Playing the Fertility Game at Work*

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Comments Welcome.

Abstract

This paper investigates whether and how a working woman's fertility decision is affected by the fertility of her co-workers at the same establishment. We model these decisions as strategic interactions in a game theoretic framework and develop an empirical approach based on this framework that simultaneously considers the fertility choices of all agents at the same workplace and explicitly accommodates multiple equilibria. Using administrative data that links individuals to their employers and family members, we instrument for co-workers' fertility using their sisters' fertility, and find evidence of positive spillovers in workplace fertility. For education, occupation and experience, we find evidence of stronger interactions between more similar women. Estimates from the full structural model are larger in magnitude than, but qualitatively similar to, the single-equation estimates.

Keywords: Fertility, Multiple Equilibria, Peer Effects, Workplace Social Interactions.

JEL Codes: J13, J38.

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1 Introduction

Low fertility rates are major a policy concern in much of the developed world. Fertility affects population size and composition, and reduced or delayed childbearing in the present contributes to population aging and worker scarcity in the future. Thus, low fertility challenges the sustainability of public and private pension schemes ((Borsch-Supan 2000)); redistribution under the welfare state ((Rangel 2003), and overall economic growth ((Lindh and Malmberg 1999)). European governments have adopted pro-natalist policies to encourage fertility (Grant et al. 2004),[1] while at the same time, wanting to encourage female labor force participation. The declining male workforce can be offset by greater female entry into the labor market, leading employers and governments to focus on recruiting and retaining women. However, these policies may conflict, as labor market participation has traditionally been associated with lower female fertility.

The major substantive goal of this paper is to understand the determinants of fertility for working women. We draw the economic approach to fertility as a rational choice ((Becker 1960); (Joseph Hotz, Klerman, and Willis 1997)), and explore the role of individual and environmental factors that affect preferences or constraints. However, unlike much of the previous literature that has modeled the fertility decision at the level of the individual woman or couple,[2]. our focus is on the interactions among women working at the same establishment. This is in line with more recent studies in economic demography that consider how the fertility decision hinges on social influences, and how these interactions may amplify or dampen fertility responses to changes in policy and economic environment.[3] Previous studies of social influences on fertility have used geographic areas or neighborhoods (Bloom et al. 2008), ethnic or religious groups (Manski and Mayshar 2003), or families (Kuziemko

[1]Fertility incentives are also present in the US. Federal child tax benefits amount to over $140 billion annually (Mumford 2007).

[2]Examples include the impact of legal access to contraceptives (Goldin and Katz JPE; Bailey QJE)

[3]See Kravdal 2002, Kohler (2001), Kravdal 2002, Bloom et al. 2008.

2006) as their primary social unit. In contrast, this paper focuses on working women and studies workplace interactions.[4]

Using matched employer-employee data, we analyze how the fertility decision of a worker depends on fertility of co-workers at the same physical work establishment. In principle, peer effects in fertility can be positive or negative at the workplace. On the one hand, a female worker may be inspired to become pregnant when she sees a coworker striking the family-work life balance. On the other hand, she may postpone childbearing, because she finds it easier to advance professionally when her coworker has a child while she herself has no child. This makes the workplace an interesting setting for empirical exploration. In addition, the workplace provides a setting where the individual spends many hours every day and where social and economic interactions are known to take place. Recent studies have found evidence evidence of social interactions at the workplace influencing behaviors including productivity (Mas and Moretti 2009; Bandiera, Barankay, and Rasul 2010), charitable contributions (Carman 2003), and retirement savings (Duflo and Saez 2003). To our knowledge, the only other study of workplace peer effects in fertility is Hensvik and Nilsson (2009).

We develop and apply a novel game theoretic framework that simultaneously considers fertility choices of all agents at the same workplace. We impose a self-consistency condition on outcomes at each workplace based on the Nash Equilibrium condition that each agent is enacting her own best response. The use of a self-consistency condition to address both individual and aggregate behavior in studies of social interactions is discussed in Brock and Durlauf (2001). However, unlike Brock and Durlauf (2001), our notion of self-consistency is not based on a rational expectations concept in which average behavior conforms to expected behavior. Rather, we use a complete information setting, and derive the self-consistency condition from the equilibrium condition of the fertility game. Our approach builds on

[4] The only other paper to estimate workplace peer effects in fertility is Hensvik and Nilsson (2009), which uses Swedish data. That paper estimates the impact of peer behavior in an individual-level model and is most similar to our reduced form approach

Ciliberto and Tamer (2009), which provide a methodology to estimate discrete games with complete information.

Using high quality, detailed, administrative records on the population of Denmark, we are able to match individuals to their coworkers and family members and track their fertility outcomes. We find evidence of positive interactions in fertility decisions between coworkers in the individual model, even after controlling for key determinants such as age, education, experience, marital status and past childbearing. The marginal effect of an additional coworker having a child in the sample period is a 0.5 percentage point increase in the individual woman's probability to have a child in that period. Relative to a mean propensity to conceive of about 24%, this corresponds to a 2% increase in the propensity to give birth in the period under consideration. In comparison, Kuziemko (2006) finds that the probability of having a child rises by 0.1 percentage points (or 15 %) in the 24 months after the birth of a niece or nephew.

The qualitative result differs somewhat across types of individuals but is robust to controlling for firm characteristics and average coworker characteristics. It may, however, still suffer from the reflection problem. We therefore estimate probit models using information about coworkers' spouses and siblings as instrumental variables for coworker fertility and confirm the evidence of social effects. The results from the full structural model also document peer effects in fertility.

In addition to the substantive contribution, this paper provides a methodological innovation that can be applied to the study of endogenous peer effects more generally. The game theoretic foundation and empirical approach based on an equilibrium concept has several advantages over an individual level, partial approach that may be important for both estimation and prediction.

Because we explicitly incorporate an equilibrium concept in our full structural model, the results incorporate both direct effects and those mediated through changes in peer behavior.

These equilibrium effects may lead to either amplified or dampened behavioral responses to small policy changes, and they cannot be reliably predicted using results from an individual-level probit or instrumental variables models. In this line of thought, Moffitt (1998) and Murray (1993) argue that social stigma associated with out-of-wedlock childbearing has dampened the short-term behavioral responses to changes in US welfare policies. Furthermore, Montgomery and Casterline (1998) argues that multiplier effects from social learning and social influences have amplified fertility transitions, through the diffusion of contraceptive technologies. While those particular channels may be less important for our sample of working women, the basic feature remains that social effects may interact with the policy environment, and thus make incentives more or less effective. In particular, our model can be used to identify critical values where players switch from one equilibrium to another. Near such critical values, small policy changes may lead to large behavioral responses or "phase changes" (Brock and Durlauf 2007) when many individual change their behavior at once. Far from such values, social forces leading to conformity may dampen individuals' responses to policy changes.

A second advantage of our empirical approach is that we allow for the possibility that, for particular values of the parameters, variables and errors, there may exist more than one Nash Equilibrium solution to the fertility game. The potential for multiple equilibria in binary choice models of social interactions has been recognized in the literature and the implications have been explored in previous work such as Brock and Durlauf (2007). Therefore, empirical researchers typically impose a rule for equilibrium selection in the regions of multiplicity (e.g. Krauth 2006). Incorporating multiple equilibria enables us to detect the presence of coordination failures that occur when agents choose actions that lead to an equilibrium outcome with lower payoffs than an alternative, available equilibrium. For example, in the presence of positive social spillovers, there may be some workplace with low fertility rates, where the workers would be better off with higher fertility, but no individual worker wants to deviate alone. In such cases, there may be a role for public policy to enhance coordination.

This paper is organized as follows. Section 2 presents the economic model and Section 3 describes the data. Section 4 discusses the econometric model and identification. Empirical results are presented in section 5, while section 7 concludes.

2 Economic Model of Fertility Decisions at Work

This section lays out the primary economic and social reasons why a woman's utility from having a child could theoretically depend on the fertility decisions of her coworkers and presents a simple formal model of the fertility game at work.

The workplace is a potentially important setting for strategic fertility interactions because of the amount of time that individuals spend at work and the range of interactions they experience there. Coworkers at the same establishment work for the same organization at the same physical location and comprise a well-defined peer group. Although the primary function of an establishment is economic rather than social, coworkers can influence each other's fertility decisions through a variety of channels. These include pressure to conform to social norms (Bernheim 1994), social learning, economies of scale in child-care and career concerns.

While the social channels are expected to lead to positive spillovers and to generate mimicry, career concerns could plausibly induce positive or negative spillovers. Increased coworker fertility can reduce the negative signal to employers associated with childbearing, leading to positive financial spillovers. Alternatively, childbearing by coworkers can make it more costly for the employer to hire temporary replacements or to rearrange work-flow during a period when several workers are absent, leading to negative spillovers.[5] Competition in internal labor markets (Lazear and Rosen 1981), may also induce negative spillovers. For example, a worker may find it easier to advance professionally when her coworker has a

[5] This is especially important in the relatively small establishments, with fewer than 50 workers, that we study.

child if she herself decides to forgo childbearing. Taken together, the social and economic considerations lead to ambiguous predictions for the nature of fertility interactions. They also suggest that different sub-groups may exert different influences on one another within the same establishment, motivating our study of heterogenous effects by worker type.

We formalize a simple model of fertility behavior, by extending the model of Jones et al. (2009), developed to explain the negative relationship between income and fertility, to incorporate peer effects. Our extension consists of introducing the number of peers with children as a determinant of individual choices such as time devoted to leisure and child-care, as well as individual consumption. For expositional simplicity we present our model in two steps: In the first step, we consider consumption and leisure choices conditional on the decision to have a child or not. In this first step, we take the number of agents at the establishment with children as given. In the second step, we consider the fertility choice while accounting for the social influence. Although this description suggests that the decision to have a child is taken before the other decisions, the model that we consider is static, and all choices should be understood as occurring simultaneously. If for instance the value of having a child is higher when it conforms to norm (i.e. when more people have children), then that would be revealed in a one shot game (and not dynamically). In the empirical analyses to be presented later, we focus exclusively on the strategic fertility decision, while the decisions regarding time allocation and investment in child quality only occur in the background.

2.1 Optimization Problem for a Childless Agent

Consider first the optimization problem of an agent who does not have a child (subscripted NK). This agent must solve:

$$\max_{c,l} u_{NK}(c, l; n)$$
$$\begin{aligned} h + l &\leq t \\ c &\leq y + h \cdot w_{NK}(n, h) \end{aligned}$$

Here, the agent chooses her leisure time (l), work time (h) and consumption (c) to maximize her utility, or well being, $u_{NK}(c,l)$. The choice of leisure and work time is constrained by the total number of hours available (t). Consumption is constrained by the endowed unearned resources of the agent (y), such as spouse income, and by her earned income. Earned income is a product of hours (h) and the wage rate, $w_{NK}(n,h)$, which is itself a function of the number of hours worked. The wage rate of an agent without a child can also depend on the number of their peers with children, n, through the career channels described above, such as internal labor market competition. We allow the wage to vary with work hours to capture returns to experience and the lower observed wage rate for part-time workers. Since motherhood has been shown to reduce wages and wage growth (see, for example, Waldfogel 1998, Miller 2010 and (Bertrand, Goldin, and Katz 2009) in the US and Nielsen, Simonsen, and Verner 2004 in Denmark), we also allow wages to depend on the fertility decision.

Solving this constrained optimization problem produces demand functions that depend on the variables that agents take as given (or exogenously determined): t and y. We denote these solutions by $l_{NK} = l(t,y,n)$ and $c_{NK} = c(t,y,n)$. Thus, we can define $u_{NK}(t,y,n)$ as the maximal utility that an agent without a child achieves, given (t,y,n). Note that this is a function of n, the number of peers with children, which is given by the solution of the fertility game, described below.

2.2 Optimization Problem for an Agent with a Child

Turning to the optimization problem of an agent who has a child:

$$\max_{c,l,b} u_K(c,l,q;n) + g(n)$$

$$\begin{aligned} h+l+b &\leq t \\ c &\leq y + h \cdot w_K(n,h) \\ q &= f(b,n) \end{aligned}$$

There are several differences between this problem and the previous problem for a childless agent. First, the agent chooses to devote time, measured by b, to caring for their child. Greater values of b lead to higher child 'quality' q (better behavior or labor market outcomes), according to the function $f(b,n)$. Parents derive utility from their own consumption and leisure and the quality of their child.

Second, the fertility decisions of coworkers affect the choices of parents and their ultimate utility. In particular, the wage rate of an agent with a child can depend on the number of peers with children, n. As discussed above, it is possible that peer fertility decisions influence the wage path for new parents (and hence the present discounted value of lifetime wages). The wage penalty associated with parenthood can increase when more workers take leave, if it is costly for the employer to hire temporary replacements or rearrange work-flow during a period when several workers are absent. As above for childless women, peer fertility can influence own wages through internal labor markets. In addition, peer fertility may affect wages for mothers if the employers' beliefs that working parents are less productive change when more workers have children. A second, separate effect of n is represented in the quality function. This captures the possibility that peers with children can reduce the time costs of child-rearing by sharing information or assisting with child-care.[6]

Finally, the presence of peers with children might generate social pressure to have children, through peer pressure or a desire to conform, or it may reduce the social stigma associated with having children. This last effect is the social effect, captured by $g(n)$. Notice that this effect does not influence the choice of leisure and work time because it is additively separable from other elements in the utility function.

The solutions to this constrained optimization problem are $l_K = l(t,y,n)$ and $c_K = c(t,y,n)$. Thus, we can define $u_K(t,y,n) + g(n)$ as the utility that an agent with a child achieves at an optimum. As in the childless case, this utility level is a function of n, the

[6]This may be regarded as contemporaneous learning, where coworkers decide to pool resources to learn about the quality of local child-care options. Our static model does not incorporate learning from past behavior and outcomes of coworkers.

number of peers with children. The value of n is determined by the the fertility game.

2.3 The Fertility Game

We can now consider the fertility decision. We illustrate the central elements of the game starting with the case of two agents, each of whom chooses to have a child ($d = 1$) or not ($d = 0$). Define the net utility gain from having a child as $v(t, y, n) = u_K(t, y, n) - u_{NK}(t, y, n)$. Agents will choose to have a child as long as their well-being with a child is greater than their childless utility (or $v(t, y, n) \geq 0$).

We introduce establishment peer effects into the model by considering the case of two agents who must each decide whether or not to have a child. Let $i = 1, 2$ denote each of the two agents. Then, the economic problem can be summarized as follows:

$$\begin{cases} d_1 = 1 \text{ if } v(t, y, d_2) + g(d_2) \geq 0, \\ d_2 = 1 \text{ if } v(t, y, d_1) + g(d_1) \geq 0. \end{cases}$$

Here, the choice of the first agent depends on the choice of the second agent and vice versa. Agent 1's well-being is normalized to 0 if she does not have a child, irrespective of Agent 2's decision. If Agent 1 has a child but Agent 2 does not, Agent 1's utility is $v(t, y, 0)$. Her utility is $v(t, y, 1) + g(1)$ if both agents have children. Agent 2's utility in the different possible outcomes of the game is defined similarly. Before solving the game, we clarify the structure and timing of the game, as well as the solution concept.

First, we assume that the game is played only once by the agents. Although employees make their fertility choices many times in their lives, this research will use a single cross-section of data at a particular point in time, and we will assume that this cross-section captures the long run equilibrium of fertility decisions within each establishment. This means that we would obtain the same empirical results, regardless of the particular time period we select. Second, the game is static, in the sense that we do not model agents as playing repeatedly over time. This may be reasonable in the context of fertility choices within a couple of years,[7] because neither researchers nor coworkers observe the time when the decision to have a child is taken.[8] Instead, we observe the timing of births. Variation in the time between the decision and actual conception makes it impossible to determine the decision date.[9] Thus, using data on births alone, we are unable to determine which agent made the decision to conceive first. Third, the game is played simultaneously. This means that all agents are assumed to make their fertility choices at the same time. In the case of fertility choices, this assumption seems, again, particularly reasonable, since we do not observe the order with which agents made their fertility choices. Furthermore, slight differences in timing can be treated as simultaneous since workers are not immediately aware of their coworkers' decisions and pregnancies.

To solve the fertility game, we use the Nash Equilibrium solution concept. An outcome is a Nash Equilibrium if neither of the two agents can improve her well-being by individually changing her action. For example, consider the case when $v(t, y, 0) < 0$, $v(t, y, 1) + g(1) > 0$. Then, there are two Nash Equilibria in the game above: $(0, 0)$ and $(v(t, y, 1) + g(1), v(t, y, 1) + g(1))$. In this case, peer effects are pivotal and either both agents have a child or neither does. This simple example illustrates how peer effects might radically change the fertility choices within an establishment.

The game is essentially unchanged if, instead of two agents, there are many agents. The only difference is that the argument in the utility function capturing coworker behavior is a count of the number of other agents having children, n, rather than a binary indicator for the other agent's action. It is crucial to observe that n, the number of agents with children, is an endogenous outcome of the model: it is part of the solution of the fertility game played by the agents.

[7] In this study, we choose a three-year window.

[8] In a sensitivity check, we confirm that the main results of the model are unchanged if we use a two-year or one-year window.

[9] According to ((S. Juul, Infertility, and Group 1999)) 40 % of fertile couples conceive within the first month, while 84% conceive within a year. According to the same source, 6-20% of couples are infertile in Europe.

3 Data Description

Our data stem from several administrative registers which are maintained by Statistics Denmark. The primary data source is a merged employer-employee data set, which includes information on the entire population of Danes aged 15-70. The data set covers the period from 1980 to 2005. Using unique person and workplace establishment identifiers we link all coworkers at the establishment level. The data hold yearly information about socioeconomic variables such as gender, age, family status as well as family identifiers, education, labor market experience, tenure at current job, unemployment levels, leave-taking, and income. Of particular interest for our study, births are identified using exact birth dates from the national fertility register.

From this population we select the group of women aged 20-40 who are employed at a given establishment within a firm in November 2002, and create an indicator variable for having a child during 2003-2005. We do not condition on employment status other than November 2002, because this would potentially introduce sample selection bias in our estimates. In our main analysis we focus on establishments with 10-50 employees thus excluding small establishments where it would be difficult to credibly distinguish peer effects from selection and large establishments where it would be difficult to identify coworkers who interact. Roughly 25% of employed women in the relevant age range work in such medium sized establishments (151,494 out of 647,678 employed women).

We define coworkers as individuals at the same establishment, that is individuals with the same employer and location of work, as of November 2002. The fertility outcomes occur between December 2002 and November 2005. In our sensitivity analyses below we will investigate the robustness of our results to the choice of this particular time frame.

Table 1: Sample Means, Individual Level

	No Baby Mean	Baby Mean	Total Mean
baby03_05	0	1	0.237
Share of co-workers with baby 2003-2005	0.225	0.244	0.229
Age	30.31	29.17	30.04
More than 12 years of education	0.269	0.401	0.300
Professional occupation	0.324	0.442	0.352
Less than four years of tenure	0.560	0.513	0.549
Experience	5.994	5.892	5.970
One child born before 2003	0.124	0.344	0.176
Two children born before 2003	0.282	0.123	0.244
More than two child born before 2003	0.0868	0.0184	0.0706
Partner	0.601	0.831	0.656
Duration of marriage	5.970	6.644	6.130
Spouse with high income	0.705	0.582	0.676
Spouse with more than five years older	0.522	0.307	0.471
Spouse with more than 12 years of education	0.556	0.445	0.530
Spouse with professional occupation	0.235	0.317	0.255
Living in big city	0.409	0.377	0.402
living in smaller city	0.303	0.306	0.304
Private company	0.671	0.620	0.659
Large establishment	0.490	0.491	0.490

3.1 Description of Women in the Sample

Table 1 presents descriptive statistics for the women in our sample. About 24% of the women in our sample give birth during 2003-2005. Importantly, the first row shows that the share of coworkers who gave birth in 2003-2005 is larger for the group of women who themselves gave birth in the period than for those who did not. Though the difference is not very large, this does suggest positive establishment peer effects in fertility. On average, about 50% of the women in our sample are mothers prior to 2003. The majority lives with a partner and has done so for a considerable period. These characteristics vary considerably by conception status in 2003-2005. Women who gave birth during the period of observation have fewer children and are themselves younger and have correspondingly lower experience, tenure, and income.

3.2 Description of Establishments in the Sample

Table 2 shows simple descriptive statistics at the establishment level. The mean number of employees is about 20 but the vast majority of establishments employs fewer than that. The average establishment employes roughly five women in the 20-40 age range and just below 20 % of the establishments only employ one woman in the relevant age range. Such women will obviously not be affected by peer fertility. This turns out to be important for identifying the effects of other explanatory variables.

Table 2: Descriptive Statistics, Establishments

	Mean	Std. Dev.
Firm size	20.46	10.11
- Share 20 employees or less	0.59	
- Share 20-20 employees	0.20	
- Share 30-39 employees	0.10	
- Share more than 40 employees	0.07	
# Women aged 20-40	4.78	3.81
# Women aged 20-40 who conceive during 2003-2005	1.65	1.73
One-woman aged 20-24	0.18	
Private firm	0.72	
# firms	31,725	

An important feature of the Danish labor market is a high degree of turnover; 48 % of the women employed with an employer in November 2002 are still employed in the same establishment a year later, while 38 % continue at the workplace two years later. We investigate the importance of this for peer effects in our sensitivity analysis below. Presumably, stayers will be more affected by their peers.

To gain further insights into the potential peer effects in fertility, we investigate the distribution of fertility shares using the establishment as the unit of observation. Figures 1 and 2 each plot the distribution of establishments with different shares of women in the sample who had babies during the sample period. Figure 1 shows the distribution for the entire sample of medium sized establishments, while Figure 2 graphs the distributions by public and private sector. In Denmark, family friendly policies vary substantially between public and private sectors, with the public sector being more generous. Public sector establishments also have higher fertility rates among employees during 2003-2005. Most notable in Figure 2 is the large mass point (17 percent) at zero fertility in the private sector.

Figure 1: Distribution of shares of co-workers with babies 2003-2005

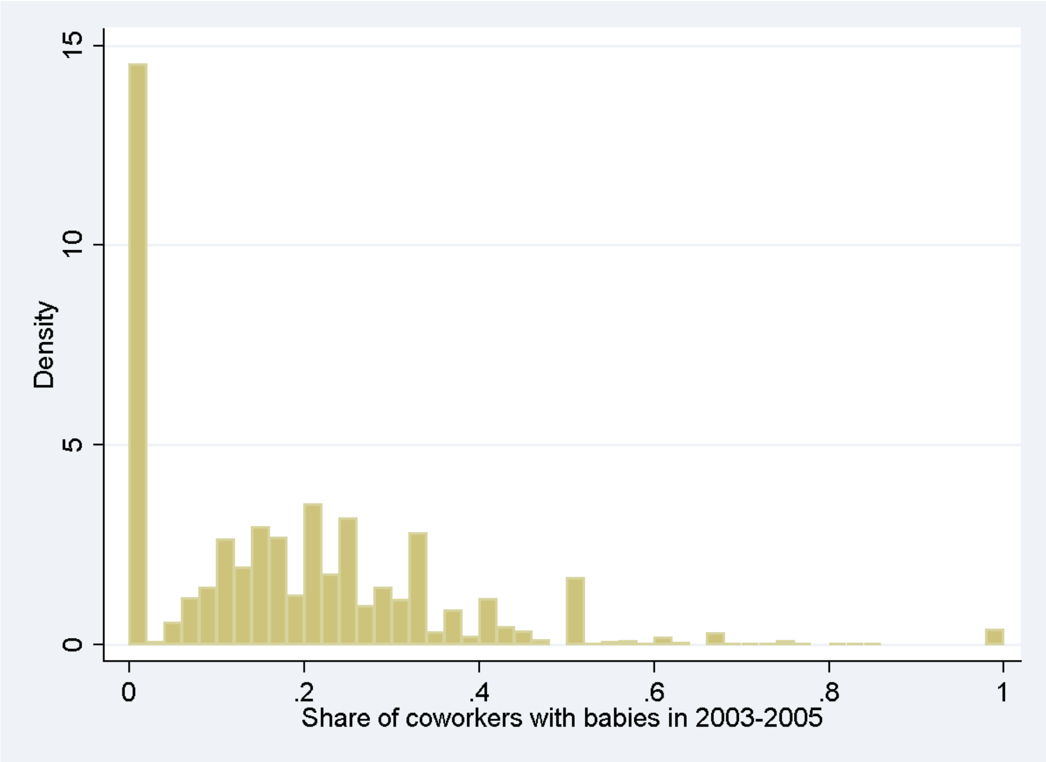
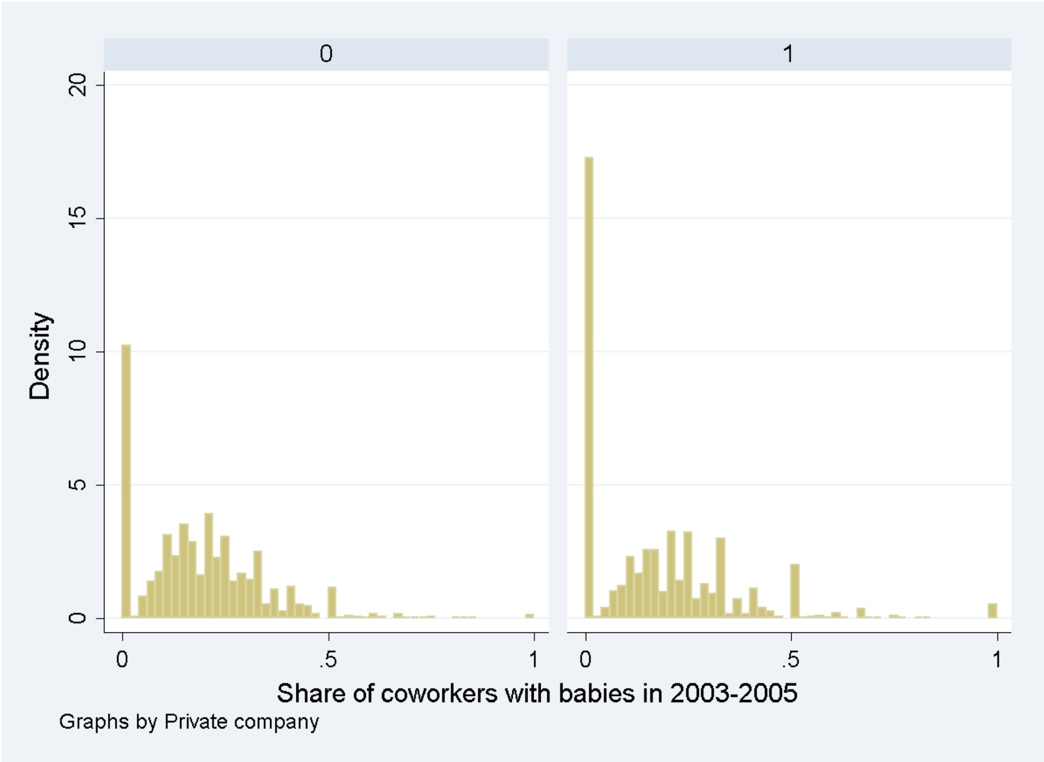


Figure 2: Distribution of shares of co-workers with babies 2003-2005

Private and public companies



4 Econometric Model

We model fertility decisions as the outcomes of static discrete choice games of complete information. Individuals decide whether or not to have a child, taking into consideration the behavior of others at their establishment peer group. If the fertility decision taken by one person affects the attractiveness of fertility for their coworkers, through positive or negative spillovers, the game theoretic model may fail to produce a unique pure strategy Nash Equilibrium, as we have shown above. In order to incorporate this possibility in estimation, we will employ the econometric methods developed in Ciliberto and Tamer (2009) for models with multiple equilibria. The key strength of this model is that it allows for general forms of heterogeneity across players without making equilibrium selection assumptions.

4.1 Establishments, Employees, and Employee "Types"

We index each establishment by $e = 1, ...E$. Each individual in an establishment e is indexed by $i = 1, ..., K_e$, where K_e is the number of employees at that establishment who could potentially have a child in the period of time that we study. In order to estimate heterogenous peer effects, by which we allow the fertility decisions of some coworkers to matter more than others, we assign employees to different worker types, based on selected exogenous (non-choice) characteristics such as sex, age, marital status, and position in the firm hierarchy. These types are defined such that $r = 1, ..., R_e$ is the set of employee types at establishment e. The utility from having a child depends on the agent's own type $r(i)$ and the fertility decisions of agents in her peer group of each type.[10]

4.2 Exogenous and Endogenous Variables

An individual i at establishment e gains net utility of $v_{ie}(X_e, n_e, \theta)$ from having a child. The vector of the number of other agents of each type that have a child in establishment e is $n_e = (n_{1e}, ..., n_{R_e e})$, where n_{1e} is the number of peers of type 1 who have a child in establishment e, and $n_{R_e e}$ is the number of peers of type R_e who have a child in establishment e.

The vector $N_e = (N_{1e}, ..., N_{R_e e})$ is the endogenous outcome of this game. Here, N_e includes all agents, while n_e includes only the peers of individual i. Clearly, if all agents are identical

[10]In the study of airline entry decisions, Ciliberto and Tamer (2009) were able to allow each agent's entry decision to have a different effect on the utility of each other agent, because the same sets of airlines were observed as potential entrants in multiple geographic markets. This is not feasible in our context of establishment peer effects, as each agent is observed as a potential child bearer only in one establishment.

then there is only one type and $N_e = N_e$ is a scalar and not a vector.[11]

The vector X_e contains a set of observable variables that determine the utility of an agent. The variables that enter into X_e are supposed to control for heterogeneity across agents, and include any exogenous variables that enter into the utility function. Thus, X_e also includes the determinants of the two constraining variables: t (the available time) and y (resources) in the economic model described in section 2. For example, leave policy would affect t, while the husband's age would affect y. The vector X_e consists of three types of variables: establishment specific characteristics (S_e), individual characteristics (Z_e), and instrumental variables (W_e). Thus, $X_e = (S_e, Z_e, W_e)$. S_e is a vector of peer group characteristics related to fertility choices that are common to all individuals at establishment e. S_e includes firm-wide or establishment-specific policies regarding maternity and paternity leave duration and compensation. $Z_e = (Z_{1e}, \ldots, Z_{Ke})$ is a vector of individual characteristics that enter into the net utility of all the workers in the peer group, for example individual productivity that affects overall firm performance and wages for all workers. $W_e = (W_{1e}, \ldots, W_{Ke})$ contains individual characteristics that enter only into individual i's utility, such as fertility of siblings. Values of W for coworkers do not directly influence the individual's own utility from having a child. This exclusion restriction allows us to separately identify endogenous fertility effects, and that is why we refer to them as instrumental variables.

4.3 Empirical Specification of the Utility Function

The utility function is specified as follows:

$$V_{ie} = v_{ie}\left(X_e, n_{1e}, ..., n_{R_e e}\right) + \sum_{r=1}^{R_e} \delta_r^{r(i)} n_{re} + \epsilon_{ie}, \text{ for each } i = 1, ..., K_e, r = 1, ..., R_e.$$

Here, $\sum_{r=1}^{R_e} \delta_r^{r(i)} n_{re}$ captures the $g\left(n\right)$ term in the utility function, allowing for different types of employees within an establishment. In particular, $\delta_r^{r(i)}$ measures the effect of the fertility of

[11] Notice that the problem is different from Ciliberto and Tamer (2009), where the outcome is a vector of binary values.

type r peers on the utility of a type $r(i)$ agent. These terms measure peer effects within and between coworker types. In our empirical analysis, we allow $\delta_r^{r(i)}$ to be positive or negative, and will estimate its sign. $v_{ie}(X_e, n_{1e}, ..., n_{R_e e})$ captures the function $v(t, y, n)$ in the utility function. We will consider a linear approximation of this function as follows:

$$v_{ie}(X_e, n_{1e}, ..., n_{R_e e}) = \alpha_r X_e + \sum_{r=1}^{R_e} \phi_r^{r(i)} X_e n_{re}.$$

Thus, the exogenous variables X_e enter the choice both directly and through their interaction with the number of other employees who have a child. The interaction terms will capture the extent to which the peer effects influence the utility function in ways different from the direct social effect measured by $\delta_r^{r(i)}$. For example, if a larger number of peers with children is associated with a smaller wage difference between agents with and without children, then we should expect the interaction of wages and number of employees with children to be positive. Finally, ϵ_{ie} is the part of utility that is unobserved by the econometrician. We assume throughout that ϵ_{ie} is observed by all players in peer group e. Thus, this is a game of complete information.

Note the utility function is defined in terms of types, not single agents. Thus, for a given value of the parameters, we will derive a predicted equilibrium outcome $N_e = (N_{1e}, ..., N_{R_e e})$, but we will still use individual utility functions to solve for the equilibrium of the game. We emphasize this subtle point to introduce our next discussion, which concerns the identification of the parameters of the utility function.

4.4 Identification

The identification of social effects is challenging in any setting (Manski 1993; Manski 1995; Blume and Durlauf 2005). Manski (1993) identifies three reasons why individuals belonging to the same peer group may tend to behave similarly. First, individual behavior may be influenced by the behavior of other group members: endogenous effects. Second, individual behavior may respond to the exogenous characteristics of the group: contextual effects.

These two comprise the social effects of interest. However, a third possibility is the presence of correlated effects in behavior that are unrelated to social interactions. This can occur if group members share similar observable or unobservable characteristics or face similar institutional environments. The fundamental problem of separately identifying these three effects from one another is denoted the reflection problem.

Even in the absence of correlated effects, the crucial novelty in our estimation framework is that we explicitly address the reflection problem by modeling the full system of individual equations. In the language of the peer effects literature, our parameter estimates capture endogenous effects (δ) and contextual effects and observable correlated effects (α), as well as their interactions (ϕ). In addition, because we can estimate the variance-covariance matrix of the unobservables, we can also capture correlated effects in the unobservables. This is very different from Manski (1993), who studies the identification of a single equation model. It is also very different from most other empirical studies of social interactions as they aim at identifying the sum of peer effects (endogenous and exogenous) from correlated effects.

The first challenge to identification is the need to distinguish endogenous fertility effects, the strategic effects of interest, from contextual effects that stem from the direct effect of coworker characteristics on one's own fertility. In order to isolate the strategic effects, we require an exclusion restriction. In particular, we need some variables that enter into an agent's own utility function but not her peers' utility functions, that is variables which are elements of W but not Z. We exploit a set of exogenous variables that enter one worker's net utility from childbearing but that do not enter the utility function of other workers. In particular, we expoit information about coworkers' siblings.

The second potential challenge to identification is from correlated errors within establishments. We address this challenge in several parts, depending on the potential source of the correlation.[12] First, there may be random shocks at the establishment level or at the firm

[12]Previous studies have adressed this problem by random assignment of individuals into peer groups (e.g. (Sacerdote 2001)) or by exploiting exogenous between-group variation

level that affect the utility from fertility for all women. We allow for these effects in the error structure. The random utility shocks have a common firm specific, common establishment specific and an idiosyncratic individual component. Second, there may be correlations in the idiosyncratic shocks among women at the same establishment. In section 5, we present estimates from a model that allows for such correlations and estimates the covariance between these errors. Finally, there may be correlation in the unobservable components of utility (recall that these are only unobservable to the econometrician) due to non-random sorting into establishments. In particular, one might be concerned that women with high intrinsic desire for children self-select into firms with favorable leave policies and family-friendly work environments.

We address this by including controls for firm factors that are related to such policies, mainly the indicator for private sector firms and larger firms, but also controls for peer characteristics such as education and occupation that might be related to such policies.

As one of the robustness exercises shown in the Appendix, we also repeat our main estimation on a sub-sample of public sector workers as the public sector is known to have a favorable family-leave environment, leading to substantial selection into the sector. However, the sub-sample estimates will exploit variation within the sector, where policy is homogenous and selection bias should not be as important.

5 Empirical Results

5.1 Evidence of Correlated Fertility Behavior

Before investigating the results from our structural model that fully incorporates strategic interactions in fertility, it is useful to consider simpler non-structural models. This subsection presents such reduced form analyses. Here we estimate simple probit models for the decision to have a child as a function of the number of coworkers who conceives in the period under

(e.g.(Graham and Hahn 2005)).

consideration while conditioning on a rich set of covariates that includes information on age, tenure, education, occupation, and partner.[13] Details on the groups of variables in the conditioning set can be found in Appendix. All analyses are performed at the individual level.

Table 3: Selected Coefficient Estimates

Effect of Peer Fertility on Own Fertility 2003-2005

Conditioning Set	# Peers w. baby 2003-2005 Coef. Est.	Std. Err.
Number of peers	0.050***	0.003
+ Personal char. and partner dummy	0.020***	0.003
+ Full set of spouse char.	0.019***	0.003
+ Establishment and peer personal char.	0.017***	0.003

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

The full set of coefficient estimates for the richest specification can be found in Appendix, Table A1.

Table 3 shows the estimated effects of peer fertility in 2003-2005 on own fertility. We start out with a simple conditioning set that only includes number of peers. We see that positive association between coworker and individual level fertility found in the raw means in Section 3 still exists when we condition on number of peers. Adding more detailed conditioning sets with information on personal, spouse, and establishment characteristics as well as contextual effects (peer characteristics) changes the coefficient estimate but it remains positive and highly significant regardless of the specification. The coefficient estimate translates into a marginal effect (evaluated at the mean) of about 0.005 in the richest specification or an elasticity of 0.03. The full set of coefficient estimates for the richest specification can be found in Appendix, Table A1. Apart from peer fertility, other strong predictors of conception status

[13] We are mainly interested in strategic interactions and thus contemporanous fertility choices but acknowledge that coworkers' prior fertility decisions may directly impact on individual level fertility but may also be endogenous in this context. The Probit results in Table 2 are robust to the addition of measures of previous fertility choices.

are age, level of education as well as cohabitation and/or marriage.

5.2 Heterogenous effects by worker type

As pointed out above, it is entirely possible that different sub-groups may exert different influences on one another within the same establishment. Because of this, it is natural to study heterogeneity in effects by worker type. Here, we focus on individuals with short and long tenure, women with and without previous children, women with and without high education and women in a professional occupation versus those who are not. Table 4 shows the probit results of the effect of peer fertility on own fertility.

Table 4: Heterogeneity by Worker Types

Probit Estimation

Effect of Peer Fertility on Own Fertility 2003-2005

	# Peers w. baby 2003-2005							
Types	Hi-on-Hi		Hi-on-Lo		Lo-on-Hi		Lo-on-Lo	
	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.	Coef. Est.	Std. Err.
Tenure	0.031*	0.005	0.007	0.006	0.013*	0.006	0.016**	0.005
Children	0.003	0.005	0.053***	0.005	0.009	0.005	0.007	0.005
Education	0.022***	0.005	0.007	0.006	0.015**	0.007	0.020***	0.004
Prof. occ.	0.024***	0.004	0.001	0.006	0.011	0.007	0.021***	0.004

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Tenure types are long (hi) and short (lo), children types are with (hi) and without (lo) existing children, education types are high (hi) level and lower (lo) level education, professional occupation types are professional (hi) and other (lo) occupation

Several interesting patterns are revealed from this exercise. Except for types defined by previous fertility, we see that individuals of the same type affect each other to a much higher degree than individuals of different types. One exception regards type of education where fertility of women with lower education has a positive effect on the fertility of women with high education but not vice versa. Also, fertility choices of women without children are mostly sensitive to fertility choices of women who already have kids. In line with this, Kuziemko (2006) finds that effects of sister fertility are especially strong for couples having their first child. The corresponding marginal effects (evaluated at the mean) are shown in Appendix Table A2. Most of the estimated marginal effects are in the order of 0.5 percentage points. Exceptions are the marginal effect associated with fertility choices of low tenure types on other low tenure types that is around 1 percentage points (elasticity of 0.009) and the marginal effect of fertility choices among women with previous children on women without children that is 1.5 percentage points (elasticity of 0.014).

Having uncovered this correlation between individual level and co-worker fertility, the first challenge of this project is to estimate a causal effect of peer behavior that accounts for the endogeneity of peer choices. This will be accomplished by an estimation strategy that exploits exogenous shifters of peer behavior (Section 5.3). The second challenge stems from the potential multiple equilibria which we explicitly handle in the structural estimation framework (Section 5.5).

5.3 Instrumental Variables Estimates of Peer Effects

This section presents the results from exploiting exogenous shifters of peer behavior to deal with potential endogeneity of the number of coworkers with babies during 2003-2005 in the context of modeling individual level fertility. We assume that excludable variables only affect coworkers' choice of childbearing but only child bearing at the individual level through their effect on coworker fertility. In line with Hensvik and Nilsson (2009) and inspired by Kuziemko (2006) we use fertility choices of workers' sisters (whether any sister has children, whether any sister has had a child recently (2000-2002) and whether co-worker has no sisters.

Table 5: Selected IV Probit Estimation Results

Effect of Peer Fertility on Own Fertility 2003-2005

Instruments	First Stage Coef. Est.	Std. Err.	# Peers w. baby 2003-2005 Coef. Est.	Std. Err.
Sister fertility:			0.136*	0.059
Share of peers				
- any sister has child	-0.301***	0.019		
- any sister has child 2000-2002	0.184***	0.022		
- without sisters	-0.283***	0.015		
Wald test, exogeneity	P=0.047			
Wald test, joint significance of IVs	P=0.000			
Overidentifying restrictions test	P=0.324			

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

The conditioning set is otherwise similar to that of the richest specification in Table 2

The test of overidentifying restrictions is the Amemiya-Lee-Newey version and implemented in STATA via overid by Baum, Schaffer, Stillman and Wiggins (2006).

Table 5 shows the IV results. The first set of columns presents the first stage and the second set of columns presents the main results. We see that all of the instruments are strong in the first stage. Sisters' fertility outcomes clearly affect individual level fertility; overall sister fertility has a negative effect on own fertility though more recent conceptions among sisters significantly increase the likelihood that a woman conceives herself. We still find a significant effect of peer fertility on own fertility when we exploit the exogenous variation in peer behavior. As is common in IV analysis, the coefficient estimate is larger than in the probit analysis and the marginal effect is about 0.04. Note though that the specification does not display strong signs of problems with endogeneity of peer fertility.

Appendix Table A3 shows a set of sensitivity checks including analyses for public sector employees only, women employed in small establishments, births in 2003 and 2003-2004, and for women employed in the same establishment for the entire period from 2003-2005. Qualitatively, our conclusions are unaltered when we restrict the analysis to include small establishments only. Similarly, our results are not sensitive to the choice of time period; considering conceptions in 2003-2004 or 2003 hardly changes coefficient estimates. Considering public establishments only (about 66 % of the women in our sample), on the other hand, reduces the estimated social effects somewhat.[14]

5.4 Simultaneous Estimation of the Fertility Game

We finally estimate the full model. This uses the exogenous variation we exploited in the previous section for the IV Probit estimates, but move the unit of analysis from an individual woman to an establishment. The main benefit is that we can incorporate the additional equilibrium constraint that ensures that all agents are enacting their own best responses. To secure feasibility of the structural estimations we randomly sample 3,000 establishments from the original 31,725 employing 14,788 individual women in the 20-40 age group. In a future version we will exploit the full sample. As expected, reducing the sample size reduces power but does not affect the parameter estimates in the reduced form analysis above.

We start out with a set of simple specifications that does not include worker types. Table 6 shows our initial structural results. Specification I only includes variables specific to the individual. Specification II then adds contextual effects through co-worker age and Specification III allows the presence of a partner to affect individual level utility. Variables that are included only at the individual level serve as instruments; these variables only affect the individual but not co-worker utility and decision making.

[14] In Appendix Table A4 we also introduce spousal information to the set of instruments (whether the co-worker has a partner, whether the spouse's income is above the mean, whether the spouse is more the five years older than the co-worker, whether the spouse is highly educated, and whether the spouse is employed in a professional occupation). The conclusions regarding peer effects are robust to this exercise. The size of the coefficient estimates depends, however, somewhat on the set of instruments.

Table 6: Structural Results

Effect of Peer Fertility on Own Fertility 2003-2005

Variables	(I)	(II)	(III)
Constant	[-13.92 - -5.67]	[-6.92 - -3.36]	[-6.25 - -4.70]
Private company	[0.54 - 4.21]	[1.00 - 2.94]	[1.13 - 2.26]
Large establishment	[-3.65 - -0.65]	[-1.54 - -0.56]	[-1.20 - -0.53]
Less than 25 years old	[-0.60 - 6.07]	[0.83 - 2.54]	[0.69 - 1.41]
Age 25-29	[0.95 - 4.13]	[1.56 - 2.97]	[1.17 - 1.85]
High education	[-3.00 - 1.65]	[-0.59 - 0.16]	[-0.33 - 0.35]
Professional occ.	[-0.99 - 0.15]	[-0.55 - 0.62]	[-0.79 - -0.16]
Experience/10	[0.77 - 7.37]	[0.54 - 1.82]	[0.26 - 0.70]
Share of peers aged less than 25		[-11.34 - -7.86]	[-11.69 - -10.65]
Share of peers aged 25-29		[-13.58 - -9.99]	[-12.67 - -11.81]
Partner			[0.69 - 1.27]
Living in a big city			
any sister has child			
any sister has child 2000-2002			
no sister			
high income spouse			
spouse more than five years older			
spouse with high education			
# Peers with children 2003-2005	[9.51 - 20.61]	[11.17 - 14.64]	[11.06 - 15.05]

Preliminary confidence bands

Table 6 ctd: Structural Results

Effect of Peer Fertility on Own Fertility 2003-2005

Variables	(IV)
Constant	[-7.08 - -3.69]
Private company	[-0.13 - 2.29]
Large establishment	[-2.30 - -0.32]
Less than 25 years old	[-0.25 - -2.35]
Age 25-29	[0.90 - 2.72]
High education	[-1.71 - 1.05]
Professional occ.	[-1.27 - 0.78]
Experience/10	[-1.01 - 1.67]
Share of peers aged less than 25	[-11.42 - -4.15]
Share of peers aged 25-29	[-10.56 - -3.79]
Partner	[-0.09 - 1.90]
Living in a big city	[-1.58 - 0.56]
any sister has child	[-1.71 - 0.51]
any sister has child 2000-2002	[-0.53 - 1.40]
no sister	[-1.04 - 0.72]
high income spouse	
spouse more than five years older	
spouse with high education	
# Peers with children 2003-2005	[7.28 - 12.71]

Preliminary confidence bands

We see that the structural model confirms the presence of social effects in fertility regardless of the specification; the number of peers who conceives during 2003-2005 has a large and positive impact on individual level fertility. Other important determinants of individual level fertility are the type and size of the company, age, experience, presence of a partner and the age composition of peers. Interestingly, having relatively young colleagues decreases the likelihood that a woman conceives.

6 Policy simulation [To Be Done]

7 Conclusions [To Be Done]

Appendix

Groups of variables in Conditioning Set

Personal characteristics: Indicator for being less than 25 years of age, indicator for being 25-29 years of age, indicator for having more than 12 years of education, indicator for professional occupation, indicator for tenure less than four years, experience, experience squared, indicator for living in a big city, indicator for living in a smaller city.

Spouse characteristics: Indicator for having a partner, indicator for high income, indicator for spouse being more than five years older, indicator for spouse having more than 12 years of education, indicator for spouse in professional occupation.

Establishment characteristics: Indicator for private company, indicator for large establishment (more than 21 employees).

Peer characteristics: Share of peers less than 25 years of age, share of peers aged 25-29, share of peers with more than 12 years of education, share of peers in professional occupation, share of peers with less than four years of tenure, mean experience among peers, mean experience squared among peers.

Estimation results

Table A1: Full set of Probit Coefficient Estimates

Living in a big city	-0.055***
	(0.0098)
Living in a smaller city	-0.037***
	(0.0096)
Less than 25 years old	0.274***
	(0.0147)
25-29 years old	0.636***
	(0.0104)
More than 12 years of education	0.172***
	(0.0108)
Partner	0.683***
	(0.0149)
Spouse with high income	0.00599
	(0.00910)
Spouse with more than five years older	-0.161***
	(0.0113)
Spouse with more than 12 years of education	0.159***
	(0.0106)
Spouse with professional occupation	0.0189*
	(0.00952)
Professional occupation	0.116***
	(0.0106)
Less than four years of tenure	-0.0303***
	(0.00804)

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table A1 continued: Full set of Probit Coefficient Estimates

Experience/10	2.111***
	(0.0554)
Experience/10 squared	-1.900***
	(0.0466)
Share of peers aged less than 25	-0.0500*
	(0.0214)
Share of peers aged 25-29	0.00861
	(0.0201)
Share of peers with more than 12 years of edu	-0.0158
	(0.0192)
Share of peers with professional occ.	-0.0126
	(0.0171)
Share of peers with tenure<4 years	-0.0166
	(0.0139)
Mean experience/10 of peers	0.148
	(0.0906)
Mean experience/10 squared of peers	-0.0909
	(0.0850)
Potential number of peers with baby 2003-2005	-0.00144
	(0.00120)

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table A1 continued: Full Set of Probit Coefficient Estimates

Large establishment	-0.0209*
	(0.00869)
Private company	0.00851
	(0.00891)
Number of peers with baby 2003-2005	0.0165***
	(0.00322)
Constant	-1.963***
	(0.0311)
Observations	151494

Standard errors in parentheses

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table A2: Heterogeneity by Worker Types, Marginal Effects, Probit Estimation

Effect of Peer Fertility on Own Fertility 2003-2005

	# Peers w. baby 2003-2005							
Types	Hi-on-Hi		Hi-on-Lo		Lo-on-Hi		Lo-on-Lo	
	Marg. Effect	Std. Err.	Marg. Effect	Std. Err.	Marg. Effect	Std. Err.	Marg. Effect	Std. Err.
Tenure	0.005**	0.001	0.004*	0.002	0.002	0.002	0.009***	0.002
Children	0.000	0.001	0.015***	0.002	0.003	0.002	0.002	0.001
Education	0.006***	0.001	0.002	0.002	0.004*	0.002	0.005***	0.001
Prof. occ.	0.007***	0.001	0.000	0.001	0.003	0.002	0.006***	0.001

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Tenure types are long (hi) and short (lo), children types are with (hi) and without (lo) existing children, education types are high (hi) level and lower (lo) level education, professional occupation types are professional (hi) and other (lo) occupation

Table A3: Sensitivity Analyses

Effect of Peer Fertility on Own Fertility 2003-2005

Subsample	# Peers w. baby 2003-2005 Coef. Est.	Std. Err.
Public Sector Employees		
Probit	0.004	0.005
IV-probit (sister fertility instruments)	0.040	0.136
Small establishments		
Probit	0.022**	0.006
IV-probit (sister fertility instruments)	0.215*	0.095
Births 2003-2004		
Probit	0.018***	0.004
IV-probit (sister fertility instruments)	0.142	0.085
Births 2003		
Probit	0.017**	0.006
IV-probit (sister fertility instruments)	-0.016	0.253
Same establishment 2003-2004		
Probit	0.016***	0.005
IV-probit (sister fertility instruments)	0.170*	0.082
Same establishment 2003-2005		
Probit	0.017**	0.005
IV-probit (sister fertility instruments)	0.309***	0.082

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table A4: Selected IV Probit Estimation Results

Effect of Peer Fertility on Own Fertility 2003-2005

Instruments	First Stage Coef. Est.	First Stage Std. Err.	# Peers w. baby 2003-2005 Coef. Est.	# Peers w. baby 2003-2005 Std. Err.
			0.042	0.018*
Sister fertility and spouse characteristics:				
Share of peers				
- any sister has child	-0.292***	0.019		
- any sister has child 2000-2002	0.162***	0.022		
- without sisters	-0.258***	0.016		
- w. partner	0.364***	0.019		
- w. high income spouse	-0.142***	0.015		
- w. spouse more than five years older	-0.521***	0.017		
- w. spouse w. high educ.	0.069**	0.017		
- w. spouse in prof. occupation	0.002	0.016		
Wald test, exogeneity	P=0.138			
Wald test, joint significance of IVs	P=0.000			
Overidentifying restrictions test	P=0.159			

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

The conditioning set is otherwise similar to that of the richest specification in Table 2

The test of overidentifying restrictions is the Amemiya-Lee-Newey version and implemented in STATA via overid by Baum, Schaffer, Stillman and Wiggins (2006).

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