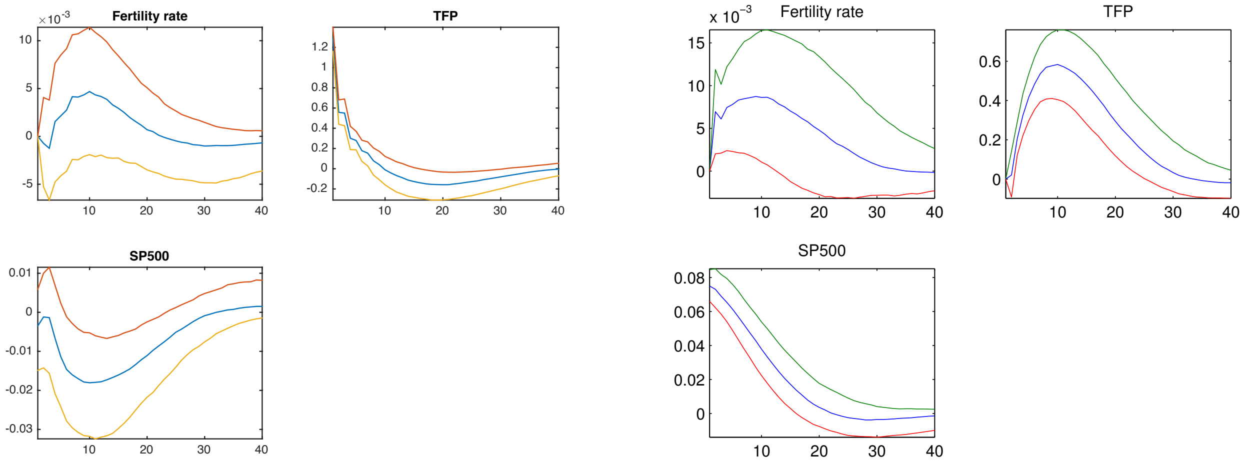
In another specification I employ a VAR model composed of fertility rates (f_t), TFP (tfp_t), and stock prices (sp_t), in this order. I analyze the effects of stock price "news" shocks on fertility rates. I use the two identification strategies employed by Beaudry and Portier (2006) for news shocks: (i) short-run (Choleski) restrictions - whereby shocks to stock prices do not contemporaneously affect TFP nor fertility rates, and (ii) long-run restrictions (Blanchard and Quah, 1989) - whereby only the identified shock can affect TFP in the long-run.

The baseline employs Choleski identification under the following order: fertility rate, TFP, and stock prices. We observe that a news shock (about future TFP) generates a significant increase in fertility rates for approximately 10 quarters. The IRFs show that news shocks to consumers' expectations and to markets' anticipation of future TFP have significant impacts on fertility rates.[10] Fertility however, does not significantly respond to TFP shocks that are unanticipated (orthogonal to stock prices). This shows most of the effect of TFP on fertility is captured by expectations of future TFP. In a bivariate VAR of fertility and TFP, a positive shock to TFP has a positive and significant effect on fertility[11].

[10] Results are robust to reordering of the fertility variable.

[11] Results are available upon request.

Figure 6: Positive TFP Shock (left) and Stock Price News Shock (right)



4 Theoretical Model

I devleop an RBC model in which fertility responds to the business cycle. I consider two versions of the model: first I derive the simple case without female leisure and then I introduce female leisure. The full derivation of the models is in the Appendix. The model sheds light on two channels that could be contributing to fertility being procyclical in the US. First, a preference shift from quantity to quality of children (possibly a byproduct of rising education) causes fertility to become increasingly procyclical. Second, credit constraints amplify the income effect relative to the substitution effect of a productivity shock, favouring procyclical fertility.

4.1 Model I: RBC model with Fertility (but No Leisure)

Couples' problem

Fertile couples are infinitely lived agents, which maximize their expected utility subject to their joint budget constraint. Couples derive utility from consumption c_t and children n_t. Their discounted expected utility function is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \{\log c_t + \sigma_n \log n_t\}$$

Children require additional consumption[12] $(\phi_c n_t)$ net of any government benefits received, where $\phi_c > 0$. Couples' joint income from working is given by the product of their wages and hours worked by the female $\left(h_t^F\right)$ and male $\left(h_t^M\right)$. We assume that males supply a fixed amount of labor $\left(h_t^M = 1\right)$ whereas females' supply of labor varies $\left(h_t^F \in [0,1]\right)$ depending on the number of children and amount of female leisure the couple chooses to have. Couples also invest (i_t) in capital (k_t) with return (r_t). Consequently, couples' joint budget constraint is given by:

$$c_t + \phi_c n_t + i_t = w_t^F h_t^F + w_t^M h^M + r_t k_t$$

Couples choose how to allocate their time between working and children (their is no leisure in this version of the model). Female endowment of hours is split between work and children, where time spent caring for children is diminishing in the number of children $(\psi_l < 1)$.

$$h_t^F + \phi_l (n_t)^{\psi_l} = 1$$

For simplicity we assume that children depreciate at rate δ_n, capturing the fact that as they turn adult they form their own household and become less costly to their parents in terms of money and time.[13] The evolution of children follows an AR(1) process and fertility is irriversible $(f_t > 0)$:

$$n_t = (1 - \delta_n) n_{t-1} + f_t$$

Similarly, capital evolves as:

$$k_t = (1 - \delta) k_{t-1} + i_t$$

In this model we can interpret children as a time-intensive and irriversible durable good from which couples derive utility.

Firms' problem

Firms operate under perfect competition and a CES production function with imperfect subsitutability between male and female labor, which gives rise to different wages for males and females. The substitutability is determined by parameter θ for the female share of hours and elasticity of substitution given by $\frac{1}{1-\rho}$. The production function takes the following form:

$$y_t = A_t k_t^{\alpha} \left[\theta \left(h_t^F\right)^{\rho} + (1-\theta)\left(h_t^M\right)^{\rho}\right]^{\frac{1-\alpha}{\rho}}$$

[12]This encompasses all costs of childrearing, including items such as food, education, and health.

[13]This simplifying assumption also means that parents' utility from having children diminishes as they grow older, which arguably is a strong assumption.

Productivity (A_t) follows an AR(1) process and is subject to iid white-noise shocks $\left(\varepsilon_t^A\right)$:

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_t^A$$

This is the source of uncertainty to couples, because it generates variation in wages.

Firms choose the amount of capital and female labor to employ in order to maximize profits, which are given by:

$$\max_{k_t, h_t^F} \pi_t = A_t k_t^\alpha \left[\theta \left(h_t^F\right)^\rho + (1-\theta)\left(h_t^M\right)^\rho\right]^{\frac{1-\alpha}{\rho}} - w_t^F h_t^F - w_t^M h_t^M - r_t k_t$$

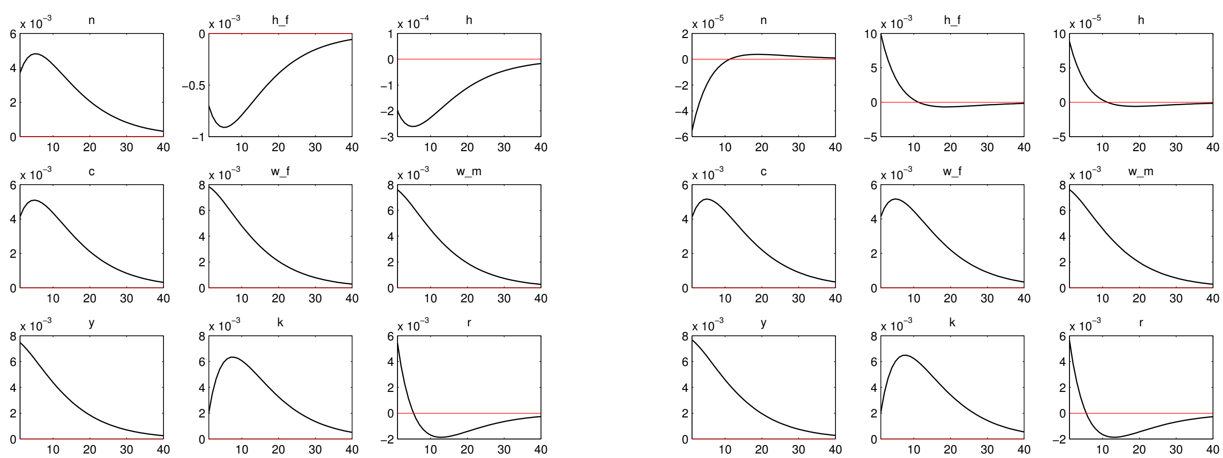
Impulse response to Positive Technology Shock

The set of equilibrium conditions are derived in the Appendix. We use a first-order log-linear approximation around the steady-state of the model, and solve model using Dynare and the Uhlig Toolkit.

Figures 6 and 7 plot impulse responses to a positive one standard deviation technology shock under high and low consumption costs of children. A positive technology shock leads women to have more children and reduce their labor supply when costs of having children are high. When costs of having children are low, usually due to government interventions such as public schooling and healthcare or subsidies for having children, fertility instead becomes countercyclical and women work more during booms and less during recessions.

Consumption costs of children have important implications for the cyclicality of female labor supply and the amplitude of buisiness cycles. According to neoclassical RBC point of view, agents optimally allocate their time between working and having children, and any intervention by the government would make agents worse off. When consumption costs of children are high, female hours are countercyclical, and dampen business cycle fluctuations in output. When instead consumption costs of children are low, female hours become procyclical, thereby amplifying business cycle fluctuations.

Figure 7: Positive technology shock when the cost of children is high, $\phi_c = 0.8$ (left) and low, $\phi_c = 0.2$ (right)



4.2 Model II: RBC model with Fertility and Female Leisure

Couples' problem

Fertile couples again maximize their expected utility subject to their joint budget constraint. They derive expected utility from consumption (c_t), female leisure $\left(l_t^F\right)$, and the number of children (n_t), given by:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t^F, n_t\right) = \max E_0 \sum_{t=0}^{\infty} \beta^t \left\{\log\left(c_t\right) + \sigma_l \log\left(l_t^F\right) + \sigma_n \log\left(n_t\right)\right\}$$

Couples invest in capital (k_t), with respective return (r_t). Children require additional consumption ($\phi_c n_t$) net of any government benefits received, where $\phi_c > 0$. Couples' joint income from working is given by the product of

their wages and hours worked by the female $\left(h_t^F\right)$ and male $\left(h_t^M\right)$. We assume that males supply a fixed amount of labor $\left(h_t^M = 1\right)$ whereas females supply labor varies $\left(h_t^F \in [0,1]\right)$ depending on the leisure and children they choose to have. Couples' joint budget constraint is given by:

$$c_t + \phi_c n_t + i_t = w_t^F h_t^F + w_t^M h_t^M + r_t k_t$$

Leisure is defined as:

$$l_t^F = 1 - h_t^F - \phi \left(n_t\right)^{\psi}$$

The number of children is given by children last period plus new borns. Couples decide the number of children by chosing their fertility rate (f_t), which is assumed to be continuous on $[0, 1]$. The evolution of the number of children is thus given by:

$$n_t = \left(1 - \delta_n\right) n_{t-1} + f_t$$

where fertility is irriversible such that $f_t > 0$, and the evolution of capital is given by:

$$k_t = \left(1 - \delta\right) k_{t-1} + i_t$$

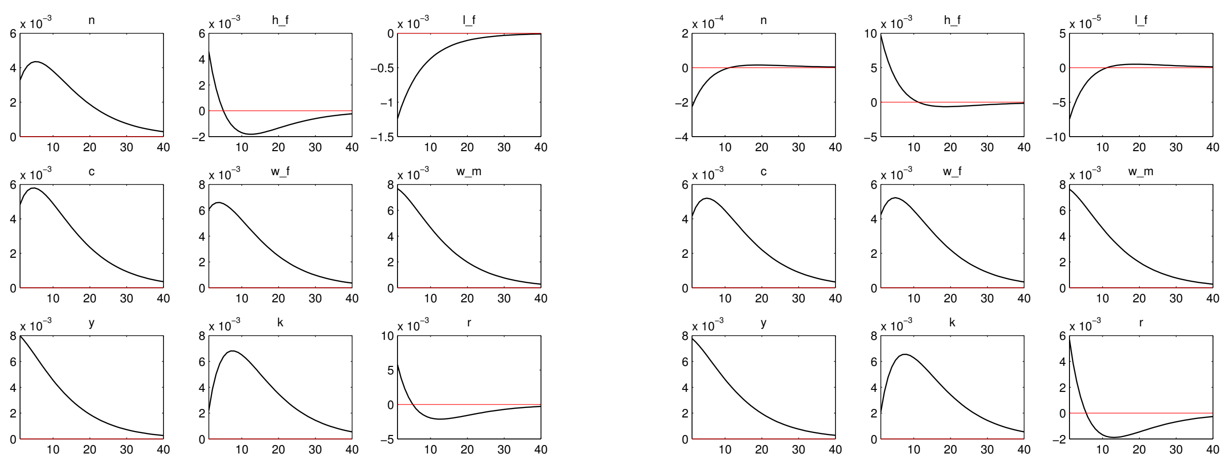
We further assume that n_0 and k_0 are given, and that n_t and $k_t > 0$.

The firms' maximization problem is the same as before.

Impulse response to Positive Technology Shock

When we introduce leisure into the equation, we see that leisure is highly countercyclical consistent with the well-known RBC model. When costs of having children are low, a positive technology shock still leads women to have more children (fertility is procyclical), whereas when costs are high fertility turns countercyclical. The effect on labor supply changes, with labor supply rising by more when costs of children are lower.

Figure 8: Positive technology shock when the cost of children is high, $\phi_c = 0.8$ (left) and low, $\phi_c = 0.2$ (right)



4.3 Theoretical Model Conclusions, Extensions, and Policy Implications

This theoretical model modifies the standard RBC model to include couples' decision to have children. Introducing children in the basic RBC model alters the response of labor supply to aggregate economy shocks. When children are very costly, the income effect dominates and fertility is procyclical - couples choose to have children during booms, and women reduce their labor supply (compared to the no-children case). When children are less costly, the substitution effect dominates and fertility is countercyclical - couples prefer to have children during recessions, when the opportunity cost of their time is lower.

In this neoclassical RBC world, agents optimize their time and consumption allocations, such that there is no room for improvment through government policy. The main assumption of RBC theory is that agents - consumers and firms - behave optimally all the time in a world without frictions. In the classical RBC model agents choose to work more during booms and less in recessions. When fertility is procyclical, female hours become less procyclical, dampening business cycle fluctuations. When instead fertility is countercyclical, this is acting as an amplifying effect for business cycles. In this simple RBC model the cost of children matters for the cyclicality of fertility and thereby also the amplitude of business cycles.

In the next subsections I consider three extensions of this model. First, I look at the response to "news shocks", modeled as technology shocks that are anticipated one period ahead. Next, I investigate the channels causing fertility to be procyclical. The second extension looks at the role of education and the trade-off between quantity and quality of children. Higher education results in a preference shift from quantity to quality of children, and increases the procyclicality of fertility. Finally, the third extension looks at the role of credit markets and whether credit constraints make fertility more procyclical.

Extension 1: News Shocks

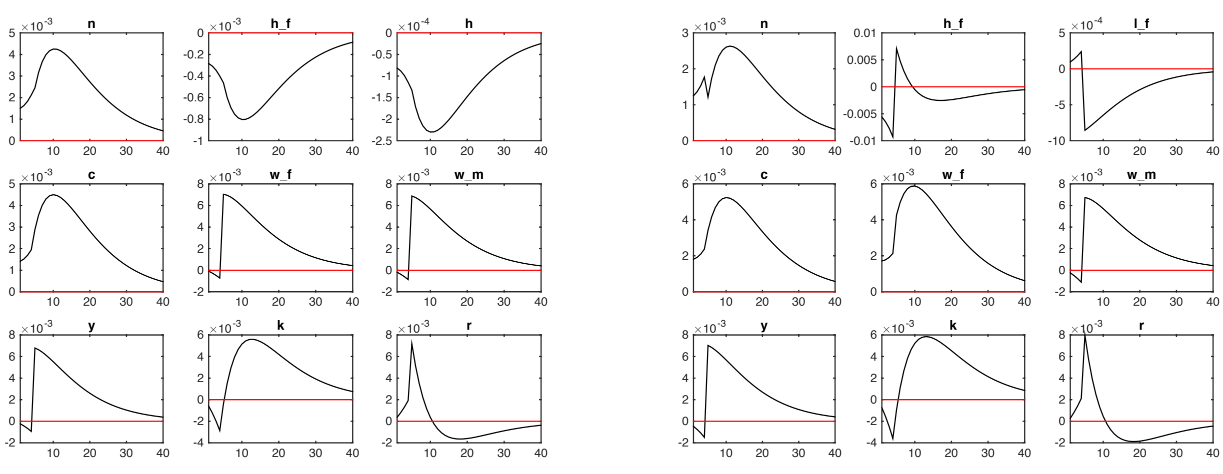
Finally, we incorporate shocks to expectations in our model. Productivity shocks have an unanticipated as well as an anticipated component, which reflect news about movements in productivity that materialize in the future. My contribution here is to show that news shocks are also an important determinant of fertility. Schmitt-Grohe and Uribe (2008) estimate that anticipated shocks explain approximately 70% of the variance of output growth, 80% of the variance of consumption growth, and 50% of the variance of investment growth. Beaudry and Portier (2007) and Jaimovich and Rebelo (2009) explore news about future productivity in RBC models.

Positive news makes agents wealthier. Wealthier agents want to enjoy more leisure, so they reduce thier labor supply today and output falls as a result. Consumption rises at all periods due to consumption smoothing. Lower output but higher consumption means investment today drops. Wages go up in the future, causing a substitution effect which counteracts the positive news wealth effect.

Productivity (A_t) here follows an AR(1) process with two iid white-noise shocks. There is an unanticipated shock, contemporaneous as before, but now there is also an anticipated component, or "news shock" (a_{t-4}) that affects productivity with a 4-quarter lag:

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_t^A + a_{t-4}$$

Figure 9: Positive anticipated technology ("news") shock - Model I (left), Model II (right) ($\phi_c = 0.8$)



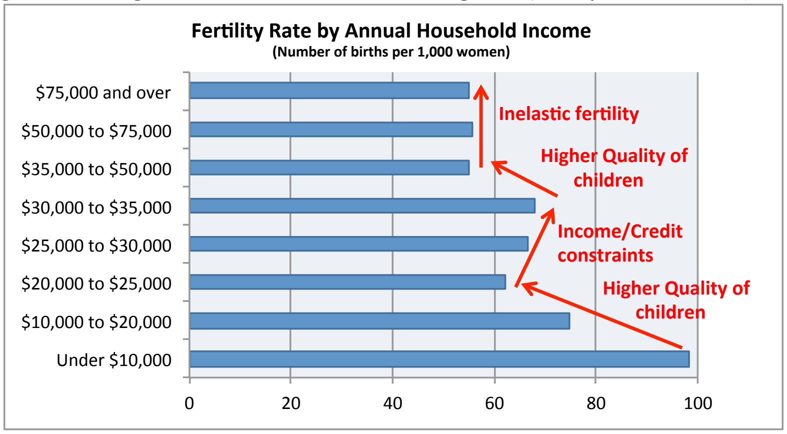
Extension 2: Preference Shift towards Quality of Children

Changes in the cost of having children affect the cyclicality of fertility.[14] There is ample evidence suggesting fertility is U-shaped or decreasing with respect to education and income. Households with low education/income

[14]Government policy can influence this cyclicality by altering the consumption cost of children. One way would be to make costs of having children procyclical, taxing them during booms and subsidizing them during recessions (or similarly, by introducing a tax on

tend to have higher fertility than middle-education/income groups. This suggests that as education and income increases, households shift their preference towards quality rather than quantity of children. In my model, this shift is represented by an increase in the child consumption cost parameter ϕ_c, which makes fertility more procyclical.

Figure 10: Higher Income and Shift to Higher Quality of Children, 2012



In the next version I would like to estimate a time-varying VAR to study whether fertility has become more procyclical over time. If such an effect is found, it would provide evidence that education, which has been increasing over time, is contributing to making fertility more procyclical. This raises the scope for endogenizing the quality of kids in our model, for example by modeling ϕ_c as an increasing function of education.

Extension 3: Credit Constraints

The predicted impact of the business cycle on fertility is ambiguous due to its two opposing effects. First, recessions cause the opportunity cost of having children to fall, creating an incentive to increase fertility (countercyclical substitution effect). At the same time, there is a credit constraint channel (procyclical income effect), whereby a lower ability to finance children could cause fertility to fall. As the opportunity cost and credit constraints effects work in opposite directions, the net effect remains an empirical question. Given the procyclical fertility observed empirically, we can postulate that the credit constraints effect (income effect) dominates.

Introducing credit market imperfections in our model can increase the magnitude of the income effect, turning fertility procyclical. This extension is related to the literature relating education to the business cycle. A similar income versus substitution effect trade-off has been identified in the literature on the cyclicality of education enrollments. For example, Dellas and Koubi (2003) remark that imperfect capital markets "favors a pro-cyclical pattern" for education demand, as the credit constraints effect (what they refer to as the income effect) of a recession is more likely to pose a problem for investing in education.

We can envision an optimal world in which optimal fertility is countercyclical, such that the substitution effect dominates. Women supply labor when times are good (employers demand more labor and the opportunity cost of not working is higher) and choose to have kids and work less when times are bad (employers demand less labor and the opportunity cost of not working is lower). With perfect access to credit, and for a given level of lifetime wealth, couples can simply postpone childbearing to economic downturns, such that they work when wages are higher rather than lower. Whereas under perfect credit markets, we would expect fertility to be countercyclical, under imperfect credit markets a procyclical pattern for fertility would arise. In this context, credit markets imperfections affect the timing of having children in a suboptimal manner.

There is supporting evidence that house price increases, which tend to relax credit constraints for home owners, raise fertility rates. Lovenheim and Mumford (2013) find that positive housing wealth shocks raises fertility among home owners, whereas the effect is insignificant among renters in the US. I find similar results using US county-level data on fertility rates, personal income, and house prices for the years 2003-2013. High house prices appear to relax credit constraints. Lagged house prices increase fertility rates for several age groups of white, African American,

children during booms and subsidizing children during recessions). To reduce time frictions and facilitate women re-entering the labor market when the economy begins to pick up, the government could try to reduce the time-cost of children by subsidizing childcare facilities.

and Asian women aged 15-44, using county and year fixed effects[15]. I also find that a high household debt burden (proxying for restricted access to new credit) reduces fertility. Using county-level fertility, personal income, and median household debt-to-income ratio[16] for the years 2001-2007, lagged debt leverage reduces fertility for most age groups across women of all races. Results are presented in Appendix Section 5.3.

In the next version I would like to model the impact of credit constraints for the cyclicality of fertility.

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5 Appendix for Theoretical Model

5.1 Model I: RBC model with Fertility (but No Leisure)

Couples' problem

The couples' Lagrangian becomes:

$$L = \max_{\{c,k,f\}} E_0 \sum_{t=0}^{\infty} \beta^t \{\log c_t + \sigma_n \log n_t\} + \lambda_t \left[w_t^F h_t^F + w_t^M h^M + r_t k_t - c_t - \phi_c n_t - k_t + (1-\delta) k_{t-1}\right] + \mu_t f_t$$

First order conditions (FOCs):

$$c_t : \frac{\beta^t}{c_t} = \lambda_t$$

$$k_t : E_t \left[\lambda_{t+1} \left(r_{t+1} + 1 - \delta\right)\right] = \lambda_t$$

[15] County-level data sources are respectively: Center for Disease Control for fertility, Bureau of Economic Analysis for personal income, and Federal Housing Finance Agency for house prices. Certain age groups are not significant though the sign is always positive, with the exception of African American women aged 40-44.

[16] Data on county-level median household debt-to-income ratio is obtained from Mian and Sufi (2009).

$$f_t: \ \frac{\beta^t \sigma_n}{n_t} + \mu_t = \lambda_t \left[w_t^F \phi_l \psi_l \left(n_t\right)^{\psi_l - 1} + \phi_c \right]$$

We can combine these FOCs to obtain:

$$E_t \left[\frac{\beta}{c_{t+1}} \left(r_{t+1} + 1 - \delta \right) \right] = \frac{1}{c_t} \tag{1}$$

$$\frac{\sigma_n}{n_t} + \mu_t = \frac{1}{c_t} \left[w_t^F \phi_l \psi_l \left(n_t\right)^{\psi_l - 1} + \phi_c \right] \tag{2}$$

The lagrangian multipliers on the contraints yield:

$$\lambda_t: \ y_t = c_t + \phi_c n_t + k_t - (1-\delta) k_{t-1} \tag{3}$$

$$\mu_t: \ (f_t = 0, \mu_t > 0) \ \ or \ \ (f_t > 0, \mu_t = 0) \tag{4}$$

We obtain an occasionally binding constraint for irriversibile fertility, which either binds ($f_t = 0$ and $\mu_t > 0$) or does not bind ($f_t > 0$ and $\mu_t = 0$).

Finally, two additional equations help characterize our variables:

$$n_t = (1 - \delta_n) n_{t-1} + f_t \tag{5}$$

$$1 = h_t^F + \phi_l \left(n_t\right)^{\psi_l} \tag{6}$$

Firms' problem

The firms' Lagrangian becomes:

$$L = \max_{\{k, h^F, h^M\}} A_t k_t^{\alpha} \left[\theta (h_t^F)^{\rho} + (1-\theta)(h_t^M)^{\rho} \right]^{\frac{1-\alpha}{\rho}} - w_t^F h_t^F - w_t^M h^M - r_t k_t$$

First order conditions (FOCs):

$$k_t: \ r_t = \alpha \frac{y_t}{k_t} \tag{7}$$

$$h_t^F: \ w_t^F = (1-\alpha) \theta (h_t^F)^{\rho - 1} \frac{y_t}{h_t^{\rho}} \tag{8}$$

$$h_t^M: \ w_t^M = (1-\alpha)(1-\theta) \frac{y_t}{h_t^{\rho}} \tag{9}$$

where:

$$y_t = A_t k_t^{\alpha} h_t^{1-\alpha} \tag{10}$$

$$h_t = \left[\theta (h_t^F)^{\rho} + (1-\theta)(h_t^M)^{\rho} \right]^{\frac{1}{\rho}} \tag{11}$$

$$\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_{At} \tag{12}$$

$$\varepsilon_{At} \sim iid \ N\left(0, \sigma_A^2\right)$$

Equations (1) through (12) define the set of equilibrium conditions.

Solving for Steady State

From condition (12) we obtain:

$$A^* = 1$$

From condition (1) we obtain:

$$r^* = \frac{1}{\beta} - 1 + \delta$$

From condition (7) we obtain:

$$\left(\frac{y}{k}\right)^* = \frac{r^*}{\alpha}$$

From condition (10) we obtain:

$$\left(\frac{h}{k}\right)^* = \left(\frac{y}{k}\right)^{*\frac{1}{1-\alpha}} = \left(\frac{r^*}{\alpha}\right)^{\frac{1}{1-\alpha}}$$

Combining the previous 2 steady states we obtain:

$$\left(\frac{y}{h}\right)^* = \left(\frac{r^*}{\alpha}\right)^{\frac{-\alpha}{1-\alpha}}$$

From conditions (2) and (8):

$$c^* = \frac{n}{\sigma_n}\left[(1-\alpha)\,\theta\left(\frac{1-\phi_l(n_t)^{\psi_l}}{\left[\theta(1-\phi_l(n_t)^{\psi_l})^\rho + 1 - \theta\right]^{\frac{1}{\rho}}}\right)^{\rho-1}\left(\frac{y}{h}\right)^* \phi_l\psi_l\,(n)^{\psi_l - 1} + \frac{\phi_c}{2}\right] = c(n^*)$$

From the budget constraint equation (3):

$$k^*\left(\frac{r}{\alpha} - \delta\right) = c(n^*) + \frac{\phi_c n^*}{2}$$

And from the production function (6) and (10):

$$\frac{r\,(k^*)^{1-\alpha}}{\alpha} = \left(1 - \phi_l\,(n^*)^{\psi_l}\right)^{1-\alpha}$$

Combining the last two equations we can solve for steady state n*:

$$\frac{r\left(c(n^*) + \frac{\phi_c n^*}{2}\right)^{1-\alpha}}{\alpha\left(\frac{r}{\alpha} - \delta\right)} = \left(1 - \phi_l\,(n^*)^{\psi_l}\right)^{1-\alpha}$$

And thus we can solve for the remaining steady state conditions:

$$h^{F*} = 1 - \phi_l\,(n^*)^{\psi_l}$$

$$h^* = \left[\theta(h^{F*})^\rho + 1 - \theta\right]^{\frac{1}{\rho}}$$

$$y^* = \left(\frac{r^*}{\alpha}\right)^{\frac{-\alpha}{1-\alpha}} h^*$$

$$w^{F*} = (1-\alpha)\,\theta\left(h^{F*}\right)^{\rho-1}\frac{y^*}{h^{*\rho}}$$

$$w^{M*} = (1-\alpha)\,(1-\theta)\frac{y^*}{h^{*\rho}}$$

$$f^* = \delta_n n^*$$

Table 1: Calibration of Parameter Values

Parameter	Value	Description	Source
β	0.98	Time discount factor	Cooley and Prescott (1995)
σ_l	1.5	Utility weight on leisure	Cooley and Prescott (1995)
σ_n	2.04	Utility weight on children	Cooley and Prescott (1995)
ϕ_l	0.417	Time cost of children (level)	Cooley and Prescott (1995)
ψ_l	0.33	Time cost of children (curvature)	Cooley and Prescott (1995)
ϕ_c	0.5	Consumption cost of children (level)	Overall cost of children = 40% GDP per capita
δ_n	0.1	Children's depreciation (cost and utility)	?
α	0.3	Share of capital in production	Standard
θ	0.35	Weight of female labor in production	Match w^F/w^M
ρ	0.65	Elasticity of substitution	Acemoglu et al (2004)
δ	0.113	Capital depreciation rate	Cooley and Prescott (1995)
ρ_A	0.9	Persistence of technology	Cooley and Prescott (1995)
σ_A	0.1	Standard deviation of technology shocks	Cooley and Prescott (1995)

Table 2: Steady State

Variable	Value	Description
c	0.375	Consumption
n	1.258	Number of children
h^F	0.550	Hours worked by female
h	0.832	Hours worked by couple
w^F	0.401	Female wages
w^M	0.604	Male wages
k	2.648	Capital stock
r	0.133	Interest rate
y	1.178	Output
A	1	Technology

5.2 Model II: RBC model with Fertility and Female Leisure

Couples' Problem

The couples' Lagrangian is:

$$L = \max_{\{c,h^F,f,k\}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log c_t + \sigma_l \log l_t^F + \sigma_n \log n_t \right\} + \lambda_t \left[w_t^F h_t^F + w_t^M h^M + r_t k_t - c_t - \phi_c n_t - i_t \right] + \mu_t f_t$$

We can substitute in the expressions for leisure, investment, and number of children to obtain:

$$L = \max_{\{c,h^F,n,k\}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log c_t + \sigma_l \log \left(1 - h_t^F - \phi_l (n_t)^{\psi_l}\right) + \sigma_n \log n_t \right\} +$$

$$+\lambda_t \left[w_t^F h_t^F + w_t^M h^M + r_t k_{t-1} - c_t - \phi_c n_t - k_t + (1-\delta) k_{t-1} \right] + \mu_t f_t$$

The FOCs are:

$$c_t : \ \frac{\beta^t}{c_t} = \lambda_t$$

$$h_t^F : \ \frac{\beta^t \sigma_l}{1 - h_t^F - \phi_l (n_t)^{\psi_l}} = \lambda_t w_t^F$$

$$n_t: \; \frac{\beta^t \sigma_n}{n_t} - \frac{\beta^t \sigma_l \psi_l (n_t)^{\psi_l - 1}}{1 - h_t^F - \phi_l (n_t)^{\psi_l}} + \mu_t = \lambda_t \phi_c$$

$$k_t: \; \lambda_{t+1} \left(r_{t+1} + 1 - \delta\right) = \lambda_t$$

We can thus combine these FOCs to obtain:

$$\frac{\sigma_l}{1 - h_t^F - \phi_l (n_t)^{\psi_l}} = \frac{w_t^F}{c_t} \tag{13}$$

$$\frac{\sigma_n}{n_t} - \frac{\sigma_l \psi_l (n_t)^{\psi_l - 1}}{1 - h_t^F - \phi_l (n_t)^{\psi_l}} + \mu_t = \frac{\phi_c}{c_t} \tag{14}$$

$$\frac{\beta}{E_t c_{t+1}} \left(E_t r_{t+1} + 1 - \delta\right) = \frac{1}{c_t} \tag{15}$$

The lagrangian multipliers on the contraints yield:

$$\lambda_t: \; y_t = c_t + \phi_c n_t + k_t - (1 - \delta) \, k_{t-1} \tag{16}$$

$$\mu_t: \; (f_t = 0, \mu_t > 0) \;\; or \;\; (f_t > 0, \mu_t = 0) \tag{17}$$

where:

$$n_t = (1 - \delta_n) \, n_{t-1} + f_t \tag{18}$$

Equations (13) - (18) together with equations (7)-(12) derived above for the firm define the set of equilibrium conditions for this model.

Steady State

From condition (11) we obtain:

$$A* = 1$$

From condition (3) we obtain:

$$r* = \frac{1}{\beta} - 1 + \delta$$

From condition (6) we obtain:

$$\left(\frac{y}{k}\right)^* = \frac{r*}{\alpha}$$

From condition (9) we obtain:

$$\left(\frac{h}{k}\right)^* = \left(\frac{y}{k}\right)^{*\frac{1}{1-\alpha}} = \left(\frac{r*}{\alpha}\right)^{\frac{1}{1-\alpha}}$$

Combining the previous 2 steady states we obtain:

$$\left(\frac{y}{h}\right)^* = \left(\frac{r*}{\alpha}\right)^{\frac{-\alpha}{1-\alpha}}$$

We assume the steady state hours worked by women is:

$$h^{F*} = 0.5$$

Then we have:

$$h^* = \left[\theta(h^{F*})^\rho + 1 - \theta\right]^{\frac{1}{\rho}}$$

$$y^* = \left(\frac{r*}{\alpha}\right)^{\frac{-\alpha}{1-\alpha}} h^*$$

$$k^* = \frac{\alpha y^*}{r^*}$$

$$w^{F*} = (1-\alpha)\,\theta(h^{F*})^{\rho-1}\,\frac{y*}{h^{*\rho}}$$

$$w^{M*} = (1-\alpha)\,(1-\theta)\frac{y^*}{h^{*\rho}}$$

$$f* = \delta_n n*$$

For the remaining steady state conditions there is no explicit analytical solution. The 3 equations solve for c, n, and h^F:

$$c^* + \phi_c n^* = y^* - \delta k*$$

$$\frac{\sigma_l}{1 - h_t^F - \phi_l(n_t)^{\psi_l}} = \frac{w_t^F}{c_t}$$

$$-\frac{\sigma_l \psi_l (n_t)^{\psi_l - 1}}{1 - h_t^F - \phi_l(n_t)^{\psi_l}} + \frac{\sigma_n}{n_t} = \frac{\phi_c}{c_t}$$

5.3 County-level Evidence on Credit Constraints

5.3.1 Lagged House Prices

Table 3: Fertility of White Women by Age Group

VARIABLES	(1) Age 15-19	(2) Age 20-24	(3) Age 25-29	(4) Age 30-34	(5) Age 35-39	(6) Age 40-44
Ln(Personal inc pc) (-1)	18.803***	25.859***	18.901***	14.386***	7.476***	0.108
	(1.960)	(3.481)	(3.298)	(2.515)	(1.531)	(0.590)
Ln(House prices) (-1)	2.390***	12.185***	8.160***	4.483***	0.991*	0.385*
	(0.732)	(1.301)	(1.232)	(0.940)	(0.572)	(0.220)
Constant	-170.905***	-232.619***	-114.060***	-71.252***	-37.669**	5.206
	(19.088)	(33.903)	(32.116)	(24.492)	(14.915)	(5.743)
Observations	4,539	4,540	4,540	4,540	4,540	4,515
R-squared	0.596	0.650	0.387	0.091	0.108	0.093
Number of countycode	454	454	454	454	454	454
Fixed Effects	County-Year	County-Year	County-Year	County-Year	County-Year	County-Year

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Fertility of African American Women by Age Group

VARIABLES	(1) Age 15-19	(2) Age 20-24	(3) Age 25-29	(4) Age 30-34	(5) Age 35-39	(6) Age 40-44
Ln(Personal inc pc) (-1)	3.118	-6.196	-6.865	6.410	-1.119	-1.034
	(4.956)	(9.730)	(9.264)	(6.976)	(4.053)	(1.494)
Ln(House prices) (-1)	-1.748	7.063*	16.194***	9.112***	3.475**	-0.159
	(1.876)	(3.631)	(3.507)	(2.641)	(1.487)	(0.524)
Constant	42.020	161.047*	100.747	-40.117	30.868	20.411
	(48.064)	(94.700)	(90.186)	(68.066)	(39.755)	(14.833)
Observations	3,615	4,101	4,013	3,810	3,198	1,805
R-squared	0.475	0.266	0.035	0.062	0.064	0.072
Number of countycode	398	438	432	417	372	241
Fixed Effects	County-Year	County-Year	County-Year	County-Year	County-Year	County-Year

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Fertility of Asian Women by Age Group

VARIABLES	(1) Age 15-19	(2) Age 20-24	(3) Age 25-29	(4) Age 30-34	(5) Age 35-39	(6) Age 40-44
Ln(Personal inc pc) (-1)	-10.962	11.393	22.967*	-12.178	-0.371	5.946*
	(9.071)	(10.996)	(12.075)	(10.960)	(7.320)	(3.401)
Ln(House prices) (-1)	5.722**	20.623***	12.891***	18.289***	3.333	-2.584***
	(2.302)	(3.711)	(4.391)	(3.925)	(2.555)	(0.987)
Constant	115.215	-149.129	-181.355	154.771	52.803	-33.610
	(91.272)	(109.218)	(119.248)	(108.105)	(72.773)	(34.309)
Observations	970	2,686	3,734	3,813	2,973	1,242
R-squared	0.244	0.139	0.048	0.016	0.013	0.013
Number of countycode	151	353	427	428	367	183
Fixed Effects	County-Year	County-Year	County-Year	County-Year	County-Year	County-Year

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.3.2 Lagged Household Debt Burden

Table 6: Fertility of White Women by Age Group

VARIABLES	(1) Age 15-19	(2) Age 20-24	(3) Age 25-29	(4) Age 30-34	(5) Age 35-39	(6) Age 40-44
Ln(Personal inc pc) (-1)	15.247***	22.654***	23.345***	21.447***	12.150***	1.498
	(3.269)	(5.718)	(6.681)	(5.082)	(3.330)	(1.305)
HH debt-to-income (-1)	-3.897***	-6.298***	-3.007**	-0.184	1.170*	-0.151
	(0.668)	(1.169)	(1.366)	(1.039)	(0.681)	(0.266)
Constant	-116.878***	-128.460**	-115.197*	-121.697**	-82.551**	-7.026
	(34.122)	(59.682)	(69.734)	(53.046)	(34.755)	(13.619)
Observations	1,816	1,816	1,816	1,816	1,816	1,806
R-squared	0.095	0.169	0.086	0.102	0.059	0.046
Number of countycode	454	454	454	454	454	454
Fixed Effects	County-Year	County-Year	County-Year	County-Year	County-Year	County-Year

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Fertility of African American Women by Age Group

VARIABLES	(1) Age 15-19	(2) Age 20-24	(3) Age 25-29	(4) Age 30-34	(5) Age 35-39	(6) Age 40-44
Ln(Personal inc pc) (-1)	21.350*	15.173	2.355	-0.329	0.368	2.296
	(11.234)	(21.888)	(18.270)	(14.033)	(7.896)	(2.852)
HH debt-to-income (-1)	-4.102*	-15.537***	-8.485**	-2.065	-2.545	-0.633
	(2.403)	(4.580)	(3.884)	(2.940)	(1.735)	(0.622)
Constant	-152.096	1.176	100.948	81.118	37.537	-13.714
	(117.362)	(228.556)	(190.859)	(146.705)	(82.728)	(30.033)
Observations	1,456	1,624	1,596	1,501	1,264	700
R-squared	0.021	0.030	0.029	0.050	0.023	0.010
Number of countycode	390	424	423	398	344	208
Fixed Effects	County-Year	County-Year	County-Year	County-Year	County-Year	County-Year

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Fertility of Asian Women by Age Group

VARIABLES	(1) Age 15-19	(2) Age 20-24	(3) Age 25-29	(4) Age 30-34	(5) Age 35-39	(6) Age 40-44
Ln(Personal inc pc) (-1)	-3.803	7.697	-0.426	9.499	-9.057	0.077
	(22.373)	(20.609)	(25.353)	(23.161)	(15.517)	(9.227)
HH debt-to-income (-1)	3.056	-8.505**	-8.711*	-5.909	-5.558*	-0.295
	(2.791)	(4.085)	(5.075)	(4.610)	(3.205)	(1.154)
Constant	63.359	4.279	137.478	30.632	169.244	15.221
	(234.113)	(215.795)	(265.277)	(242.348)	(163.007)	(97.526)
Observations	415	1,090	1,482	1,500	1,168	459
R-squared	0.094	0.019	0.027	0.004	0.010	0.009
Number of countycode	135	326	404	406	332	145
Fixed Effects	County-Year	County-Year	County-Year	County-Year	County-Year	County-Year

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1