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*Research Article*

# Family policies in the context of low fertility and social structure

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# Family policies in the context of low fertility and social structure

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## Abstract

**OBJECTIVE**
In this paper we investigate the effectiveness of family policies in the context of the social structure of a population.

**METHODS**
We use an agent-based model to analyse the impact of policies on individual fertility decisions and on fertility at the aggregate level. The crucial features of our model are the interactions between family policies and social structure, the agents' heterogeneity, and the structure and influence of the social network. This modelling framework allows us to disentangle the direct effect (the alleviation of resource constraints) from the indirect effect (the diffusion of fertility intentions via social ties) of family policies.

**RESULTS**
Our results indicate that family policies have a positive and significant impact on fertility. In addition, the specific characteristics of the social network and social effects do not only relate to fertility, but also influence the effectiveness of family policies.

**CONCLUSIONS**
Family policies can only be successful if they are designed to take into account the characteristics of the society in which they are implemented.

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## 1. Introduction

Many countries of the Western world have witnessed below-replacement fertility, with fertility rates falling to ever lower levels during the 1980s and 1990s. Despite the slight increases observed in several countries (Myrskylä, Kohler, and Billari 2009; Goldstein, Sobotka, and Jasilioniene 2009), the continuation of current fertility trends may lead to population ageing and shrinkage over the long run. Governments are increasingly interested in developing family policies that address the possible causes of these trends. Currently, however, there is no broad consensus on the effectiveness of policies intended to achieve a sustainable increase in — or at least stabilisation of — fertility.

Having assessed data from 22 industrialised countries over the period 1970–1990, Gauthier and Hatzius (1997) found that cash benefits in the form of family allowances are positively related to fertility. McDonald (2006), on the other hand, has argued that pronatalist policies are both expensive and ineffective. After examining Swedish data, Björklund (2006) found that the extension of family policies from the mid-1960s to around 1980 raised the level of fertility. Using data from high-income countries in Europe and North America, Feyrer, Sacerdote, and Stern (2008) found that a doubling of spending per child is associated with an increase in fertility of 0.15 children. Gauthier (2007), trying to generalise empirical findings in a comprehensive survey, noted that studies using micro-level data often show that parental and maternity leave schemes have positive effects on completed cohort fertility, while studies using macro-level data typically find that family policies influence the timing of births, rather than the total number of children. However, she inferred that the impact of these schemes tends to be small, and varies depending on the data used and on the type of policies.

Many empirical studies on the effectiveness of family policies suffer from a static concept of cause and effect that disregards the peer group effects of family policies exerted via social learning and social influence mechanisms. Moreover, studies comparing the impact of family policies in different countries often ignore differences in the societal structures in the countries under consideration. This is surprising given that the literature on fertility has identified social networks as a key mechanism in explaining fertility intentions (for a comprehensive literature survey, see Balbo, Billari, and Mills 2013, p.15). Kohler, Billari, and Ortega (2002) identified economic and social changes, social interaction processes, institutional changes, and postponement-quantum interactions as the main causes of low fertility in Europe. Social interactions, such as personal communication about fertility intentions or perceived social norms and social pressure, may influence childbearing decisions (Bernardi 2003; Fernandez and Fogli 2006). Moreover, social networks may not only influence individual childbearing preferences, but also the individual feasibility of realising these preferences based on the availability of resources such as informal childcare, emotional assistance, and material support (Bühler and Philipov 2005; Philipov, Spéder, and Billari 2006; Balbo and Mills 2011). However, Montgomery and Casterline (1996) claimed that several empirical studies assessing social effects on fertility apply designs that are not capable of accounting for endogenous social network formation.

Our main hypothesis is that social structure, social learning, and social influence mechanisms influence the effectiveness of family policies. Montgomery and Casterline (1996) distinguish between social learning, which means referring to the knowledge and information of others; and social influence, which is based on the desire to avoid conflict within social groups and the threat of group disintegration. They argue that social networks (i) provide information that expands the set of choices, (ii) demonstrate the consequences of behaviour adopted within the group, and (iii) affect individual preferences through social influence effects and conformity pressures. Thus, one individual adopting a certain behaviour may induce a snowball process, with the behaviour spreading from person to person. We build upon this idea, assuming that fertility preferences, and particularly the change in fertility preferences induced by family policies, are also subject to diffusion processes. We integrate the role of social effects into a model of fertility decisions and investigate whether and to what extent the effectiveness of family policies is affected by the social structure. More specifically, family policies may have a direct and an indirect effect on fertility. The direct effect is based on the alleviation of resource constraints, for instance by providing institutional childcare or financial benefits, and allows parents to achieve their intended level of fertility. The indirect effect of family policies rests on the assumption that many people imitate or consult with their friends, siblings, or parents in choosing their intended level of fertility. Local interactions translate into large-scale patterns that again feed back into small groups (Granovetter 1973). Hence, any additional birth resulting from family policies may cause an increase in fertility intentions within the peer group of the family giving birth. Policies causing a modest effect on fertility at the individual level may have a large impact at the macro level due to such peer effects (Feyrer, Sacerdote, and Stern 2008). Therefore, we have developed a model that takes social structure into account and investigated the sensitivity of fertility intentions and realisations with respect to family policies and the parameters that distinguish the social structures. With this contribution, we aim to resolve the confusion and disagreement about the effectiveness of family policies by explicitly addressing their twofold impact.

Family policies can affect fertility through their influence on the costs of children, on individuals' income levels, and on preferences. Most governments now refrain from providing universal cash benefits and instead aim to reduce the structural barriers to combining work and childcare. Individuals differ in their needs, tastes, and objectives; but public policy makers face the challenge of establishing a uniform set of policies to serve a heterogeneous population. Neither the micro nor the macro level alone can explain the influence of family policies (imposed at the macro level) on individual childbearing decisions (taken at the micro level) and the resulting period and cohort fertility patterns (observed at the macro level) to its full extent. In order to model the impact of family policies on fertility decisions, it is necessary to include the decision mechanism at the micro level, the society at the macro level, the interaction between the micro and macro levels, and the interactions of individuals within their peer groups. Granovetter (1973) stated that the analysis of processes in interpersonal networks provides the most fruitful micro-macro bridge.

Therefore, we apply an agent-based model (ABM) to evaluate the impact of alternative family policies on fertility in the context of social and institutional structures which differ across countries. ABMs offer the opportunity to capture individual heterogeneity with respect to several characteristics and allow us to test hypotheses regarding fertility behaviour in the context of different cultures and different types of family policies. ABMs add a behavioural dimension to the analysis (Morand et al. 2010). While the focus is on the aggregate level (completed fertility), our model is based on the micro level and explains how aggregate-level properties emerge from the behaviour of the agents at the micro level. As the recent literature argues that social interaction is a key factor in shaping fertility decisions and preferences, we explicitly account for peer group effects in our model. Recently, ABMs have been applied in demography to explain mate choice and marriage behaviour (Simão and Todd 2003; Todd and Billari 2003; Todd, Billari, and Simão 2005; Aparicio Diaz and Fent 2006; Billari et al. 2007; Walker and Davis 2013), fertility (Aparicio Diaz et al. 2011), and migration patterns. Baroni, Žamac, and Öberg (2009b); Baroni et al. (2009a) applied ABMs to investigate the role of family policies in Sweden.

The paper is organised as follows. In section 2. we present the model structure, in section 3. we illustrate the results of the numerical simulations, in section 4. we summarise our findings and offer some conclusions, in Appendix A we discuss technical details, empirical data, and the parameter space, in Appendix B we sketch an extension of our model, in Appendix C we comment on the social muliplier introduced by Becker and Murphy (2000), and in Appendix D we discuss the animation linked to this paper.

## 2. The model

In this section we present an agent-based computational model to investigate how social structures influence the effectiveness of family policies. In particular, we study the impact of fixed and variable family policies on individual fertility decisions and on the resulting cohort fertility, intended fertility, and the fertility gap (the difference between intended fertility and actual fertility) at the aggregate level. We consider a one-sex model containing only female agents. The crucial features of our model are the agents' heterogeneity with respect to age, household budget, parity, and intended fertility; the social network which links the agents to a small subset of the population and the social effects acting via that network.[4] The agents are endowed with a certain amount of time and money which they allocate to satisfy their own and their childrens' needs. To keep the model simple, we assume that each household considers one unit of time equivalent to $\gamma_{i,t}$ monetary units. This could mean, for example, that working for one unit of time results in $\gamma_{i,t}$ units of monetary income, or spending $\gamma_{i,t}$ monetary units for a babysitter or for domestic aid results in a gain of one time unit. Consequently, we consider only one combined resource stock $w_{i,t}$ for each household, which is the sum of household income plus the monetary equivalent of non-working time. The explicit modelling of the social network and social effects allows us to capture the direct and the indirect effects of family policies. Our aim is to gain general insights into the impact of family policies on fertility under different assumptions regarding the social structure of a population. While we present the main mechanisms of the model in this section, we discuss technical details, sources of empirical data, and the parameter space in Appendix A.

## 2.1 Initial population

At time $t$ each agent $i$ is characterised by her age $x_{i,t}$, household budget $w_{i,t}$ capturing the sum of the monetary equivalent of the time budget and the monetary income, parity $p_{i,t}$, the number of her dependent children (who do not yet have their own income) $n_{i,t}$, and her intended fertility $f_{i,t}$. Agents are assigned a value $z_i$, which determines the quantile in the age specific income distribution they belong to. We assume that the agents remain in the same quantile over their entire lives while still progessing to higher income levels as they age.

## 2.2 Budget restrictions and children

The agent's own consumption (of time and money), $c_{i,t}$, is assumed to be a concave function of the household budget, $c_{i,t} = \sigma\sqrt{w_{i,t}}$, and the consumption level of $n_{i,t}$ dependent children is defined as $c_{i,t}^{(n_{i,t})} = n_{i,t}\,\tau\sqrt{w_{i,t}}$. Thus, consumption levels of children and parents rise more slowly than linearly with household budget. This is based on empirical evidence showing that wealthier households have a higher saving rate (i.e. lower consumption rate) compared to less wealthy households (see e.g. Cutler and Katz 1992;

[4]We are aware that other characteristics, such as education, also have an impact on childbearing behaviour. However, we refrain from including additional characteristics as this would come at the cost of additional model complexity without providing any further insights regarding the impact of the social structure on the effectiveness of family policies. Moreover, education is highly correlated with income. Therefore, if we include both, income and education, it will be difficult to disentangle the effects of these two factors.

Börsch-Supan and Essig 2005; Fessler, Mooslechner, and Schürz 2012). Comparing two model households with the same number of children but different levels of household budget shows that expenditures per child are higher in the wealthier household which corresponds with the quantity quality literature.

Then, the disposable budget $y_{i,t}$ — the difference between household budget $w_{i,t}$ and consumption — becomes $y_{i,t} = w_{i,t} - c_{i,t} - c_{i,t}^{(n_{i,t})}$. If the household's intended fertility exceeds the actual parity,

$$f_{i,t} > p_{i,t}, \tag{1}$$

and the disposable budget is equal to or greater than the estimated needs of an additional child,

$$y_{i,t} \geq \tau\sqrt{w_{i,t}} \iff \sqrt{w_{i,t}} \geq \sigma + (n_{i,t}+1)\tau, \tag{2}$$

the agent is exposed to the biological probability (fecundity) of having another child (Leridon 2004, 2008). In case of a female birth, a new agent $k$ with age $x_{k,t} = 0$ is generated. This new agent is mutually linked to her mother and her sisters (see 2.4).

Each agent ages by one year in each time step, $x_{i,t+1} = x_{i,t} + 1$, and children will eventually turn into adults who earn their own income. The probability of this transition depends on the agent's age and is based on age specific labour force participation rates. After the child's transition to adulthood, the number of her mother's dependent children is reduced by one, but her mother's parity is unchanged. Moreover, the new adult agent is assigned her own income level $z_i$, which determines her household budget $w_{i,t} = w_{i,t}(z_i, x_{i,t})$, her own social network (see 2.4), and her own fertility intentions. Thereafter, she starts to evaluate her fertility intentions according to the inequalities (1) and (2).

### 2.3 Impact of family policies

The aim of the policy maker is to allocate resources to households with children to provide parents with the means to have and raise children. These resources may be cash benefits or nonmonetary means, such as publicly subsidised childcare or legislative actions supporting the combination of working and raising a family. The policy maker may apply a mix of fixed family policies, $b^f$, providing a fixed service or payment per child, and family policies proportional to the household budget, $b^v w_{i,t}$. To keep the numerical simulations tractable and to avoid an excessive number of numerical parameters (see 3.), we investigate a model using one combined resource that captures the sum of the monetary equivalent of nonmonetary resources (e.g. time) and monetary resources. In the case of nonmonetary benefits, $b^f$ and $b^v w_{i,t}$ represent the monetary equivalent from the viewpoint of the household. In Appendix B we elaborate on a model that considers monetary and nonmonetary resources independently.

Any policy mix, $b^f + b^v w_{i,t}$, greater than zero partially covers the needs of $n_{i,t}$ dependent children, $c_{i,t}^{(n_{i,t})} = n_{i,t}\left(\tau\sqrt{w_{i,t}} - b^f - b^v w_{i,t}\right)$, and the disposable budget can be expressed as $y_{i,t} = w_{i,t} - \sigma\sqrt{w_{i,t}} - n_{i,t}\left(\tau\sqrt{w_{i,t}} - b^f - b^v w_{i,t}\right)$. The necessary condition for having an additional child becomes

$$\sqrt{w_{i,t}} \geq \sigma + (n_{i,t}+1)\left(\tau - \frac{b^f}{\sqrt{w_{i,t}}} - b^v\sqrt{w_{i,t}}\right). \tag{3}$$

This inequality embraces the direct effect of family policies, i.e. the alleviation of the budget constraints, which enable parents to realise their fertility intentions.

### 2.4 Endogenous social network

Individuals communicate about various intimate aspects of their lives if they are closely connected. In the context of our modelling framework, we refer to this group as an agent's social network or peer group. Fertility intentions and their realisations are discussed among individuals who are connected. This social network is of crucial importance because it connects the micro and the macro levels. Granovetter defined the strength of a tie as a combination of the amount of time, the emotional intensity, the intimacy, and the reciprocal services which characterise the tie. The strength of the tie connecting two individuals is related to the similarity of the connected individuals. Moreover, the stronger the tie between two individuals, the larger the proportion of individuals to whom they will both be tied (Granovetter 1973).

The mechanisms generating the endogenous social network in this paper are grounded on these theoretical considerations. The similarity of the agents' characteristics has an impact on the probability of being chosen to join an agent's social network (Watts, Dodds, and Newman 2002; Aparicio Diaz et al. 2011). We consider age, income, and intended fertility as the characteristics that determine an agent's social background. Moreover, we assume a certain degree of network transitivity or clustering, i.e. the tendency that two agents who are both connected to the same agent establish a mutual relationship over time (the friends of my friends are also my friends).

Although the mechanism generating the network is based on socioeconomic and demographic similarities, ascribed relations such as family relations and kinship are also captured since every agent is linked to her mother and to her children (see 2.2). Combining this with the built-in network transitivity, the probability of establishing links with sisters, the grandmother, and grandchildren is high compared to the chance of relationships with completely unrelated individuals. In a further step the probability of establishing a link with aunts or cousins is higher than the probability of establishing a link with unrelated individuals, but not as high as the chance of forming relationships with closer relatives.

### 2.5 Social effects and intended fertility

Each agent has an intended fertility defined as the sum of current parity and the intended number of additional children. The intended fertility may be altered due to social learning and social influence imposed by the peer group. Like Montgomery and Casterline (1996) we combine social learning and social influence to general social effects. We assume that interpersonal communication about individual fertility preferences, together with the imitation of peers, may shape preferences. Thus, the dynamics of intended fertility are driven by diffusion via local ties. The adaptations of individual fertility intentions capture the indirect effect of family policies. Parents who have additional children because of the direct effect (see 2.3) may subsequently exert social effects on their peers, resulting in an increase in their fertility intentions.

The network influence operates along two dimensions: the degree to which individuals express their opinions or perform certain types of behaviour, and the closeness and strength of a relationship. We assume that each link to a peer with a parity higher (lower) than the intended fertility of the focal individual $i$ implies a chance that $i$ will increase (decrease) her own fertility intention. Since we do not explicitly trace the strength of ties connecting individuals, we assume constant probabilities for positive or negative influence. Thus, each tie connecting two individuals may be strong or weak depending on random numbers generated during the simulation.

Our model continues the approaches of Rosero-Bixby and Casterline (1993) and Montgomery and Casterline (1996), who applied social learning and social influence mechanisms to model the adoption of contraceptive use. Rosero-Bixby and Casterline (1993) used a differential equation model based on the classic, deterministic diffusion model describing the adoption of an innovation. This approach describes the dynamics of the number of adopters at the population level. Such a framework is capable of considering the interactions among peers, but it focuses entirely on population averages and does not allow for individual heterogeneity. Montgomery and Casterline (1996) developed an empirical specification to estimate the impact of socioeconomic determinants, family planning programmes, and peer group behaviour on the individual propensity to adopt contraception. Aparicio Diaz et al. (2011), on the other hand, used an agent-based model to study the impact of peer group interactions on the shift in age specific fertility between 1984 and 2004.

## 3. Simulation results

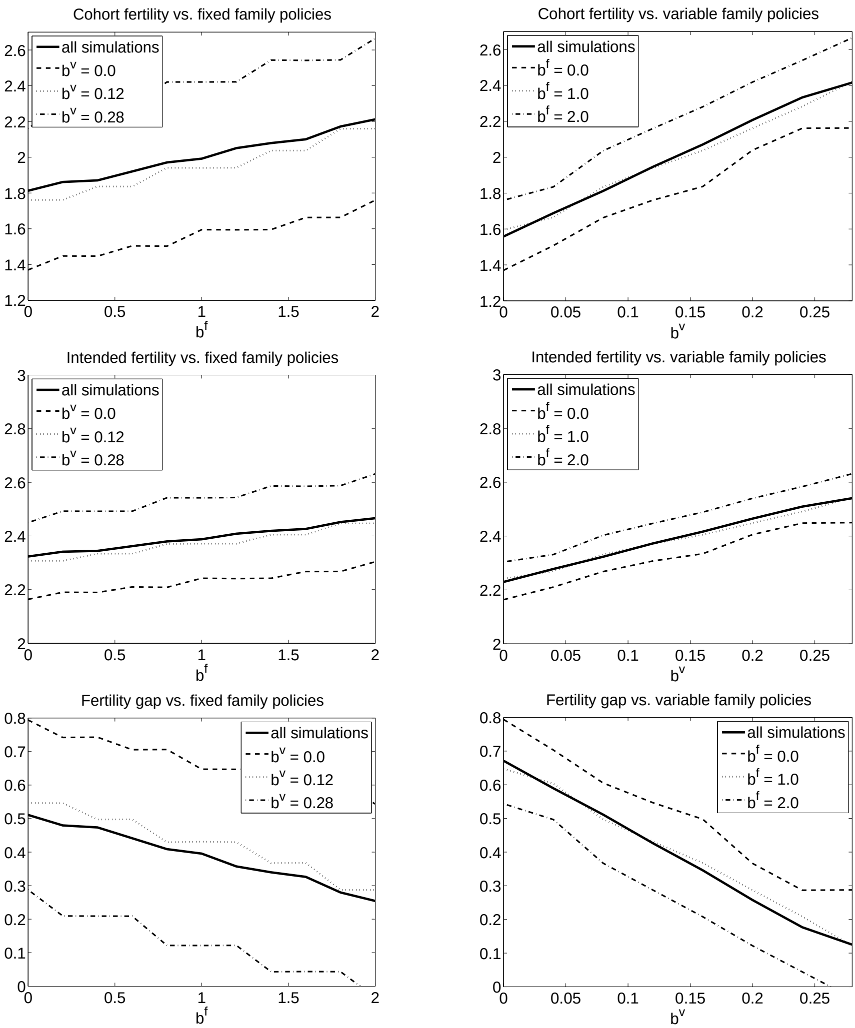
To explore the simulation model described in the previous section, we generate six distinct initial populations of agents endowed with the characteristics age, parity, number of dependent children, intended fertility, and household budget. For all six initial populations the distributions of the individual characteristics are based on the same probabilities but the actual realisations are different. All initial populations consist of 5000 agents. Since we are interested in the role of social structure with regard to the impact of family policies, we vary the level of fixed and proportional family policies $b^f$ and $b^v$, homophily $\alpha$, the degree of network transitivity $pr_2$, the weight of intended fertility $\epsilon_2$, and the strength of positive and negative social influence $pr_3$ and $pr_4$. In particular, we set $\epsilon_1 = 1$, $\tau = 2.3$, $\sigma = 2.5$, $\kappa = 0.7$, $\alpha = 0.2 : 0.4 : 1.0$,[5] $\epsilon_2 = 0 : 3 : 3$, $b^f = 0 : 0.2 : 2.0$, $b^v = 0 : 0.04 : 0.28$, $pr_2 = 0.1 : 0.3 : 0.7$, and $pr_3 - pr_4 = -0.06 : 0.02 : 0.06$. This results in 123,552 different sets of parameter combinations. We discuss these parameters and their feasible ranges in Appendix A. We combine each of these parameter combinations with each of the six initial populations, which means a total of 741,312 simulations, and run each simulation for 100 time steps (years). This may be interpreted as applying 88 different sets of family policies (determined by the parameters $b^f$ and $b^v$) on 8424 different societies (represented by $\alpha$, $\epsilon_2$, $pr_2$, $pr_3$, $pr_3 - pr_4$, and the initial population). For each simulation run we record completed cohort fertility, intended fertility, and the fertility gap (the difference between intended and completed cohort fertility) on the aggregate level. This section summarises the results obtained from these simulations.

Agent-based simulations allow for experiments that would not be feasible in the real world, and these experiments help us to visualise trends and relationships. The medium range of parameter settings and the medium range of fertility outcomes represent somewhat realistic scenarios, while the extreme ends of the parameter range are applied to capture the interdependencies between family policies, network characteristics, and fertility. Because actual fertility depends on the realisation of fertility intentions, we investigate the two components intended fertility and fertility gap independently. The fertility gap indicates to what extent fertility intentions result in actual fertility behaviour. Individuals adapt their fertility intentions if they interact with individuals with higher or lower parity. Therefore, the fertility gap allows us to measure the direct effect of family policies, and the comparison of fertility intentions resulting from different policies allows us to measure the indirect effect.

Figure 1 depicts completed cohort fertility, intended fertility, and the fertility gap of those birth cohorts finishing their reproductive period during the last 10 years of the simulation versus fixed (graphs in the left column) and variable (graphs in the right column) family policies.

[5] This means the parameter $\alpha$ is varied from 0.2 to 1.0 by increments of 0.4

**Figure 1: Completed cohort fertility, intended fertility, and fertility gap by fixed, $b^f$, and variable, $b^v$, family policies.**




*Note*: Both types of family policies have a positive impact on cohort fertility and intended fertility, and a negative impact on the fertility gap.

Due to the large number of simulations, the relatively small size of the agent populations (even small countries like e.g. Andorra, Monaco or San Marino have a lot more than 5000 inhabitants), and the long time span of 100 years, there are some outliers deviating strongly from the number of simulations. That is why we present averages of many simulation runs in the graphs. Here and in the following figures, the solid line always represents the average over all of the simulations. In the left column, the dashed, dotted, and dot-dashed lines show the averages over all simulations with the same level of proportional family policies ($b^v$), and in the right column they depict the averages over all simulations with the same level of fixed family policies ($b^f$). Both the fixed and the variable family policies appear to have a positive influence on cohort fertility, a small positive impact on intended fertility, and a negative impact on the fertility gap. Because the impact of family policies on the fertility gap appears to be more pronounced than the impact on intended fertility, we may conclude that, in our simulation model and for the specific parameter range, the direct effect of family policies is stronger than the indirect effect.

In addition to these graphical visualisations, we present statistical estimates on the impact of family policies in Tables 1 and 2. All of the regression results are based on simulations, and we use ordinary least squares estimation. The dependent variables are completed cohort fertility ($ctfr$), intended fertility ($f$), and the fertility gap ($gap$) of those birth cohorts finishing their reproductive period during the last ten years of the simulation. The explanatory variables are the monetary equivalents of fixed family policies ($unitbf$) and proportional family policies ($unitbv$) measured in monetary units per child per year.

**Table 1: Estimation of the impact of fixed, $unitbf$, and variable, $unitbv$, family policies on completed cohort fertility, intended fertility, and the fertility gap, standard errors in parentheses.**

| dependent variable | $ctfr$ | $f$ | $gap$ |
|---|---:|---:|---:|
| $unitbf$ | .217598*** | .0762465*** | -.1413515*** |
| | (.0016135) | (.0024278) | (.0009583) |
| $unitbv$ | .0673663*** | .0193482*** | -.0480182*** |
| | (.0002631) | (.0003959) | (.0001562) |
| Adjusted $R^2$ | 0.0979 | 0.0043 | 0.1311 |
| Number of observations | 741312 | 741312 | 741312 |

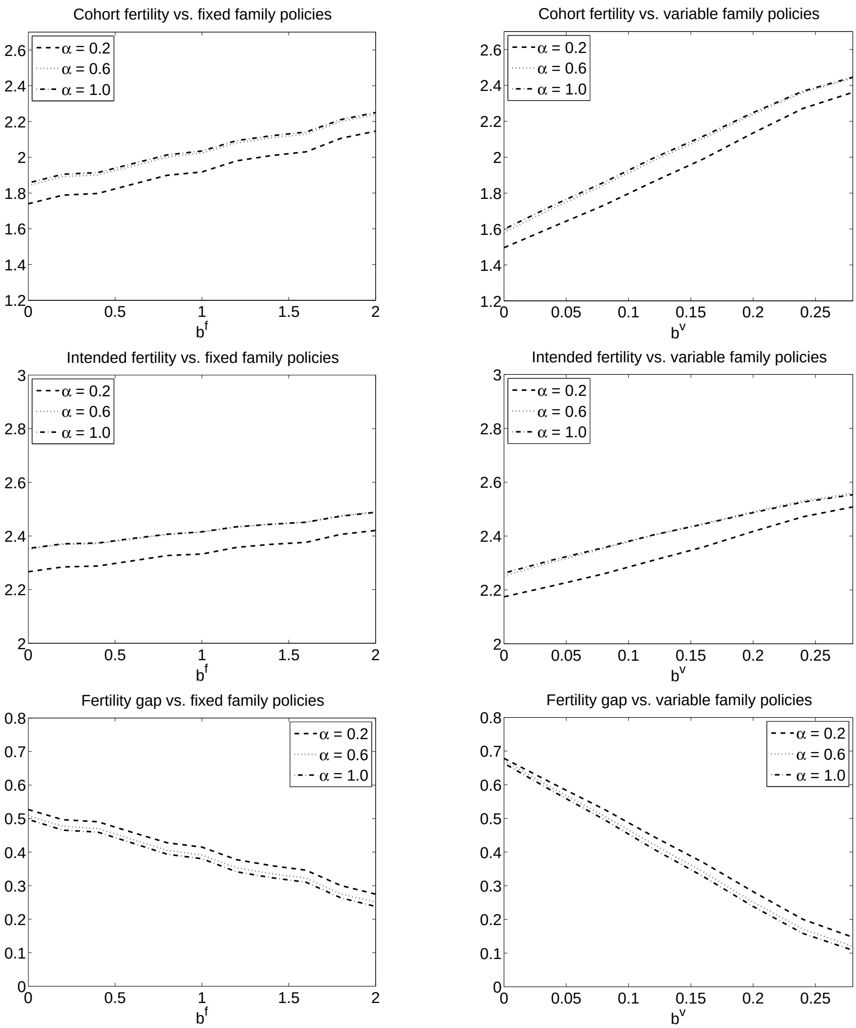
*** significant at 1 percent

The regressions confirm that both types of family policies have a significant positive impact on cohort fertility and intended fertility, and a significant negative impact on the fertility gap. Fixed family policies show a stronger impact. The coefficient for $unitbf$ explaining cohort fertility, $0.217598$, can be interpreted as demonstrating that increasing public investments in children by 1000 Euro per child and year would increase cohort fertility by about $0.22$. However, this result should be interpreted with caution for two reasons. Firstly, all family policy measures in our model refer to combined resources capturing the sum of cash plus the monetary equivalent of nonmonetary policies from the viewpoint of the household. Secondly, the parameters determining the social structure do not only influence the fertility level but also the impact of family policies. We will show this in Table 2.

Figures 2 and 3 again depict cohort fertility, intended fertility, and the fertility gap versus fixed and proportional family policies. In Figure 2 dashed, dotted, and dot-dashed lines indicate different levels of agents' homophily $\alpha$, in Figure 3 they indicate the difference between the probabilities of being influenced by peers with higher or lower parity, $pr_3 - pr_4$ (see A5).

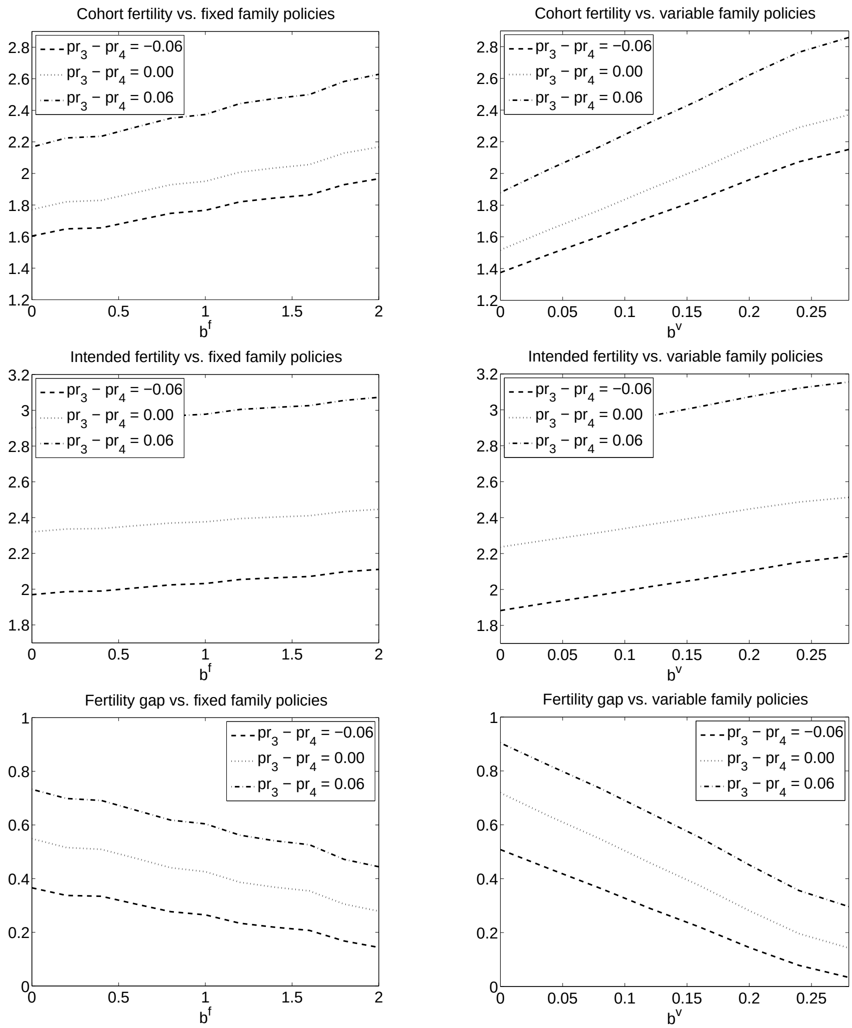
The graphs reveal that homophily $\alpha$ has a visible impact on completed cohort fertility and intended fertility but only a small impact on the fertility gap. Thus, we conclude that the level of homophily in a society has an impact on the indirect effect of family policies, i.e. on the transmission of changes in fertility intentions caused by family policies. The difference $pr_3 - pr_4$ has a positive impact on completed cohort fertility and on the fertility gap, and a strong positive impact on intended fertility. Thus, the influence mechanism determined by the parameters $pr_3$ and $pr_4$ can alter the indirect effect of family policies. Figure 4 depicts cohort fertility, intended fertility, and the fertility gap versus the difference $pr_3 - pr_4$. In the left (right) column, the dashed, dotted, and dot-dashed lines represent the averages over all simulations with the same level of variable (fixed) family policies. These graphs again illustrate the strong positive impact of the difference $pr_3 - pr_4$ on the three measures. Moreover, the graphs in the second row show that the impact of $pr_3 - pr_4$ on the indirect effect of policies exceeds the impact of the policy mix (because the range of intended fertility captured by each of the curves is larger than the gap between the curves). The graphs in the third row show that the direct effect of fixed and proportional family policies (depicted by the distances between the lines) and the impact of $pr_3 - pr_4$ on the fertility gap (illustrated by the range captured by each single line) are both very strong. Finally, all six graphs in this figure reveal a nonlinear impact of $pr_3 - pr_4$. We will consider this nonlinearity in the following statistical investigation.

**Figure 2: Completed cohort fertility, intended fertility, and the fertility gap by fixed, $b^f$, and variable, $b^v$, family policies and by homophily $\alpha$.**



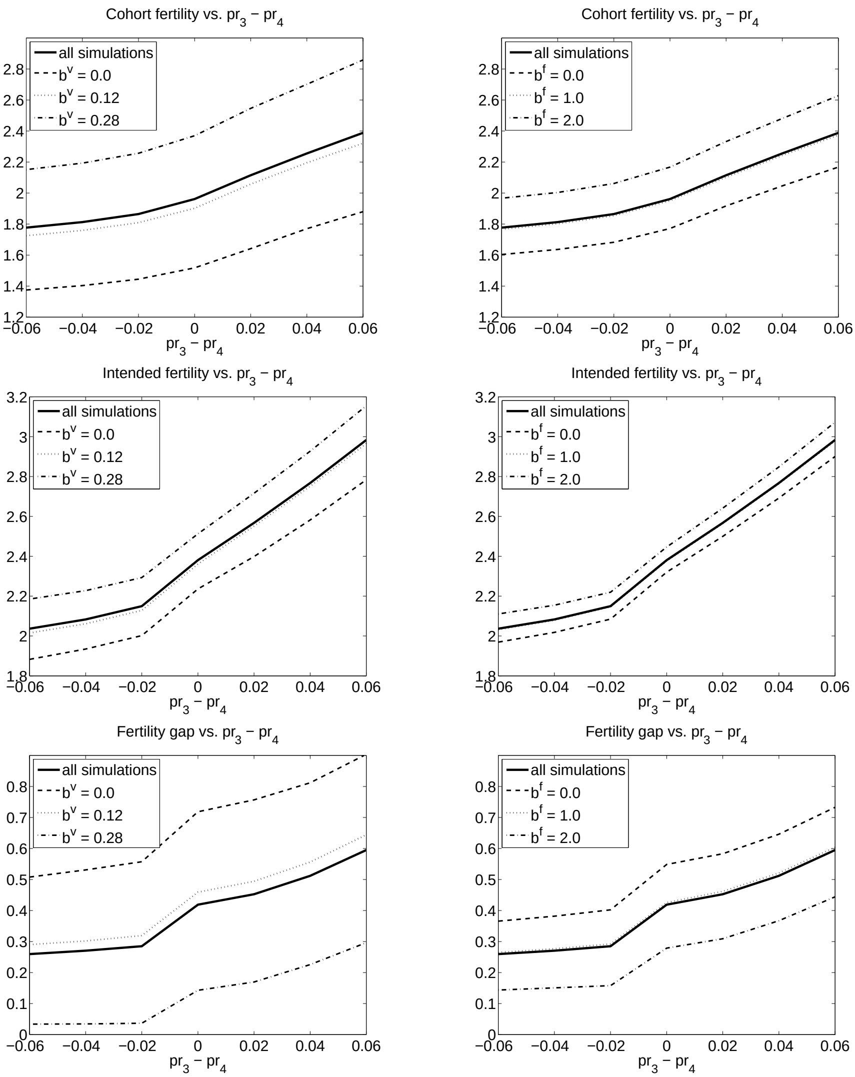

*Note*: Homophily appears to have a positive impact on completed cohort fertility and intended fertility. The overall impact of homophily is small compared to the impact of the policy mix.

**Figure 3: Completed cohort fertility, intended fertility, and fertility gap by fixed, $b^f$, and variable, $b^v$, family policies and $pr_3 - pr_4$, the difference between the probabilities of positive and negative social influence.**




*Note*: The difference has a positive impact on completed cohort fertility and on the fertility gap, and a strong positive impact on intended fertility.

**Figure 4:** **Completed cohort fertility, intended fertility, and fertility gap by $pr_3 - pr_4$, the difference between the probabilities of positive and negative social influence and by fixed, $b^f$, and variable, $b^v$, family policies.**




*Note*: The difference has a strong positive impact on completed cohort fertility and on the fertility gap, and an extremely strong positive impact on intended fertility that actually exceeds the impact of the policy mix.

In Table 2, we present statistical estimates on the impact of child support on fertility, controlling for network parameters and for social effects. Again, the regression results are based on simulations and we use ordinary least squares estimation. As in the previous regressions, the dependent variables are completed cohort fertility ($ctfr$), intended fertility ($f$), and the fertility gap ($gap$) of those birth cohorts finishing their reproductive period during the last ten years of the simulation. The explanatory variables are $unitbf$, $unitbv$, dummy variables $initpop2$, ..., $initpop6$ controlling for the initial pupulation used for each particular simulation run (initial population 1 serves as the reference group), $\alpha$, $pr_2$, $\epsilon_2$, $pr_3$, and $pr_3 - pr_4$. Moreover, we include the interaction terms $unitbf * unitbv$, $\alpha * unitbf$, $\alpha * unitbv$, $pr_2 * unitbf$, $pr_2 * unitbv$, $\epsilon_2 * unitbf$, $\epsilon_2 * unitbv$, $(pr_3 - pr_4) * unitbf$, and $(pr_3 - pr_4) * unitbv$; and the quadratic terms $unitbf^2$, $unitbv^2$, and $(pr_3 - pr_4)^2$ to control for nonlinear effects.

**Table 2: Estimation of the impact of family policies and parameters determining the social structure on completed cohort fertility, intended fertility, and the fertility gap, standard errors in parentheses**

| dependent variable | $ctfr$ | $f$ | $gap$ |
|---|---:|---:|---:|
| $unitbf$ | 0.1545912*** | 0.0769988*** | -0.0775923*** |
| | (0.0036223) | (0.0058995) | (0.0029992) |
| $unitbv$ | 0.1219109*** | 0.0933596*** | -0.0285513*** |
| | (0.0005237) | (0.0008529) | (0.0004336) |
| $unitbf^2$ | 0.0166549*** | 0.005283** | -0.0113719*** |
| | (0.001333) | (0.002171) | (0.0011037) |
| $unitbv^2$ | -0.0044754*** | -0.0056254*** | -0.0011501*** |
| | (0.0000276) | (0.000045) | (0.0000229) |
| $unitbf * unitbv$ | 0.0046409*** | -0.0021794*** | -0.0068203*** |
| | (0.0001936) | (0.0003154) | (0.0001603) |
| $initpop2$ | 0.5934949*** | 0.7079207*** | 0.1144258*** |
| | (0.001634) | (0.0026612) | (0.0013529) |
| $initpop3$ | 2.028357*** | 3.092795*** | 1.064438*** |
| | (0.001633) | (0.0026596) | (0.0013521) |
| $initpop4$ | 1.670658*** | 2.363395*** | 0.6927377*** |
| | (0.0016337) | (0.0026607) | (0.0013527) |
| $initpop5$ | 1.667212*** | 2.359704*** | 0.6924919*** |
| | (0.0016338) | (0.0026609) | (0.0013528) |

**Table 2: (Continued)**

| dependent variable | $ctfr$ | $f$ | $gap$ |
|---|---|---|---|
| $initpop6$ | 1.671556*** | 2.364802*** | 0.6932458*** |
| | (0.0016338) | (0.0026608) | (0.0013527) |
| $\alpha$ | 0.1508017*** | 0.1296827*** | -0.021119*** |
| | (0.0035742) | (0.0058212) | (0.0029594) |
| $\alpha * unitbf$ | -0.0087852*** | -0.0149187*** | -0.0061335*** |
| | (0.0022807) | (0.0037145) | (0.0018884) |
| $\alpha * unitbv$ | -0.0024081*** | -0.0030503*** | -0.0006423** |
| | (0.0003724) | (0.0006065) | (0.0003083) |
| $pr_2$ | -0.0102794** | -0.017301** | -0.0070216* |
| | (0.0047677) | (0.0077649) | (0.0039476) |
| $pr_2 * unitbf$ | 0.0026065 | 0.0050076 | 0.0024011 |
| | (0.0030405) | (0.0049519) | (0.0025175) |
| $pr_2 * unitbv$ | 0.0001563 | 0.0011218 | 0.0009655** |
| | (0.0004958) | (0.0008075) | (0.0004105) |
| $\epsilon_2$ | -0.0023557*** | -0.0017662 | 0.0005895 |
| | (0.0007785) | (0.001268) | (0.0006446) |
| $\epsilon_2 * unitbf$ | 0.0013926*** | 0.0010154 | -0.0003773 |
| | (0.0004965) | (0.0008086) | (0.0004111) |
| $\epsilon_2 * unitbv$ | 0.0004723*** | 0.0003697*** | -0.0001026 |
| | (0.000081) | (0.0001319) | (0.000067) |
| $pr_3$ | 2.297383*** | 0.9056272*** | -1.391756*** |
| | (0.0073055) | (0.0118982) | (0.006049) |
| $pr_3 - pr_4$ | 2.269449*** | 6.23648*** | 3.967031*** |
| | (0.0299195) | (0.0487284) | (0.0247732) |
| $(pr_3 - pr_4)^2$ | 26.72111*** | 42.07791*** | 15.35679*** |
| | (0.3443813) | (0.5608764) | (0.2851463) |
| $(pr_3 - pr_4) * unitbf$ | 0.4931002*** | 0.1841282*** | -0.308972*** |
| | (0.0190671) | (0.0310536) | (0.0157875) |
| $(pr_3 - pr_4) * unitbv$ | 0.3081202*** | 0.2467376*** | -0.0613826*** |
| | (0.0031235) | (0.0050871) | (0.0025862) |
| constant | -0.3477147*** | 0.0317416*** | 0.3794563*** |
| | (0.0039059) | (0.0063614) | (0.0032341) |
| Adjusted $R^2$ | 0.8078 | 0.7515 | 0.6402 |
| Number of observations | 741 312 | 741 312 | 741 312 |

* significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

As in the previous estimation, $unitbf$ and $unitbv$ have a significant positive impact on cohort fertility and intended fertility, and a significant negative impact on the fertility gap. Variable family policies contribute more to the indirect effect ($f$), while for fixed family policies the direct and indirect effects are nearly equal. The quadratic terms and the interaction of fixed and variable family policies are strongly significant but the coefficients are small. The dummy variables representing the initial populations have a big impact and are strongly significant. Thus, the initial conditions at the beginning of the simulation run determine a large portion of the results at the end of the simulation. Homophily $\alpha$ has a significant positive impact on cohort fertility and intended fertility, and a significant but small negative impact on the fertility gap. This means homophily operates mostly on the indirect effect. The interactions of homophily with family policies $\alpha * unitbf$ and $\alpha * unitbv$ are strongly significant and the coefficients are all negative and small. Consequently, societies characterised by a high level of homophily tend to higher levels of fertility, the impact of policies on the direct effect ($gap$) is slightly stronger, and the impact of policies in such societies on the indirect effect ($f$) is weaker. Network transitivity, $pr_2$, has a negative impact on completed cohort fertility, intended fertility, and on the fertility gap, and the interactions of transitivity with family policies have a positive impact on all three dependent variables. Like in the case of homophily, this may be interpreted such that societies with a high level of network transitivity tend to lower fertility levels, the impact of policies on the indirect effect ($f$) is stronger, and the impact of policies on the indirect effect ($gap$) is weaker. However, in the case of transitivity, not only are the respective coefficients small, but the level of significance is also weak. The weight of intended fertility for calculating the social distance in equation (10), $\epsilon_2$, has a small but strongly significant negative impact on cohort fertility, and no significant impact on the other measures. Thus, an increase in $\epsilon_2$ slightly reduces cohort fertility. The interactions with policies, on the other hand, mitigate that effect. The coefficients for cohort fertility have a positive sign and are strongly significant. As expected, the probability of being positively influenced by a peer with higher parity, $pr_3$, has a positive impact on intended fertility. Moreover, the impact on the fertility gap is significant and negative, resulting in an even stronger positive and significant impact on cohort fertility. The difference between the probabilities of being influenced by peers with higher or lower parities, $(pr_3 - pr_4)$, has a strong positive impact on intended fertility and cohort fertility, but also on the fertility gap. Thus, the increased intentions cannot always be fulfilled due to the budgetary constraints which counteract high fertility intentions. The quadratic term $(pr_3 - pr_4)^2$ has an even stronger positive impact on the three dependent variables, confirming the convex curves depicted in Figure 4. The interaction $(pr_3 - pr_4) * unitbf$ has a significant positive impact on completed cohort fertility and intended fertility, and a significant negative impact on the fertility gap. The same holds true for the interaction with variable family policies, $(pr_3 - pr_4) * unitbv$. Thus, the difference $(pr_3 - pr_4)$ supports the direct and indirect effect of both fixed and variable family policies resulting in higher cohort fertility and a smaller fertility gap. The estimated coefficients show that the indirect effect of proportional policies is more sensitive to social effects than is the indirect effect of fixed policies. This is in agreement with our results regarding the social multiplier (see C). The direct effect of fixed policies, on the other hand, is more sensitive to social effects than is the direct effect of proportional policies.

The coefficients listed in the second column of Table 2 (completed cohort fertility $ctfr$) are based on the empirical specification

$$\begin{aligned}
ctfr &= \beta_0 + \beta_1 unitbf + \beta_2 unitbv + \beta_3 unitbf^2 + \beta_4 unitbv^2 + \beta_5 unitbf * unitbv \\
&+ \beta_6\, initpop2 + \beta_7\, initpop3 + \beta_8\, initpop4 + \beta_9\, initpop5 + \beta_{10}\, initpop6 \\
&+ \beta_{11}\alpha + \beta_{12}\alpha * unitbf + \beta_{13}\alpha * unitbv \\
&+ \beta_{14} pr_2 + \beta_{15} pr_2 * unitbf + \beta_{16} pr_2 * unitbv \\
&+ \beta_{17}\epsilon_2 + \beta_{18}\epsilon_2 * unitbf + \beta_{19}\epsilon_2 * unitbv \\
&+ \beta_{20} pr_3 + \beta_{21}(pr_3 - pr_4) + \beta_{22}(pr_3 - pr_4)^2 \\
&+ \beta_{23}(pr_3 - pr_4) * unitbf + \beta_{24}(pr_3 - pr_4) * unitbv. \qquad (4)
\end{aligned}$$

Then, in a given society characterised by numerical parameters $\alpha$, $pr_2$, $\epsilon_2$, $pr_3$, and $pr_4$, the marginal impact of one monetary unit of fixed family policies (a monetary equivalent of 1000 Euro) on completed cohort fertility can be estimated as the partial derivative of (4) with respect to $unitbf$,

$$\begin{aligned}
ctfr_{unitbf} &= \beta_1 + \beta_3 unitbf + \beta_5 unitbv \\
&+ \beta_{12}\alpha + \beta_{15} pr_2 + \beta_{18}\epsilon_2 + \beta_{23}(pr_3 - pr_4), \qquad (5)
\end{aligned}$$

and in the same way the marginal impact of one monetary unit of variable family policies on completed cohort fertility may be depicted in the form

$$\begin{aligned}
ctfr_{unitbv} &= \beta_2 + \beta_4 unitbv + \beta_5 unitbf \\
&+ \beta_{13}\alpha + \beta_{16} pr_2 + \beta_{19}\epsilon_2 + \beta_{24}(pr_3 - pr_4). \qquad (6)
\end{aligned}$$

Taking together the numerical results from Table 2, the marginal impacts in (5) and (6) become

$$\begin{aligned} ctfr_{unitbf} &= .1545912 + .0166549 * unitbf + .0046409 * unitbv \\ &\quad -.0087852 * \alpha + .0026065 * pr_2 + .0013926 * \epsilon_2 \\ &\quad +.4931002 * (pr_3 - pr_4) \qquad (7) \\ ctfr_{unitbv} &= .1219109 - .0044754 * unitbv + .0046409 * unitbf \\ &\quad -.0024081 * \alpha + .0001563 * pr_2 + .0004723 * \epsilon_2 \\ &\quad +.3081202 * (pr_3 - pr_4). \qquad (8) \end{aligned}$$

Applying the numerical parameters used for the simulations, the mean value of the marginal impact $ctfr_{unitbf}$ is .195 and the mean value of $ctfr_{unitbv}$ is .0978. Hence, providing a monetary equivalent of 1000 Euro per child and year for fixed family policies could raise cohort fertility on average by almost 0.2 and supplying a monetary equivalent of 1000 Euro per child and year in terms of proportional family policies could raise cohort fertility on average by nearly 0.1. Depending on the magnitude of the numerical parameters, the pure impact of family policies given by the constant term in (7) and (8) may not only be amplified or damped but even reversed in extreme cases. Comparing the estimated coefficients in Table 1 with the corresponding coefficients in Table 2 reveals that neglecting the social structure in our simulation model and parameter space results in an overestimation of the impact of fixed policies on completed cohort fertility and on the fertility gap (the coefficients for intended fertility do not differ very much), an underestimation of the impact of proportional policies on completed cohort fertility and on intended fertility, and an overestimation of the impact of proportional policies on the fertility gap.

## 4. Summary and conclusions

We study the impact of fixed and proportional family policies on intended fertility, on the realisation of intended fertility, and on the resulting completed cohort fertility. In particular, we investigate whether the structure of a society represented by parameters specifying the social network and social effects has the potential to alter the role of family policies. In our modelling framework, individuals are characterised by their sociodemographic characteristics age, household budget, parity, the number of dependent children, and intended fertility. The agents are closely linked to a set of other agents with whom they discuss their fertility intentions and the realisation of their plans. We refer to this group as the agent's social network. The whole agent population constitutes the society. The agents are not directly linked to those agents who do not belong to their social network, but any agent may indirectly influence any other agent via intermediaries.[6] The above-mentioned characteristics, as well as the family policy measures and social effects transmitted via the social network, have an impact on the agents' fertility intentions and behaviour. The model allows us to carry out experiments to test various combinations of childcare benefits and combine them with different assumptions regarding the underlying social structure.

Our simulations reveal that both fixed and proportional family policies have positive effects on completed cohort fertility and intended fertility and a negative impact on the fertility gap. These findings are in line with empirical studies (Gauthier and Hatzius 1997; Björklund 2006; Gauthier 2007; Feyrer, Sacerdote, and Stern 2008; Egger and Radulescu 2012) and microsimulation models (Kalb and Thoresen 2010). Social networks and social effects are also found to affect fertility, which coincides with empirical results (Bühler and Philipov 2005; Philipov, Spéder, and Billari 2006; Balbo and Mills 2011) and with simulation models (Zamac, Hallberg, and Lindh 2010). Moreover, proportional policies contribute more to the indirect effect (increase in intended fertility) while the contribution of fixed policies to the direct effect (reduction of the gap between intended fertility and completed cohort fertility) and indirect effect are approximately equal. Consequently, the indirect effect of proportional policies is more sensitive to social effects than is the indirect effect of fixed policies. The direct effect of fixed policies, on the other hand, is more sensitive to social effects than is the direct effect of proportional policies. The social multipliers which can be computed for any given level of social effects allows us to quantify to what extent the effectiveness of family policies is mitigated or reinforced by social effects (see C). Our findings that the probability of being positively influenced by a peer with higher parity and the difference between the probabilities of being influenced by peers with higher or lower parities have positive effects on completed cohort fertility and intended fertility, have empirical support from Balbo and Mills (2011), who showed that increased social pressure from parents, relatives, and friends increases the likelihood that a woman will plan to have another child.

Several parameters determining the network and social effects do not only influence fertility itself, but also the effectiveness of family policies, often in a detrimental way. The key element of our model is the combination of family policies and social effects. This allows us to investigate not only the individual effects of policies and social networks but also their interactions. For example, while a higher degree of homophily among the network partners appears to have a positive effect on fertility (intentions and realisations), family policies may be less effective in such a society. Similar results hold for the parameter that characterises the weight put on intended fertility in the selection of the social

[6] Harary, Norman, and Cartwright (1965) use the term "bridge" for those links that provide the only connection between two otherwise unconnected subgroups of the population, and Granovetter (1973) defines "local bridges" as those links that provide the shortest connection between two subgroups.

network, and for the parameters that determine the social influence on intended fertility among network partners. We infer that empirical studies gain from the inclusion of variables depicting the social structure. Kalb and Thoresen (2010), for instance, compare the Australian support scheme which is based on means-tested or income-tested transfers and the Nordic scheme of subsidised non-parental care and a universal child benefit schedule. Means-tested transfers and subsidised non-parental care correspond to proportional policies in our framework and universal family income support is the equivalent to fixed family policies. Kalb and Thoresen investigate the impact of policiy changes in the context of different labour market characteristics and different behavioural responses in the two countries. They find that reduced childcare fees encourage female labour supply but do not contribute to a more equal distribution of income. They conclude that family policies that redistribute income are more preferable in the Australian context. Parr and Guest (2011) use a longitudinal survey to isolate the effects of family policy changes from general socioeconomic and demographic trends. They conclude that the effect of policy changes is small and not statistically significant.

The main conclusion of our model and simulation exercise is clearly the role of social interaction for the effectiveness of family policies in addition to the direct effect of social interaction on fertility. As well as family policies, social interaction may also influence other determinants of fertility. E.g. the role of economic uncertainty for fertility may be different depending on the social structure of the population. More generally, our modelling framework offers a tool to investigate and disentangle indirect effects of fertility determinants from direct ones. In our case the indirect effects work through social interaction and the determinant we are interested in is family policy. However, instead of social interaction or maybe in addition to social interaction other aspects of a society, such as attitudes, norms, and values, may induce an indirect effect on fertility. Similarly the fertility determinant we are interested in, i.e. family policy, may be any other or a set of other family determinants.

A comprehensive review of fertility determinants in advanced societies is given in Balbo, Billari, and Mills (2013). Obviously our model includes only a selection of variables influencing fertility. At the micro/individual level important extensions of our model are the consideration of partners and employment uncertainties. At the meso level not only social interaction but social capital and place of residence may be important characteristics to include as well. At the macro level, additional components of family policies (e.g. entitlement to monetary transfers, maternal and paternal leave periods), economic trends, changes in values and attitudes, and the advancement in reproductive technologies are important determinants to be included.

Our simulation model allows for any variation of social networks and social effects which may have an impact on the diffusion of fertility intentions, and, therefore, the indirect effect of family policies. Because empirical research on the effects of social capital and social pressure on fertility intentions has identified significant cross-country differences (Philipov, Spéder, and Billari 2006; Balbo and Mills 2011), the correct assessment of the effectiveness of family policies requires controlling for social effects. Knack and Keefer (1997) found marked cross country variations in social capital; Wright (1997) noted that the level of homophily varies from country to country; and Kalmijn (1998) inferred that educational homogamy in marriage increased strongly in the United States, but that most countries showed no trend, and that some showed a decrease. Consequently, attempts to transfer a certain policy mix that has proved successful in one country at a certain time to another country or society while ignoring differences in social structure may fail. Family policies can only be successful if they explicitly take into account the characteristics of the society to which they are applied. For instace our simulation shows that in the presence of strong positive social effects fixed policies reduce the fertility gap more effectively, while proportional policies increase intended fertility and vice versa.

We further conclude that cross-country comparisons of different types of family policies should be seen in the context of the social and economic structures. The impact of a certain policy depends on the subset of policies being investigated but comprehensive experiments that study any and all possible policy mixes are not feasible in the real world. Moreover, empirical studies addressing the impact of social learning, social pressure, and social capital on fertility and fertility intentions show a strong influence of the social structure on intended and actual fertility. We combine the impact of family policies, social networks, and social effects into one unifying framework in order to gain a better understanding of how family policies interact with social and societal structures.

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# Appendix

## A Technical details of the model

In this section we elaborate on the technical details, on the empirical data we used to obtain the distributions of the agents' characteristics, and on the feasible parameter space of the model presented in Section 2.. Although we use Austrian data to obtain the distributions of age, parity, income, and intended fertility, the model should not be interpreted as an accurate microsimulation of Austrian society. The intention is to get realistic distributions which resemble typical Western European low-fertility societies.

### A1 Initial population

We use census data to obtain an initial age and parity distribution. The parity distribution and the distribution of the age of the children are based on data on the mothers' age at birth in 2008.[7] Moreover, we apply data from the income tax statistics[8] for the distribution of household income. We use age-specific data on the 25% quantile, the median value, and the 75% quantile of the annual net income; and interpolate the data. We then use data from the Gender and Generation Survey (GGS) to estimate the distribution of the desire for additional children given the agents' age and parity. We define the probability $\pi_i^m$ that agent $i$ wants at least $m$ additional children $(1 \leq m \leq 8)$ and use the logit model

$$\text{logit}(\pi_i^m) = \beta_0^m + \beta_1^m x_i + \beta_2^m p_i \tag{9}$$

for each $m$ to estimate the respective probabilities from the GGS data for the initial population.

### A2 Budget restrictions and children

The numerical parameters $\sigma$ and $\tau$ need to be nonnegative and sufficiently small. Negative values would correspond to negative consumption needs, which are unrealistic and would allow for infinite consumption and, in case of negative $\tau$, for an infinite number of children. Excessively high values would not allow for any children. For instance, $\sigma = \sqrt{w_{i,t}}$ (or $\tau = \sqrt{w_{i,t}}$, respectively) means that the agent's entire budget is needed to cover her own needs (the needs of one child).

In case of a successful live birth, a new agent is generated with a probability depending on the Austrian sex ratio at birth, since our simulation only keeps track of female

[7] STATISTIK AUSTRIA, Statistik der natürlichen Bevölkerungsbewegung 2008
[8] STATISTIK AUSTRIA, Allgemeiner Einkommensbericht 2008

individuals. Male children are not implemented as agents within the artificial population, but they contribute to the parity and number of dependent children of their mothers.

Since the distribution of fertility preferences in the artificial society may change over time, we compute for each $m$ the aggregate share of adult agents with parity $p_i < m$ who desire at least $m$ children, $\Pi_t^m$. We use these shares to update the parameters $\beta_0^m$ in equation (9) every five years according to

$$\beta_{0,t}^m = \beta_0^m \frac{\log \frac{\Pi_t^m}{1-\Pi_t^m}}{\log \frac{\Pi_0^m}{1-\Pi_0^m}} ,$$

and the new adult agent's intended fertility is assigned according to the probabilities

$$\pi_i^m = \frac{\exp(\beta_{0,t}^m + \beta_1^m x_i)}{1 + \exp(\beta_{0,t}^m + \beta_1^m x_i)}.$$

Finally, agents die off with a probability based on the Austrian female life table.

## A3 Impact of family policies

From inequalities (1) and (2) it becomes immediately clear that family policies can be effective for those households with unsatisfied fertility preferences and with a funding gap, i.e. households with a disposable budget that is insufficient to meet the needs of an additional child. Thus, it is possible to calculate the level of support needed to increase parity by one for each household. However, due to the heterogeneous distribution of (unsatisfied) fertility preferences (which are dynamically adapted via social effects, see 2.5 and A5), the heterogeneous distribution of resources, and the nonlinear relationship between resources and needs, it is not possible to calculate the direct impact of family policies at the aggregate level analytically.

The parameters $b^f$ and $b^v$ need to be nonnegative. Negative values would mean that the policymaker imposes additional costs or burdens on parents, and the derivation of the neccesary condition for having an additional child (see 2.3) would become invalid. On the other hand, an upper limit for meaningful family policies can be identified at the level at which the family supports per child equal the needs per child, $b^f + b^v w_{i,t} = \tau \sqrt{w_{i,t}}$.

## A4 Endogenous social network

The social distance between agents $i$ and $j$ is defined as

$$d_{ij} = |x_i - x_j| + \epsilon_1 |z_i - z_j| + \epsilon_2 |f_i - f_j| . \tag{10}$$

The parameter $\epsilon_1$ determines the weight of the income difference and $\epsilon_2$ determines the weight of the differences in the intended fertility of the two agents. Differences in income or intended fertility are ignored when setting the respective parameter zero. To build up the social network, an agent chooses a distance $d$ with probability $pr_1(d) = c\exp(-\alpha d)$ and then picks an agent with distance $d$ as a new friend (Watts, Dodds, and Newman 2002; Aparicio Diaz et al. 2011). For this choice, we define another probability $pr_2$, which determines whether this new friend is chosen among those individuals who are not linked to any of the agent's peers or only among those individuals who are linked to at least one of the agent's friends. This parameter allows us to adjust the degree of transitivity in the social network which to some degree also serves as a measure of the strength of the ties. The constant $c$ is a normalisation parameter to ensure that the probabilities of all of the feasible distances sum up to one, and the parameter $\alpha$ determines the agents' level of homophily. If $\alpha$ is assigned high values, the chances of a connection forming between similar individuals become high. The selecting agent is also added to the network of the selected agent. Thus, we assume a mutual friendship relation which means that the underlying network topology is represented by an undirected graph. This procedure is repeated until the desired number of peers, $s$, is found. This desired network size is drawn from a log normal distribution (see for instance Dunbar and Spoors 1995, Fig. 1) with mean $\bar{s} = 10$ and rounded to the nearest integer.

The weights $\epsilon_1$ and $\epsilon_2$ have to be nonnegative but may take any finite number. Very high values mean a dominance of one characteristic in determining the social distance. The parameter $\alpha$ determining the level of homphily may also take any nonnegative value. The probability $pr_2$ may take any value from the closed interval $[0, 1]$.

## A5 Social effects and intended fertility

At time $t$ agent $i$ has an intended fertility of $f_{i,t}$, which must be a nonnegative integer, and is defined as the sum of current parity $p_{i,t}$ and the intended additional children. Since we need an approach based at the individual level that allows for nonlinear interaction of positive and negative influence, we implement social effects similar to Goldenberg et al. (2007). We assume that intended fertility increases (decreases) by one with probability $pr_3$ ($pr_4$) due to the social effects exerted by a peer with a parity greater (less) than the agent's intended fertility. Then, we compute $\pi_i^+$ ($\pi_i^-$), the number of agents $j$ who are linked to $i$ and have a parity greater (less) than the intended fertility of agent $i$, i.e. $p_{j,t} > f_{i,t}$ ($p_{j,t} < f_{i,t}$). Based on these calculations, we compute the probabilities for an agent to be positively or negatively influenced by at least one agent from the peer group,[9]

[9]If $pr_3$ is the probability of increasing intended fertility due to meeting one peer with a higher parity, then $(1 - pr_3)$ is the probability of not increasing intended fertility despite this one peer, $(1 - pr_3)^{\pi_i^+}$ is the

$p^+_{i,t} = 1 - (1 - pr_3)^{\pi^+_i}$ and $p^-_{i,t} = 1 - (1 - pr_4)^{\pi^-_i}$. Individuals may be exposed to positive influence, negative influence, both positive and negative influence, or neither. Hence, the probability of being only positively (negatively) influenced becomes $(1 - p^-_{i,t})p^+_{i,t}$ (respectively $(1 - p^+_{i,t})p^-_{i,t}$) and the probability of being both positively and negatively influenced is $p^+_{i,t}p^-_{i,t}$. We use the parameter $\kappa$ (or $(1 - \kappa)$) to determine the fraction of individuals who increase (decrease) their intended fertility in the case of mixed influence. Then the probabilities of increasing, decreasing or keeping the intended fertility constant are

$$\begin{aligned} p_i(f_{i,t+1} = f_{i,t} + 1) &= (1 - p^-_{i,t})p^+_{i,t} + \kappa p^+_{i,t}p^-_{i,t} \\ p_i(f_{i,t+1} = f_{i,t} - 1) &= (1 - p^+_{i,t})p^-_{i,t} + (1 - \kappa)p^+_{i,t}p^-_{i,t} \\ p_i(f_{i,t+1} = f_{i,t}) &= (1 - p^+_{i,t})(1 - p^-_{i,t})\,. \end{aligned}$$

The probabilities $pr_3$ and $pr_4$ and the parameter $\kappa$ may take any value from the closed interval $[0, 1]$. In the case of new products any adopter may influence friends to adopt this product as well (Goldenberg et al. 2007); in our model, actual births are assumed to influence fertility intentions, which do not need to be realised immediately. Thus, we allow for different probabilities for the increase and decrease since the actual parity within the network is usually lower than the desired fertility of the peers. Using the same probability for increasing and decreasing results in a steady bias towards lower levels of intended fertility.

## B An extended model with two resources

In the case of two scarce resources — for example, time and money — the household budget, consumption needs, and family supports provided by the public administration (family policies) must be considered for both components. Let us assume household $i$ has a budget of $u_{i,t}$ units of time and $v_{i,t}$ units of money at time $t$. The agent's own consumption of time, $\tilde{c}_{i,t}$, and money, $\hat{c}_{i,t}$, are assumed to be concave functions of the respective household budgets (here and in the following ˜ denotes quantities of time and ˆ refers to quantities of money),

$$\tilde{c}_{i,t} = \tilde{\sigma}_{i,t}\sqrt{u_{i,t}} \quad \text{and} \quad \hat{c}_{i,t} = \hat{\sigma}_{i,t}\sqrt{v_{i,t}}\,,$$

and the respective consumption levels of $n_{i,t}$ dependent children are defined as

$$\tilde{c}^{(n_{i,t})} = n_{i,t}\,\tilde{\tau}_{i,t}\sqrt{u_{i,t}} \quad \text{and} \quad \hat{c}^{(n_{i,t})} = n_{i,t}\,\hat{\tau}_{i,t}\sqrt{v_{i,t}}\,.$$

probability of not increasing intended fertility despite $\pi^+_i$ peers with higher parities, and $1 - (1 - pr_3)^{\pi^+_i}$ is the probability of increasing intended fertility when exposed to $\pi^+_i$ peers with higher parities.

Therefore, the disposable budgets $\tilde{y}_{i,t}$ and $\hat{y}_{i,t}$ — the difference between the budget and consumption, which can be used, for example, to cover the needs of an additional child — become

$$\tilde{y}_{i,t} = u_{i,t} - \tilde{c}_{i,t} - \tilde{c}_{i,t}^{(n_{i,t})} \quad \text{and} \quad \hat{y}_{i,t} = v_{i,t} - \hat{c}_{i,t} - \hat{c}_{i,t}^{(n_{i,t})}.$$

The necessary conditions to allow for an additional child require that the disposable budgets are equal to or greater than the estimated needs of an additional child, $\tilde{y}_{i,t} \geq \tilde{\tau}_{i,t}\sqrt{u_{i,t}}$ and $\hat{y}_{i,t} \geq \hat{\tau}_{i,t}\sqrt{v_{i,t}}$ leading to

$$\sqrt{u_{i,t}} \geq \tilde{\sigma}_{i,t} + (n_{i,t}+1)\tilde{\tau}_{i,t} \quad \text{and} \quad \sqrt{v_{i,t}} \geq \hat{\sigma}_{i,t} + (n_{i,t}+1)\hat{\tau}_{i,t}.$$

The policy maker may provide a mix of fixed family policies per child, $\tilde{b}^f$ and $\hat{b}^f$, and child benefits proportional to the households resources, $\tilde{b}^v u_{i,t}$ and $\hat{b}^v v_{i,t}$. The parameters $\tilde{b}^f$ and $\tilde{b}^v$ determine financial supports, while $\hat{b}^f$ and $\hat{b}^v$ represent the additional time gained by the parents as the result of nonmonetary benefits, such as the provision of public childcare.[10] Any policy mix, $\tilde{b}^f + \tilde{b}^v u_{i,t}$, $\hat{b}^f + \hat{b}^v v_{i,t}$ greater than zero partially covers the demand of $n_{i,t}$ dependent children,

$$\begin{aligned} \tilde{c}_{i,t}^{(n_{i,t})} &= n_{i,t}\left(\tilde{\tau}_{i,t}\sqrt{u_{i,t}} - \tilde{b}^f - \tilde{b}^v u_{i,t}\right) \\ \hat{c}_{i,t}^{(n_{i,t})} &= n_{i,t}\left(\hat{\tau}_{i,t}\sqrt{v_{i,t}} - \hat{b}^f - \hat{b}^v v_{i,t}\right), \end{aligned}$$

and the disposable budgets can be expressed as

$$\begin{aligned} \tilde{y}_{i,t} &= u_{i,t} - \tilde{\sigma}\sqrt{u_{i,t}} - n_{i,t}\left(\tilde{\tau}_{i,t}\sqrt{u_{i,t}} - \tilde{b}^f - \tilde{b}^v u_{i,t}\right) \\ \hat{y}_{i,t} &= v_{i,t} - \hat{\sigma}\sqrt{v_{i,t}} - n_{i,t}\left(\hat{\tau}_{i,t}\sqrt{v_{i,t}} - \hat{b}^f - \hat{b}^v v_{i,t}\right). \end{aligned}$$

The necessary conditions for having an additional child become

$$\begin{aligned} \sqrt{u_{i,t}} &\geq \tilde{\sigma}_{i,t} + (n_{i,t}+1)\left(\tilde{\tau}_{i,t} - \frac{\tilde{b}^f}{\sqrt{u_{i,t}}} - \tilde{b}^v\sqrt{u_{i,t}}\right) \\ \sqrt{v_{i,t}} &\geq \hat{\sigma}_{i,t} + (n_{i,t}+1)\left(\hat{\tau}_{i,t} - \frac{\hat{b}^f}{\sqrt{v_{i,t}}} - \hat{b}^v\sqrt{v_{i,t}}\right). \end{aligned}$$

[10] These functional forms suggest that parents with a higher time budget gain more time from nonmonetary policies. However, the parameter $\hat{b}^v$ may be zero or negative. We include the variable term $\hat{b}^v v_{i,t}$ to avoid unnecessary restrictions.

These inequalities embrace the direct effect of family policies, i.e. the alleviation of the resource constraints enabling parents to realise their fertility intentions. Now let us assume that every household $i$ considers at time $t$ one unit of time equivalent to $\gamma_{i,t}$ monetary units. This could mean, for example, that working for one unit of time results in $\gamma_{i,t}$ units of monetary income or spending $\gamma_{i,t}$ monetary units for a babysitter or for domestic aid results in a gain of one time unit. Then the combined household budget becomes $w_{i,t} = \gamma_{i,t} u_{i,t} + v_{i,t}$ and the individual consumption needs can be expressed as

$$\begin{aligned} c_{i,t} &= \gamma_{i,t}\,\tilde{c}_{i,t} + \hat{c}_{i,t} \\ &= \gamma_{i,t}\,\tilde{\sigma}_{i,t}\sqrt{u_{i,t}} + \hat{\sigma}_{i,t}\sqrt{v_{i,t}} \\ &= \left[\gamma_{i,t}\,\tilde{\sigma}_{i,t}\sqrt{\frac{u_{i,t}}{w_{i,t}}} + \hat{\sigma}_{i,t}\sqrt{\frac{v_{i,t}}{w_{i,t}}}\right]\sqrt{w_{i,t}}\,. \end{aligned} \tag{11}$$

This equation explains consumption of a compound resource $w_{i,t}$ as a function of the square root of the household budget (in terms of the compound resource) times a multiplier consisting of two components $\gamma_{i,t}\,\tilde{\sigma}_{i,t}\sqrt{\frac{u_{i,t}}{w_{i,t}}}$ and $\hat{\sigma}_{i,t}\sqrt{\frac{v_{i,t}}{w_{i,t}}}$ representing the shares of the demands for time and money, respectively. The parameters $\tilde{\sigma}_{i,t}$ and $\hat{\sigma}_{i,t}$ indicate the household's propensity to consume its budget of time and money, respectively. In the special case $\tilde{\sigma}_{i,t} = \sigma\sqrt{\frac{u_{i,t}}{w_{i,t}}}$ and $\hat{\sigma}_{i,t} = \sigma\sqrt{\frac{v_{i,t}}{w_{i,t}}}$ the multiplier in equation (11) can be expressed as

$$\begin{aligned} \gamma_{i,t}\,\tilde{\sigma}_{i,t}\sqrt{\frac{u_{i,t}}{w_{i,t}}} + \hat{\sigma}_{i,t}\sqrt{\frac{v_{i,t}}{w_{i,t}}} &= \gamma_{i,t}\,\sigma\frac{u_{i,t}}{w_{i,t}} + \sigma\frac{v_{i,t}}{w_{i,t}} \\ &= \sigma\,\frac{\gamma_{i,t}u_{i,t} + v_{i,t}}{w_{i,t}} \\ &= \sigma\,\frac{w_{i,t}}{w_{i,t}} = \sigma \end{aligned}$$

and equation (11) becomes $c_{i,t} = \sigma\sqrt{w_{i,t}}$ which is the consumption function with only one compound resource and a constant propensity to consume presented in Section 2. In the same way, we may choose $\tilde{\tau}_{i,t} = \tau\sqrt{\frac{u_{i,t}}{w_{i,t}}}$ and $\hat{\tau}_{i,t} = \tau\sqrt{\frac{v_{i,t}}{w_{i,t}}}$ to express the children's consumption of the compound resource as

$$\begin{aligned} c_{i,t}^{n_{i,t}} &= \gamma_{i,t}\,\tilde{c}_{i,t}^{(n_{i,t})} + \hat{c}_{i,t}^{(n_{i,t})} \\ &= \gamma_{i,t}\,n_{i,t}\,\tilde{\tau}_{i,t}\sqrt{u_{i,t}} + n_{i,t}\,\hat{\tau}_{i,t}\sqrt{v_{i,t}} \\ &= \gamma_{i,t}\,n_{i,t}\,\tau\frac{u_{i,t}}{\sqrt{w_{i,t}}} + n_{i,t}\,\tau\frac{v_{i,t}}{\sqrt{w_{i,t}}} \\ &= n_{i,t}\,\tau\sqrt{w_{i,t}}\,. \end{aligned}$$

Finally, if the parameters defining the policy mix to support families fulfil $b^f = \gamma_{i,t}\tilde{b}^f + \hat{b}^f$ and $b^v = \tilde{b}^v = \hat{b}^v$ the support can be decomposed as

$$\begin{aligned} b^f + b^v w_{i,t} &= b^f + b^v(\gamma_{i,t}u_{i,t} + v_{i,t}) \\ &= \gamma_{i,t}\tilde{b}^f + \hat{b}^f + \gamma_{i,t}\tilde{b}^v u_{i,t} + \hat{b}^v v_{i,t} \\ &= \gamma_{i,t}(\tilde{b}^f + \tilde{b}^v u_{i,t}) + (\hat{b}^f + \hat{b}^v v_{i,t}), \end{aligned}$$

which is the sum of the monetary equivalent of the family support provided in terms of time units (i.e. institutional childcare) plus the cash benefits.

# C The social multiplier

Becker and Murphy (2000) conceptualised the social multiplier that can magnify small initial changes. In their approach the social environment, goods, and services serve as arguments in the utilty function in order to analyse how changes in the enviroment affect choices and behaviour. Changes of social capital raise or lower the level of utility and influence behaviour if marginal utilities of goods or services change. If a shock affects several individuals simultaneously, the cumulative effect of individual choices may be larger than could be predicted by summing up individual reactions. Although each individual response has only a small impact on others, social capital mutiplies the effect via the interaction of the small individual effects. The social multiplier is defined as the ratio between the marginal impact of an exogenous change on average behaviour — at the macro level — to the marginal impact of the same exogenous change on individual behaviour in the absence of social effects. According to Glaeser, Sacerdote, and Scheinkman (2002) "an estimated aggregate elasticity incorporates both the true individual level response and effects stemming from social interactions". They "define the social multiplier as the ratio of the group level coefficient to the individual level coefficient, or the amount that the coefficient rises as" they "move from individual to group level regressions". While the formal approach of Becker and Murphy (2000) is based on mathematical functions determining each agent's reaction to changes in social capital, the empirical approach of Glaeser, Sacerdote, and Scheinkman (2002) relies on regressions at different levels of aggregation. Comparisons of aggregate levels with the individual level are assumed to reflect the impact of social interactions.

To translate these formal and empirical approaches into a simulation environment, we take advantage of the fact that numerical simulations allow for controlled experiments via parameter variations. Our modelling framework does not provide a hierarchical structure of different levels of aggregation, but we can vary the parameters determining the strength of social influence, $pr_3$ and $pr_4$. In the absence of social effects — that is, $pr_3 = pr_4 = 0$

— individual choices are not affected by others. Hence, the impact at the aggregate level is simply the sum of pure individual level responses. We estimate the impact of family policies and simulation parameters on completed cohort fertility over the subsample containing only those simulations with no social effects using a specification similar to (4) and compute the marginal impacts of one monetary unit[11]

$$\begin{aligned}
\widetilde{ctfr}_{unitbf} &= .1309621 + .0115419 * unitbf + .00842 * unitbv \\
&\quad +.0028102 * \alpha + .0052886 * pr_2 + .0000447 * \epsilon_2 \qquad (12)\\
\widetilde{ctfr}_{unitbv} &= .0455181 - .0009613 * unitbv + .00842 * unitbf \\
&\quad +.0001837 * \alpha - .0004116 * pr_2 + .0000733 * \epsilon_2. \qquad (13)
\end{aligned}$$

This allows us to compute the social multiplier as the ratio of the marginal impact of family policies on completed cohort fertility for a given level of social influence — given by equations (7) and (8) — to the marginal impact in absence of any social influence. Taking (7), (8), (12), and (13) together, the social multipliers for fixed and proportional family policies can be given as

$$\begin{aligned}
m_f &= \frac{ctfr_{unitbf}}{\widetilde{ctfr}_{unitbf}} \\
m_v &= \frac{ctfr_{unitbv}}{\widetilde{ctfr}_{unitbv}}.
\end{aligned}$$

In the case of negative social influence (i.e. $pr_3 < pr_4$) the social multipliers are less than one (because the negative social effects mitigate the effectiveness of family policies) while they are greater than one for positive social effects ($pr_3 > pr_4$). In order to quantify the magnitude of the social multipliers we compute the mean values of the marginal impacts (equations 7 and 8) for the subsample with positive social effects. For $ctfr_{unitbf}$ we obtain a mean value of .224 and for $ctfr_{unitbv}$ we get .0808. Considering those simulations omitting social effects ($pr_3 = pr_4 = 0$) the mean value of the marginal impact $\widetilde{ctfr}_{unitbf}$ is .202 and the mean value of $\widetilde{ctfr}_{unitbv}$ is .0604. Dividing the respective mean values of marginal impacts obtained from these subsamples the social multipliers become $m_f = 1.107$ and $m_v = 1.338$. This leads us to the conclusion that proportional family support schemes are more stronlgy reinforced by social effects than fixed family supports. This corresponds with the finding that proportional family policies contribute more to the indirect effect than fixed policies (see Section 3.).

[11]Because $pr_3 = pr_4 = 0$ we skip those covariates containing $pr_3$ or $pr_4$.

# D Animation

The animation linked to figure A-1 illustrates the life course of three agents born in the simulation years 47, 48, and 50 who are connected via social ties. Agent 1 reaches adulthood at age 21 with an initial intended fertility of 1 at time 68, agent 3 reaches adulthood at age 19 with intended fertility 2 at time 69, and agent 2 reaches adulthood at age 28 with intended fertility 0 at time 76. For agents 1 and 2 the budget constraint (3) is not active, which means they could afford a child under the given level of public family support. This is indicated by a green line following the transition to adulthood. For agent 3 the budget constraint (3) is active. Therefore, she cannot afford to fulfil her wish to have children. This is indicated by a red line following the transition to adulthood. Agent 1 gives birth to her first child at age 30 at time 77. Because of this experience, agent 2 increases her intended fertility to 1 at age 30 at time 78. In the sequel, she actually gives birth at age 35 at time 83. Finally, agent 3 dies at age 78 at time 128, agent 2 dies at age 94 at time 142, and agent 1 dies at age 97 at time 144.

**Figure A-1: The life course of three agents who are connected via social ties**

Click here for animated Lexis diagram