Does fertility behavior spread among friends?

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Abstract

This paper investigates how social interactions among friends shape fertility. We specifically examine whether and how friends' fertility behavior affects an individual's transition to parenthood. By integrating insights from economic and sociological theories, we elaborate on the mechanisms via which interactions among friends might affect an individual's risk of becoming a parent. By exploiting the survey design of the Add Health data, we follow a strategy that allows us to properly identify interaction effects and distinguish them from selection and contextual effects. We engage in a series of discrete time event history models with random effect at the dyadic level. Results show that, net of confounding effects, a friend's childbearing increases an individual's risk of becoming a parent. We find a short-term, curvilinear effect: an individual's risk of childbearing starts increasing after a friend's childbearing, it reaches its peak around two years later, and then decreases.

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Introduction

Several fertility studies have highlighted the importance of diffusion and social interaction processes for childbearing behavior (Bongaarts and Watkins 1996; Montgomery and Casterline 1996). Looking at human beings as social actors who make decisions and act while embedded in a web of social relationships with kin and peers, demographers have increasingly acknowledged the role of interpersonal interactions in shaping fertility decision-making (Kohler 2001; Bernardi, 2003).

At the macro level, researchers have often turned to diffusion and social interaction theories to explain fertility differentials across time and place (Bongaarts and Watkins, 1996; Montgomery and Casterline 1996; Kohler, Billari and Ortega, 2002, 2006). Persistent diversity of fertility behavior between countries, regions or over time might be due to social interaction effects, that amplify the behavioral impact of certain socio-economic and institutional changes (i.e., *social multiplier effects*) or maintain long-term behavioral differences across areas (i.e., *multiple equilibria* and *path dependence*. Billari, 2004). However, the acknowledgment of the importance of social interaction in explaining observed fertility patterns has not been coupled with a satisfactory body of empirical research at the micro level. The main reasons rest with the lack of suitable data and the difficulty to model and properly identify social interaction effects (Manski, 1993, 1995). The existing meagre research on the effect of social networks on fertility is mainly based on data from developing countries and primarily investigates the use of contraception (Kohler, Berhman and Watkins, 2001 ; Behrman, Kohler and Watkins, 2002). Only a small number of studies focus on advanced societies, and it mainly consists in small-scale qualitative work (e.g., Bernardi 2003; Bernardi, Keim, and von der Lippe, 2007; Keim, Klärner and Bernardi, 2009). However, there have recently been signals of a growing interest in a more rigorous quantitative approach. A few studies engaged in quantitative analyses showing that social interactions among siblings (Kuziemko, 2006; Lyngstad and Prskawetz, 2010), co-workers (Hensvik and Nilsson, 2010; Ciliberto et al., 2010), and peers belonging to the same ethnic-religious group (Manski and Mayshar, 2003) shape the individual's fertility decisions. Moreover, another innovative approach is the one adopted by Aparicio Diaz and colleagues (2011), who applied an agent-based simulation model to assess the importance of social interdependencies among individuals for explaining fertility changes in Austria during the period 1984-2004.

We contribute to this growing line of research by studying the effect of the friendship network on the individual's childbearing. Though it is to be expected that friends influence each other in their family formation behaviors, cross-friend effects on fertility have not yet been scientifically examined. Therefore, the aim of this paper is to examine if and how friends' fertility behaviors affect the individual's transition to parenthood. In doing so, we adopt an analytical strategy that allows us to properly identify interactions effects while ruling out possible confounding factors.

Overall, our paper provides two distinct, yet interrelated contributions to the literature. The first contribution consists in proposing an innovative strategy to deal with identification issues that are typical of social interaction processes. By exploiting the network panel survey design of the Add Health data, we use a dynamic model in which we disentangle selection and contextual effects from true friends' influence effects. On top of this methodological innovation, our second contribution pertains to the theoretical mechanisms underlying the effects of social influence on fertility behavior among friends. We offer a theoretical framework that integrates insights from both sociology and economics to specify pathways via which cross-friend effects affect fertility behavior.

In the rest of the paper, we first outline our theoretical assumptions and make our hypotheses. We then describe the data and the study sample, while explaining our empirical strategy. In the end, after presenting our results, we conclude with a discussion and reflection on the theoretical and practical implications of our findings.

Theoretical framework

Building on diffusion and social interaction theories (Bongaarts and Watkins 1996; Montgomery and Casterline 1996; Kohler 2001; Bernardi, 2003), the starting assumption of this paper is that an individual's life course decision-making, such as the decision to become a parent, is not only driven by his or her own personal characteristics or relevant contextual factors, but also influenced by the characteristics and the behavior of people whom that individual interacts with.

According to socialization theories, an individual's behavior is shaped by interactions with relevant socialization sources (Oetting and Donnermeyer, 1998). In existing fertility research, most of the studies have identified the main socialization source with the family. They have emphasized the importance for childbearing choices of socialization processes that operate through the direct transmission of fertility behaviors and attitudes from parents to children at a very early stage in life (Thornton, 1980; Barber, 2000; Murphy and Wang, 2001; Riken and Liefbroer, 2009), or through later intra-family interactions, such as those among siblings (Lyngstad and Prskawetz, 2010). However, socialization does not only occur within the kinship network, but also outside it, through social exchange and interaction with peers and friends. In today's individualized societies, friends might be as important as or even more influential than siblings or other family members, since they have been freely chosen by the individual. According to the Second Demographic Transition perspective (Lesthaeghe and Van de Kaa, 1986), voluntary relationships have gained in importance compared to ascribed family relationships. We therefore envision that interactions with friends might play a crucial role in an individual's fertility decision-making.

This paper specifically focuses on the transition to parenthood in early adulthood (people who are up to 30 years old). Keeping in mind that the transition to first birth in the United States happens at a relatively young age (according to the National Center for Health Statistics (NCHS) the mean age at first birth was 25 in 2008), young adults are a very suitable sample for investigating whether and how transition to parenthood is affected by cross-friend interactions. A growing body of research has emphasized the importance of peer social networks in influencing an individual's behavior during early adulthood. These studies have focused on peer effects on health (e.g., obesity, Christakis and Fowler, 2007; Fowler and Christakis, 2008; or smoking behavior, Mercken et al, 2009, Pollard et al., 2010), and other individual outcomes (e.g. delinquency, Knecht et al., 2010; or sexual behavior, Ali and Dwyer, 2010), showing how these behaviors spread within the network, becoming contagious. Building on this literature, we believe that cross-friend effects on fertility might be particularly strong among young adults, likely affecting the probability and timing of becoming a parent.

So far, in fertility research, two main mechanisms have been identified as channels via which social interaction works: social influence and social learning. The first process identifies how consensus in peer groups constrains attitudes and behavior, whereas the second refers to how individuals gain knowledge from others (Montgomery and Casterline, 1996; Kohler et al., 2001). Certainly, friends play a crucial role in both mechanisms. Social influence among friends might be very well explained by the theory of social comparison (Festinger, 1954) and the concept of descriptive norms (Cialdini, Reno and Kallgren, 1990). According to the theory of social comparison, individuals adapt their behavior to the one of those who are considered in a similar social position or who share similar characteristics. Friends clearly belong to this comparison group, thereby individuals likely conform their behavior to what their friends do. Similarly, Cialdini et al. (1990:1015) claim the importance of the effect of *descriptive norms* on an individual's conduct. These norms are defined as "what is typical or *normal*, thus, what most people do", and consequently what becomes "sensible to do". In line with this argument, Rindfuss, Morgan and Swicegood (1988) have shown that norms play a primary role in shaping the transition to first birth and its timing in the United Sates. Therefore it is likely that individuals who have several friends with children might be more likely to have one as well. On the other hand, friends are also a source of learning because, next to siblings (Axinn, Clarkberg and Thornton, 1994; East, 1998), they offer behavioral examples and their childbearing experiences provide relevant information on how to face the transition to parenthood and deal with the substantial life changes it brings about (Bernardi, 2003).

Next to social influence and social learning, economic theories also highlight how diffusion processes in fertility can be explained by cost-sharing mechanisms and network externalities (Kuziemko, 2006). Having a child is associated with uncertainty and monetary as well as non-monetary costs (e.g., foregone earnings, opportunity costs in terms of a professional career or maintaining a certain social life). Uncertainty and non-monetary costs might be particularly high in the transition to first birth, because it is a transition to a completely new life state, that is, parenthood (Billari, Philipov and Testa, 2009). As shown by Lyngstad and Prskawetz (2010), the recent childbearing of a sibling has a strong positive effect on first-birth rate, whereas this effect is almost negligible on the second child. Building on this, we extend this reasoning to a friendship context. We assume that having friends with whom and individual can share his or her experience as a parent might reduce the uncertainty associated to it because friends can share not only information, but also feelings and worries. Moreover, going through such a unique life transition as the only person within a peer group likely leads to bear higher relational costs. Becoming a parent is a radical change in one's life style, that strongly impacts the amount and the nature of leisure time, and thereby the time spent with friends. Therefore, having the opportunity of experiencing parenthood together with (or right after) other friends make this transition less relationally costly, because life changes within a social group are synchronized (or anyway shared) and the risk of being left alone or lagged behind is reduced. Looking at this mechanism from the benefit side (i.e., network externalities, Katz and Shapiro, 1985; Kuziemko, 2006), having a child around the same time of other friends likely makes the whole childbearing experience even more enjoyable because "consumed" together.

Based on the outlined social interaction mechanisms, we envision that a friend's childbearing can trigger an individual's decision to have the first baby. Therefore, the first hypothesis we postulate is that: *H1) a friend's childbearing has a positive effect on an individual's entry into parenthood (i.e., first-birth).*

Kuziemko (2006) and Lyngstad and Prskawetz (2010) have consistently shown that cross-sibling effects on fertility have a specific time pattern. The contagion effect is very strong and increasing in the 12 (Lyngstad and Prskawetz, 2010) or even 24 months (Kuziemko, 2006) after the sibling's childbearing. It then declines, becoming negligible after three years.

We envision finding the same time pattern among friends as well, as a result of an individual's cost-sharing strategy. As mentioned earlier, experiencing the transition to parenthood together with other friends might reduce the relational costs that such a transition brings about. Therefore, an individual should become a parent around the same time her friends do, in order to synchronize her life path to the one of her friends, and thereby coordinate their life changes. This leads us to envision a strong short-term influence effect, which is likely to become negligible in the long run.

For the outlined non-linear effect of social interactions on first birth, an additional explanation, which would not compete, but actually reinforce the cost-sharing argument, could rest with the pattern of happiness surrounding the birth of a first child (Pouwels, 2011). Pouwels (2011) has shown that, in the year before and after the first childbirth, parents experience a sharp increase in the level of happiness. Happiness is however found to drop some months after the delivery of the child and new parents are found to be less happy than before the birth, for a long time. This curvilinear relationship between happiness levels and childbearing seems to translate into a similar influence effect on others' fertility, with a lag of a couple of years. Building on Fowler's and Christakis's findings (2008), according to which happiness spreads within a social network, we can assume that people are likely influenced by seeing relevant others (e.g., siblings or friends) being happier when they become parents, and this might in turn positively affects their desire to have a child as well. Conversely, experiencing the unhappiness of the new parents might make people (more) aware of the toughness associated to childbearing, thereby reducing their own likelihood to have a child. The lag of one or two years in an individual's reaction seems to be consistent with the average time it takes to conceive and deliver a child (Gnoth et al., 2003).

Following the cost-sharing argument, and in light of the outlined relationship between happiness and transition to first child, we therefore envision that: *H2) the effect of a friend's childbearing on an individual's risk of becoming a parent is:*

1. *A short-term effect*
2. *Inverse U-shaped: an individual's parenthood rate increases in the period following the childbearing of a friend, and, after reaching this peak, it starts decreasing.*

Besides a few studies on the use of contraceptive in developing countries (Behrman et al., 2002; Kohler et al., 2001), and the qualitative analysis of Bernardi (2003), up-to-date research lacks quantitative studies on the role of friendships and cross-friend effects on fertility. The reason for that rests with the friendship's nature itself and its formation process. Friendships are not ascribed but voluntary relationships, meaning that individuals select their friends. This selection might be direct, that is, individuals choose friends based on similarity in behavior and attitudes (Lazarsfeld and Merton 1954), or indirect, that is, people select social settings in which they live (e.g., school, workplace, etc...) and within these settings they bond with people who are similar and behave alike in virtue of the fact that they have chosen or simply share the same social context (Feld, 1981, 1982). The first selection mechanism (that, from now on, we will refer to as *selection*) is widely explained in terms of homophily, that assumes similarity in behavior as a cause of interpersonal relationships (McPherson, Smith-Lovin and Cook, 2001).

The second selection mechanisms is actually a correlation between similarity in behavior and friendship formation, due to confounding contextual effects, since people who live in (and sometimes deliberately choose) the same social context also share similar characteristics (and from now on we will refer to this as *contextual effect*). These selection and contextual effects make it difficult for researchers to disentangle the role of social influence (from now on, we will use *influence* as a synonym of “pure” social interaction effect) from other determinants like individual or contextual factors that may affect both friendship formation and fertility decisions. Variables that should measure social interaction effects might be correlated with some unobserved factors that affect the individual probability of having a child as well as bonding with a specific friend (Kravdal, 2003). To avoid severe bias in the estimates, and therefore properly identify social interaction effects, suitable model specifications and exclusion criteria are needed (Manski 1993, 1995). The relevance of this identification problem is evident from the active and still ongoing debate on the possible empirical strategies to disentangle selection and contextual effects from influence (Christakis and Fowler, 2007; Cohen-Cole and Fletcher, 2008; Fowler and Christakis, 2009; Bramoullè, Djebbari and Fortin, 2009; Steglich, Snijders and Pearson, 2010; Fletcher, 2011. Note that selection, contextual and influence effect are named in several different ways). Given that this issue is still very much open, in this paper we propose an innovative way to deal with it. We aim to investigate cross-friend effects on fertility behavior, net of selection and contextual effects. In the next section, we provide a detailed description of our analytical strategy.

Data and method

Data and sample

The data we use come from the four waves of the National Longitudinal Study of Adolescent Health (Add Health), a panel study of a nationally representative sample of adolescents, who in Wave I (1995) were in grades 7-12 in the United States. The Add Health cohort (born between 1976 and 1982) has been followed into young adulthood with four in-home interviews (Wave I in 1995, Wave II in 1996, Wave III in 2001-2 and Wave IV in 2008-9), at the end of which the sample was between 24 and 32 years old. Add Health provides us with the great opportunity to make use and combine three different types of information: longitudinal data on respondents' socio-economic, psychological and physical characteristics, information on their life course events and trajectories, and data on the social context and networks (e.g., family, neighborhood, community, school, friendships, peer groups). Therefore, these data perfectly serve our purpose of investigating the impact of social interaction among friends on the transition to parenthood.

We restrict our sample to women only, not younger than 15 years old, who are observed till around age 30. The decision to exclude men from our analysis rests with substantial data limitations. As already well explained by Schoen, Landale and Daniels (2007) and Amato, Landale and Havasevich-Brooks (2008), there is a systematic misreporting of childbirths in the fertility history modules (refer to the mentioned studies for further details). However, while we could make use of the information in the household roster to adjust omitted fertility data for women (we followed the same procedure described by Schoen et al. in their paper, 2007:810), this was not possible for men. Thereby, men were excluded from the study sample.

In Wave I, in-home and an in-school questionnaires were administered to 15,356 respondents. In the latter questionnaire, in-school network information was collected, and up to 10 friendship ties for each respondent were identified. In Wave III, a sort of follow-up of the Wave I network module (from now on called *friends module*) was administered to 3,572 respondents, who were in in 7th and 8th grade at Wave I. Among those people, we included in our sample only women who were interviewed not only in all of the previous waves, but also in the last one (Wave IV). Our final sample results in 1,726 individuals. In the *friends module* of Wave III, respondents were asked a battery of questions about the current relationship (or lack of it) with 10 former school mates. These 10 people were selected into a respondent's questionnaire by a name generator based on the probability of remaining friend with that respondent[1]. They therefore were chosen based on the in-school network information and behavior characteristics collected in Wave I. Every selected school mate was also a respondent in the previous Waves, as well as in the in-home survey at Wave III. Among the 10 former school mates of each respondent, we excluded men (for the same reason why we only included women in our sample, see above), and those who were identified as kin (e.g., cousins, siblings), in order to specifically focus on former school mate who were not part of the family network. Using information on friendship status at Wave III, we defined two typologies of network relationship: *peers* (i.e., former school mates who have never been friends) and *friends* (i.e., former school mates who became friends during high school and have remained so over time). We excluded from a respondent's list of 10 former school mates those individuals who used to be respondent's friends but were not any more at Wave III (i.e., former friends). This was done because there are no reliable information on the length of friendship and therefore we could not analyze the pattern of influence of former friends. The friendship network that we could draw for each respondent using the *friends module* of Wave III represents only a partial view of an individual's entire friendship network. However, we rely on the assumption that the partial network of friends from high school is a representative selection of an individual's entire friendship network during early adulthood. We discuss the implication of this assumption in the concluding section of this article.

In our sample, each respondent has on average 3.5 peers and 0.8 friends. Our analysis includes 7,256 dyads, among which 1,357 (19%) are friendships. In total, 967,231 dyadic spells are included in our analysis. During the considered exposure time, 820 respondents became parents, and the median age at first birth in our sample is 27.2.

Empirical strategy

In order to test whether a friend's childbearing has a positive effect on an individual's risk of becoming a parent, we engaged in a series of discrete time event history models with random effect at the dyadic level. Although the inclusion of dyadic random effect already allows us to control for unobservable time-constant factors affecting both members of the dyad (e.g., same experiences during adolescence, similar attitudes and preferences, and so forth), contextual and selection effects need to be further taken into account.

To properly disentangle confounding contextual effects from true influence effects, we adopted a strategy that draws on the work of Bramoullè and colleagues (2009), who identified peer effects through some characteristics of the network. We exploited the Add Health survey design and in particular information on the network structure from the *friends module* at Wave III. Similarly to the strategy used by Elwert and Christakis (2008), who disentangled causation from shared-exposure bias in the "widowhood effect" between spouses by examining both wives and ex-wives, we distinguished dyads of friends from those of peers. We considered two former school mates as friends when at least one of two individuals had identified the other as her current friend at Wave III. We instead defined as peers those pairs of people who went to high school together but have never been friends. By including and estimating both types of ties in our analysis, we could separate the effect of the shared social context (operationalized by peer effect) from the cross-friend interaction effect.

Our unit of analysis is the unidirectional dyad (i.e., friendship might not be symmetric), within which we aim to model the fertility behavior of one of the two members as a function of the occurrence of the other one's childbearing. Therefore the outcome of the same individual is repeated for each peer and/or friend. Moreover, the same individual can act both as respondent *i* and as peer/friend *j*. This strategy rests with the assumption that each dyad in our sample is independent, therefore it might not take into account that friends of the same friend might as well influence each other. Unfortunately we could not include an individual fixed effect in the regression model because those women who were censored without experiencing childbearing during the period of observation would not have otherwise been taken into account. However, in order to check whether the assumption of independence between dyads is a too restrictive one, we engaged in a permutation test that is reported in Appendix A2. This robustness check gave consistent results with those we report in the following part of the paper.

We treated selection in two alternative ways, by making and consequently implementing two different assumptions. In a first stage, in virtue of the survey design, we simply assumed friendship to be exogenous to the fertility decision-making. Friendships and peer relationships under study were formed at latest when respondents were around 12-15 years old (Wave I); therefore we could assume that their formation is exogenous to the decision to have a child. Put in another way, the decision to become friend is antecedent, and therefore independent from the one to become a parent. It is very much unlikely that adolescents choose their friends based on their family attitude and orientations. However, since we followed individuals and friendships over time, a selection issue might however arise. From a certain age onwards, people may decide to remain friends only with those persons who share similar family attitudes with them. Therefore, in a second stage, we instead made the less restrictive assumption that friendship might be endogenous to the fertility decision-making. To control for the fact that the two decisions (i.e., having a child and choosing a certain friend) might be interrelated, we then engaged in a simultaneous equation model.

As the economic literature has highlighted (Manski, 1993), another issue that arises in the identification of social interaction effects is the "reflection" problem. This term refers to the difficulty in disentangling whether a friend's behavior is the cause or just the reflection of the individual's behavior. In our strategy, however, this issue does not seem to affect our analysis. By exploiting the panel design we have, we can assume that, if the friend's childbearing occurs before the individual's childbearing, the former can only be the cause of the latter, and not the reflection of something that has not happened yet.

In the following sub-sections of this paragraph, two different model specifications are proposed. The second one advances the first by specifically modeling the time pattern of cross-friends effects. Within each model design, selection is first treated as exogenous and then assumed endogenous to the fertility process.

<u>Model specification 1: Modeling cross-friends effects using time-varying covariates.</u> In order to model the hazard of having the first birth during month t for individual i having a peer/friend j, we used a *probit* discrete time hazard function. The hazard function for the probability that the respondent i of the dyad ij becomes mother at time t is represented by $h_{ij}(t)$, where:

(1) $$\Phi^{-1}(h_{ij}(t)) = \alpha D_i(t) + \beta_1 X_i + \beta_2 Z_i(t) + F_{ij}\beta_3 P_j(t) + (1-F_{ij})\beta_4 P_j(t) + u_{ij}$$

$D_i\ (t)$ is the baseline hazard, that in our case is a quadratic function at time t of the individual i's duration (in age) between entry into the risk set (age 15) and the childbirth: $\alpha\, D_i\,(t) = \alpha_0 + \alpha_1(age_i) + \alpha_2(age_i)^2$. X_i and $Z_i\ (t)$ are respectively observed time-constant and time-varying covariates measuring individual i's observable characteristics that affect i's transition to first birth. $P_j(t)$ is a time-varying variable indicating when the other member of the dyad, j, had her first child. F_{ij} is a dummy variable and its value depends on the relationship between individual i and j. If j is a *friend* of individual i, F_{ij} takes on value 1 if the individual i and j are friends. Vice versa if j is a *peer* of individual i (i.e., just a former school mate), F_{ij} takes on value 0. Unobserved time-invariant dyad-specific factors are represented by normally distributed random effect u_{ij}, with zero mean and variance estimated by the model.

To carry out this analysis, we created a dyad-month file and we assumed that each dyad of female friends is independent from the others. For each of the 7,256 dyads, we set as dependent variable a dummy that takes on value 1 when the individual i gives birth, 0 in the other months. This variable was computed using the fertility history of each respondent up to Wave IV.

So far, we have assumed friendship formation to be exogenous to the fertility decision-making. In order to relax this assumption, we needed to jointly estimated the individual i's risk of becoming a parent and the probability for individual i to be friend with individual j. We specifically engaged in a recursive bivariate probit model, that is, we jointly estimated two probit models with correlated error terms and robust standard error clustered by dyad, in which the binary dependent variable of the second equation is an endogenous regressor in the first equation. (Wilde, 2000). This model belongs to the class of simultaneous equation models with dummy endogenous variables developed by Heckman (1978). However, the recursive bivariate probit model is specifically characterized by having both dependent variables as binary and can be estimated using full information maximum likelihood. This latter feature allows the model to be identified by functional form also in absence of any exclusion restriction. In our model, the first equation predicts the individual *i*'s risk of becoming a parent using the same variables of Equation 1. The second probit equation predicts the probability for individual *i* to be friend with individual *j* based on similarities between *i* and *j* and their geographical distance. Based on homophily theory, people with similar characteristics and background (we specifically considered similarities in race, parental education and income, family type) are more likely to be friends. Moreover, former school mates who lived close to each other during high school (at Wave I) as well as afterwards (at Wave III) are also more likely to stay in touch and therefore be friends. We assumed that the individual *i*'s risk of becoming a parent is only influenced by her own characteristics and the potential occurrence of the friend *j*'s childbearing, but not by dyadic common characteristics (i.e., similarities between friends), that we therefore considered as exogenous. These latter characteristics, together with the geographical distance, are instead assumed to affect friendship formation, acting thereby as exclusion restrictions. Therefore our simultaneous equation model has the following form:

(2)

$$\begin{cases} \Phi^{-1}(h_{ij}(t)) = \alpha D_i(t) + \beta_1 X_i + \beta_2 Z_i(t) + F_{ij}\beta_3 P_j(t) + (1-F_{ij})\beta_4 P_j(t) + \varepsilon_{1ij} \\ \Phi^{-1}(\Pr(F_{ij} = 1)) = \alpha_0 + \alpha_1 H_{ij} + \alpha_2 G_{ij} + \varepsilon_{2ij} \end{cases}$$

where $h_{ij}(t)$ is the individual *j*'s risk of becoming a parent and $\Pr(F_{ij} = 1)$ is the probability for individual *i* to be friend with individual *j*. The error terms of the two equations are correlated, that is, $cov\ [\varepsilon_1; \varepsilon_2] \neq 0$. In the first equation of the two systems, we used the same variable specification of Equation 1, so the reader should refer to the above mentioned variables' description. As far as the second equation is concerned, H_{ij} are a set of dummy variables that take on value 1 when individual *i* and *j* share a given characteristic, zero otherwise. We specifically considered similarities in race, parental education and income, family type (e.g., single, step or both parent family during adolescence). G_{ij} represents the geographical distance between *i* and *j* and it is computed using two dummy variables that take on value 1 when both members of the dyad live in the same census tract, respectively at Wave I and Wave III.

<u>Model specification 2: Modeling cross-friends effects using a piecewise strategy</u>

In order to study the timing of influence on childbearing among friends, we adopted a piecewise approach to model the time pattern of cross-friend effect on transition to first birth. Specifically, instead of estimating time-varying covariates for a friend's or peer's childbearing (β_3 and β_4 in Equation 1), we used dummy variables, four for each type of possible tie, that is friendship and peer relationship. These variables take on value 1 if the friend or peer had a child respectively in the last 11 months, 12-23 months ago, 24-35 months ago, and more than 36 months ago. This model therefore has the following form:

(3) $$\Phi^{-1}(h_{ij}(t)) = \alpha D_i(t) + \beta_1 X_i + \beta_2 Z_i(t) + F_{ij}\sum_{k=1}^{4}\gamma_k P_{kj} + (1 - F_{ij})\sum_{k=1}^{4}\delta_k P_{kj} \ + u_{ij}$$

where P_{kj} represents a set of four timing dummy variables indicating when the friend or the peer j gave birth.

Following the same strategy we adopted before, also within this model specification we relaxed the assumption of exogeneity of friendship. The simultaneous equation model we used looks as follows (see the above described Model 3 for a detailed explanation of the formula):

(4) $$\begin{cases} \Phi^{-1}(h_{ij}(t)) = \Phi^{-1}(h_{ij}(t)) = \alpha D_i(t) + \beta_1 X_i + \beta_2 Z_i(t) + F_{ij}\sum_{k=1}^{4}\gamma_k P_{kj} + (1 - F_{ij})\sum_{k=1}^{4}\delta_k P_{kj} \ + \varepsilon_{1ij} \\ \Phi^{-1}(\Pr(F_{ij} = 1)) = \alpha_0 + \alpha_1 H_{ij} + \alpha_2 G_{ij} + \varepsilon_{2ij} \end{cases}$$

Control variables

As we have just highlighted in the description of the models we used, besides controlling for unobserved time-invariant dyad-specific factors (by means of estimating random effects), we also included in our analyses several observable time-invariant as well as time-varying variables. We identified some factors that might confound the effect of a friend's childbearing on the risk of having the first birth. Specifically, we controlled for relevant socio-demographic individual characteristics, namely, race, parental education and income, and family type (measured at Wave I). Moreover, besides including age as a measure of the baseline time profile, that we assume to be quadratic, we also included partnership status as a time-varying covariate (we identified when respondents are cohabiting and when they are married). The latter variable might strongly affect the risk of becoming a parent and therefore buffer potential cross-friend effects.

Results

Table 1 reports some descriptive statistics of the sample, that we divided into two further sub-samples: women who experienced childbearing in the observation period and women that have not yet become mothers by Wave IV. The two groups differ in compositional characteristics. Early mothers are more likely to come from low socioeconomic status, measured in term of parental education and family income at Wave I. Moreover, they are less likely to grow up in a family with both biological parents and they have, in average, more siblings. We do not observe, instead, substantial differences between the two groups of women in the number of friends at Wave III; both groups have an average number of friends of 0.8 and 3.5 peers. Therefore these results do not give evidence of substantial differences on the number of network relationship between the two groups. Overall, the majority of women have experienced childbearing before Wave IV (52%), and the median age at first birth of our sample is around 27.

>> INSERT TABLE 1 ROUGHLY HERE<<

Table 2 gives a description of the network dyads included in the models. Descriptive results indicate a high degree of similarity among friends in terms of race, parental education family type and parental income[2]. It shows that people bond with individuals with similar background. However, the common social context is also responsible for a certain degree of homogeneity. Although peers seem to be less alike than friends, the difference between dyads of peers and those of friends in the degree of similarity is not big, showing that individuals who share the same context are rather similar with respect to a large set of demographic and socio-economic characteristics. Table 2 also presents a summary of geographical characteristics at the dyadic level. Friends exhibit a greater geographical homophily compared to peers both at Wave I and Wave III. The average living distance between two school mates who are also friends is lower than the average distance between two non-friend school mates (i.e., peers), showing that pupils tend to be friends with those school mates who live close to them. The geographical proximity between friends is higher also during early adulthood. Although we do not observe differences between dyads of friends and peers in the probability of living in the same state or county, we find that friends are much more likely to live in the same census tract or block. We believe, therefore, that geographical proximity can be used to model the probability to be friends at Wave III.

>> INSERT TABLE 2 ROUGHLY HERE<<

Results for the *probit* time hazard of becoming a parent are shown in Table 3, which reports the model estimating the friend's childbearing effect as a time-varying covariate, and Table 4, where the timing of the friend's childbearing is estimated using a piecewise approach.

In Table 3, Model 1 estimates the effect of a friend's childbearing on an individual's risk of having the first child, net of baseline hazard and control variables, but without controlling for contextual and selection effects. In line with our hypothesis 1, we find that, when a friend becomes a parent, an individual's risk of becoming a mother increases. The duration pattern, as a quadratic function of an individual's age, shows a clear curvilinear shape. The positive effect of older age on first birth rate is coupled with a small negative effect of age squared indicating that the effect of an individuals' age becomes weaker or negative, the older the individual is. As for the control variables, we observe some significant, although not big, ethnic differences. Black and Hispanic women are at risk of becoming mother sooner than white ones. In line with previous studies (e.g., Rijken and Liefbroer, 2009), we find that the higher the number of siblings, the younger the age at first birth is. Moreover, when individuals cohabit or are married they are more at risk of becoming parents than when are single. Looking at the economic situation of the family of origin, we observe that women who come from poorer families have a higher risk of becoming parents sooner than those who come from a better-off family. A similar result is found for the effect of parental education: people who have more educated parents seem to have the first child later than those who come from a less educated family. Presumably this effect is the result of the fact that the first group of individuals is more likely to stay in education longer, thereby delaying the entry into parenthood (Rijken and Liefbroer, 2009). Finally, we find that individuals who grew up with both biological parents become parents later than those who live their adolescence in a step or single parent family. Besides ethnic differences that seem to disappear once we control for selection, the effects of control variables are consistent in all of our models.

In order to control for contextual effects, Model 2, which is also reported in Table 3, takes additionally into account the effect of a peer's childbearing. We find a positive effect, although smaller than in the case of a friend, of a peer's fertility on a woman's first-birth rate, meaning that the social context plays a relevant role in shaping an individual's reproductive behavior. However, even after controlling for such a contextual effect, the influence of a friend's fertility is still significant, and actually stronger.

Model 3 and 4 (again Table 3) report two simultaneous equation systems that allow us to estimates cross-friend effects on fertility net of selection effects. Given a dyad, we jointly estimated the risk of one dyad's member of becoming a parent and the probability of being friend one with another. In this way, we allowed the residual component of the two equations to be correlated. We wanted to make sure that similarities in fertility behavior among friends are the result of their interaction and not vice versa. Once people get older, they might choose to remain friends with those former school mates with whom they share similar family attitudes and plans. In this case, similarities in family orientations would be the cause and not the consequence of friendship. Model 3 shows that, when we control for selection, cross-friend effects on childbearing are even stronger than in the un-adjusted models and ethnic differences disappear. The same findings can be found in Model 4, which is the most complete model because it does also control for contextual effects. Net of selection bias, a peer's childbearing does not longer seem to affect an individual's risk of becoming a mother.

The second equation of Model 3 and 4 estimates the probability of being friends for a pair of former school mates, and we can see that it is very well predicted by homophily. People who have the same race, similar parental education and family type are also more likely to be friends. Moreover, the closer they live (i.e., living in the same census tract), the higher the likelihood of being friends.

>> INSERT TABLE 3 ROUGHLY HERE<<

In order to investigate the time pattern of cross-friend effects on an individual's risk of becoming a parent, we adopted a piecewise approach. Models reported in Table 4 estimate the effect of a friend's or peer's childbearing within 1 year, between 1 and 2 years, between 2 and 3 years, and after 3 years. Following the same strategy we used in the previous model specification (in Table 3), we first estimated a model including only control variables and the dummy variables measuring when a friend's childbearing occurred (Model 1), then we also included the set of dummy variables for a peer's fertility, thereby controlling for possible contextual effects (Model 2). Finally we reported the two simultaneous equation models to adjust for selection, with and without peers effect (Model 3 and 4, respectively). While in the first, un-adjusted model we do not seem to find any cross-friend effect on an individual's risk of having the first child, once we control for confounding effects, we always find a curvilinear effect in the years after a friend become a parent.

>> INSERT TABLE 4 ROUGHLY HERE<<

Model 2, next to the variables catching a friend's childbearing, also includes the effect of peers on the propensity to become a mother. Estimates show that a friend's effect starts to be significant one year after her childbearing, it increases until it reaches a peak around three years later and it then starts declining. Put in another way, a woman is more likely to become a mother between one and three years after one of her friends had her first child (see Figure 1). As for the effect of a peer's childbearing, the effect is much smaller than for a friend, and it seems U-shaped (Figure 1). A peer's fertility behavior has a small immediate effect, which might be explained not as a real influence effect, but rather as an age effect. Peers of the same age, who also come from the same social context, are likely to experience life transitions at the same time. Moreover, we also observe a peers' effect in the long-run, after three years. This may be an indication of peer social pressure. With the increase of age, more and more people experience childbearing. Women who see many people of their age having children may feel pressured and therefore be more likely to have one as well.

>> INSERT FIGURE 1 ROUGHLY HERE<<

Model 3 and 4 show that, when selection bias is taken into account, a friend's influence effect is even more immediate. As shown by Figure 2, it reaches its peak around two years later, and it then declines. When we control for selection, in the same way as shown in the previous type of model (Table 3), peers and ethnic effects are no longer significant.

>> INSERT FIGURE 2 ROUGHLY HERE<<

These findings seem to support our second hypothesis, by giving evidence of a short-term, inverse U-shaped cross-friend effect on an individual's first birth rate. This pattern clearly resembles the one found for cross-sibling effect on fertility by previous studies (Kuziemko, 2006; Lyngstad and Prskawetz, 2010). It is though interesting to note that friend effect seems to be delayed compared to sibling effect, that is found to be stronger less than one year after a sibling's childbirth (Lyngstad and Prskawetz, 2010). This more immediate influence of siblings might be due to the fact that cost-sharing dynamics are stronger within the family network.

In all of the models where we estimate a dyadic random effect (σ_u in Model 1 and 2 both in Table 3 and Table 4), we find a significant unobserved heterogeneity, meaning that there are unobserved dyad-specific factors that influence an individual's (member of the dyad) risk of becoming a parent. Moreover, our simultaneous equation models (Model 3 and 4 both in Table 3 and 4), show a significant, although small, negative correlation (ρ). This can be explained as a signal of the fact that the decision to remain friend to a certain former school mate might be marginally endogenous to the decision to have a child in a certain moment in life.

Conclusions

The aim of this paper was twofold. First, we attempted to contribute to existing research on the impact of social interactions on fertility by elaborating on the mechanisms underlying fertility diffusion effects among friends. Studies on the influence of friendship on fertility decision-making are lacking, and empirical efforts to identify processes via which social interaction works are still scarce. Our second contribution is at the methodological level. We proposed an innovative strategy that makes use of the panel survey design to properly identify social interaction effects and disentangle them from possible confounding effects.

We envisioned that a friend's childbearing experience might be an important source of learning, because it provides relevant and useful information on how to face the transition to parenthood. Moreover, a friend's behavior can also work as source of influence because people compare themselves with their friends. Next to social learning and influence, another mechanism might be at play. Drawing upon economic theories, we argued that fertility influence among friends may also be the result of cost-sharing strategies. Transition to parenthood brings about high relational costs and big changes in one's life. Synchronizing childbearing with other friends might make the parenthood experience more enjoyable, because it can be shared, and may also reduce the risk of being left behind by those friends who have already had a child.

Using the 4 Waves of the Add Health data, we engaged in a series of discrete time event history models with random effect at the dyadic level. By exploiting the Add Health network design, we could distinguish dyads of friends from those of people who just went to school together but have never been friends (defined as peers) and therefore simply shared the same social context. This allowed us to estimate cross-dyad childbearing effects for both types of pairs, thereby separating true cross-friend interaction from contextual effects. Moreover, in order to distinguish selection from influence (people might remain friends with those who share similar family attitudes and plans), we engaged in a simultaneous equation model, in which we jointly estimated the probability for an individual of being current friend with the other person in the dyad, and the risk for a member of the dyad of becoming a parent.

Results showed that, net of selection and contextual effects, a friend's childbearing positively influences an individual's risk of becoming a parent. We found this effect to be short-term and inverse U-shaped: an individual's risk of childbearing starts increasing after a friend's childbearing, it reaches its peak around two years later, and then decreases. While controlling for contextual effects, we found that peers' behavior seems to have an effect only in the long-run. We interpreted this as an indication of social pressure. With the increase of age, women who see many people of their age having children may feel pressured to have one as well.

We acknowledge some limitations of the present study. First of all, the data we used did not allow us to look at the individual's complete network. We relied on the assumption that the partial network of friends from high school is a representative selection of an individual's entire friendship network during early adulthood. Although we believe it is reasonable to assume the former high school mates play a relevant role in a young adult's network, we miss a complete picture of it. We acknowledge this assumption might hold less for those women who remained in education longer, maybe even moving to another city, because they might have made new friends at college or university. By only looking at high school mates we made a conservative estimation of friend effects, which might have underestimated the true social influence on fertility. Second, our analytical strategy also led us to make another restrictive assumption, by considering each dyad in our sample as independent. Although we still consider this as a limitation, we are at the same time confident that it is not detrimental for our analysis. As a robustness check, we indeed ran a permutation test in order to relax this assumption, and we obtained consistent findings (see Appendix A2). Finally, we could only measure friendship status of each dyad at Wave III, whereas we considered the fertility history of each respondent and friend/peer up to Wave IV (around 6 years later). We therefore assumed that those people who were friends at Wave III remained so even afterward. Although this might not be true fall of the pairs, we consider plausible that two former school mates, who have kept in touch for some years after they finished school, are willing to invest in their friendship, which is therefore likely to be a long-lasting one.

We could carry out this study thanks to the availability of network-based, panel data like Add Health. However, such datasets are still very scarce, especially in Europe. We hope that studies like the present one, that show the importance of social interaction effects on fertility, can stimulate the collection of more and new network data on a large, international scale.

Next to the study of Aparicio Diaz and collegaues (2011), who made use of an agent-based simulation model to study the macro outcome of social interaction effects on fertility among individuals, we believe that also our analysis might have relevant policy implications. By making use of real data, we showed that friendships strongly shape an individual's fertility choices. Acknowledging that friendship networks usually play a primary role in a young adult's life, policy-makers should take into account that social networks might work as leverage for family policies especially if addressed to young adults.

We believe that our study contributed to gain important insights on the mechanisms via which friendship networks influence an individual's fertility behavior, also providing an interesting strategy to deal with identification issues. However, further research should be carried out. Future efforts should address whether social interaction has different effects on fertility for different social groups (e.g., by education or race). We therefore hope that further studies can take social stratification into account while studying social interaction effects. Moreover, a natural extension of this research would be to also look at men. Finally, since the family formation process consists of several, closely interrelated decisions (e.g., leaving parental home, union formation, childbearing), it would be very interesting to further investigate whether cross-friend effects also or even mainly work via other family formation decisions, such as marriage.

Endnotes

1. Probable friends were chosen based on two types of information: the attributes' similarity between ego and alter (i.e., the former school mate) and the relative network position of ego and alter. The predicted probability of being friends is based on a dyad-level logistic regression. Further details provided by the Add Health team can be found in appendix A1.
2. Dummy variable measuring similarities are based on the same categories shown in Table 1.

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Tables

Table 1. Descriptive statistics of the sample.

	Women who not experienced childbearing	Women who experienced childbearing	Total
Parent education			
Less than High school	7.4	12.7	9.9
High school or equivalent	27.5	39.0	33.0
Some College	18.4	19.0	18.7
College education or more	39.0	17.8	28.9
Unknown	7.7	11.5	9.5
Family type			
Living with biological parents at Wave I	64.2	44.3	54.8
Living in a step family at Wave I	7.7	12.7	10.1
Living with single mother at Wave I	23.3	34.9	28.8
Living with single father at Wave I	1.4	2.7	2.0
Living in other typology of family at Wave I	3.3	5.5	4.4
Race/Ethnicity			
Hispanic	8.6	10.6	9.6
Black	22.3	30.7	26.3
Asian	5.4	2.2	3.9
White	63.7	56.5	60.3
Parental Income			
1st quintile	17.3	28.9	22.7
2nd quintile	16.2	25.6	20.6
3rd quintile	22.0	21.1	21.6
4th quintile	20.9	15.4	18.4
5th quintile	23.6	8.9	16.8
Average number of siblings	1.49	1.71	1.6
Average number of friends	0.82	0.78	0.8
Average number of peers	3.43	3.55	3.5
Median age at first birth	-	-	27.2
Number of women observed	906	820	1726

Table 2. Overview of some characteristics of the network dyads in the sample.

	Peers	Friends	Total sample
Proportion of dyads with same race	0.72	0.82	0.74
Proportion of dyads with same parent education	0.31	0.36	0.32
Proportion of dyads with same family type	0.42	0.50	0.44
Proportion of dyads with same parental income	0.22	0.29	0.23
Proportion living in the same state at WI	1.00	1.00	1.00
Proportion living in the same county at WI	0.90	0.90	0.90
Proportion living in the same census tract at WI	0.28	0.39	0.30
Proportion living in the same block at WI	0.09	0.17	0.11
Proportion living in the same state at WIII	0.78	0.79	0.78
Proportion living in the same county at WIII	0.51	0.52	0.51
Proportion living in the same census tract at WIII	0.09	0.16	0.10
Proportion living in the same block at WIII	0.03	0.08	0.04
Number of dyads	5,899	1,357	7,256

Table 3. Coefficient estimates of the probit discrete time hazard of becoming a parent, using a friend's childbearing as a time-varying covariate.

	(1)	(2)	(3)	(4)
Friend becomes mother	0.117*	0.130**	0.134***	0.137***
	(0.046)	(0.046)	(0.040)	(0.040)
Peer becomes mother		0.052*		0.026
		(0.025)		(0.020)
Age in years	0.435***	0.431***	0.340***	0.338***
	(0.046)	(0.046)	(0.030)	(0.030)
Age squared	-0.009***	-0.009***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Race *(ref: white)*				
Black	0.057*	0.054*	0.035	0.033
	(0.026)	(0.026)	(0.018)	(0.018)
Hispanics	0.079*	0.079*	0.034	0.034
	(0.038)	(0.038)	(0.026)	(0.026)
Number of siblings	0.053***	0.053***	0.039***	0.039***
	(0.009)	(0.009)	(0.005)	(0.005)
Parents with college education *(ref.: parents with lower education)*	-0.129***	-0.129***	-0.081***	-0.081***
	(0.026)	(0.026)	(0.017)	(0.017)
Living with biological parents at WI *(ref.: living in a single parent or step family)*	-0.201***	-0.200***	-0.135***	-0.135***
	(0.026)	(0.026)	(0.016)	(0.016)
Parental income *(ref.: 5th quintile)*				
1st quintile	0.425***	0.420***	0.269***	0.267***
	(0.054)	(0.054)	(0.029)	(0.029)
2nd quintile	0.475***	0.471***	0.317***	0.315***
	(0.054)	(0.053)	(0.028)	(0.028)
3rd quintile	0.350***	0.348***	0.236***	0.235***
	(0.047)	(0.046)	(0.027)	(0.027)
4th quintile	0.218***	0.218***	0.153***	0.153***
	(0.043)	(0.043)	(0.028)	(0.028)
Marriage	0.386***	0.387***	0.303***	0.304***
	(0.046)	(0.046)	(0.040)	(0.040)
Cohabitation	0.248***	0.249***	0.205***	0.205***
	(0.024)	(0.024)	(0.021)	(0.021)
Constant	-8.280***	-8.226***	-6.672***	-6.648***
	(0.586)	(0.582)	(0.312)	(0.312)

Same race/ethnicity			0.239***	0.239***
			(0.052)	(0.052)
Same parent education			0.108*	0.108*
			(0.045)	(0.045)
Same type of family at WI			0.132**	0.132**
			(0.043)	(0.043)
Same census tract at WI			0.176***	0.176***
			(0.049)	(0.049)
Same census tract at WIII			0.159*	0.159*
			(0.070)	(0.070)
Constant			-1.192***	-1.192***
			(0.051)	(0.051)
N of dyadic spells	557485	557485	557485	557485
σ_u	0.469	0.469		
	(0.063)	(0.063)		
ρ			-0.036**	-0.032**
			(0.012)	(0.012)
Log likelihood	-14962.859	-14960.702	-291268.093	-291267.172

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (two-tailed test)

Table 4. Coefficient estimates of the discrete time hazard of becoming a parent, modeling the timing of a friend's childbearing using a piecewise approach.

	(1)	(2)	(3)	(4)
Friend (0-11 months)	0.065	0.076	0.111	0.112
	(0.084)	(0.084)	(0.078)	(0.078)
Friend (12-23 months)	0.165	0.178*	0.195*	0.197*
	(0.084)	(0.084)	(0.077)	(0.077)
Friend (24-35 months)	0.167	0.181*	0.176*	0.178*
	(0.090)	(0.091)	(0.085)	(0.085)
Friend (36+ months)	0.099	0.120	0.102	0.107*
	(0.062)	(0.063)	(0.053)	(0.053)
Peer (0-11 months)		0.087*		0.071
		(0.041)		(0.036)
Peer (12-23 months)		-0.024		-0.040
		(0.049)		(0.044)
Peer (24-35 months)		0.004		-0.005
		(0.048)		(0.043)
Peer (36+ months)		0.080*		0.038
		(0.032)		(0.026)
Age in years	0.434***	0.438***	0.338***	0.339***
	(0.047)	(0.047)	(0.030)	(0.030)
Age squared	-0.009***	-0.009***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Race *(ref.: white)*				
Black	0.057*	0.054*	0.035	0.033
	(0.026)	(0.027)	(0.018)	(0.018)
Hispanics	0.079*	0.080*	0.034	0.034
	(0.038)	(0.038)	(0.026)	(0.026)
Number of siblings	0.053***	0.053***	0.039***	0.039***
	(0.009)	(0.009)	(0.005)	(0.005)
Parents with college education *(ref.: parents with lower education)*	-0.128***	-0.129***	-0.081***	-0.081***
	(0.026)	(0.026)	(0.017)	(0.017)
Living with biological parents at WI *(ref.: living in a single parent or step family)*	-0.201***	-0.202***	-0.135***	-0.135***
	(0.026)	(0.027)	(0.016)	(0.016)
Parental income *(5th quintile)*				
1st quintile	0.426***	0.423***	0.269***	0.267***
	(0.054)	(0.054)	(0.029)	(0.029)
2nd quintile	0.475***	0.474***	0.317***	0.315***
	(0.054)	(0.054)	(0.028)	(0.028)
3rd quintile	0.351***	0.351***	0.236***	0.235***
	(0.047)	(0.047)	(0.027)	(0.027)
4th quintile	0.218***	0.219***	0.153***	0.153***
	(0.043)	(0.043)	(0.028)	(0.028)

Marriage	0.386***	0.388***	0.304***	0.304***
	(0.046)	(0.046)	(0.040)	(0.040)
Cohabitation	0.248***	0.250***	0.205***	0.206***
	(0.024)	(0.024)	(0.021)	(0.021)
Constant	-8.273***	-8.309***	-6.657***	-6.658***
	(0.590)	(0.596)	(0.312)	(0.313)
Second equation: probability of being friends				
Same race/ethnicity			0.239***	0.239***
			(0.052)	(0.052)
Same parent education			0.108*	0.108*
			(0.045)	(0.045)
Same type of family at WI			0.132**	0.132**
			(0.043)	(0.043)
Same census tract at WI			0.176***	0.176***
			(0.049)	(0.049)
Same census tract at WIII			0.159*	0.159*
			(0.070)	(0.070)
Constant			-1.192***	-1.192***
			(0.051)	(0.051)
N of dyadic spells	557485	557485	557485	557485
σ_u	0.470	0.475		
	(0.064)	(0.064)		
ρ			-0.036**	-0.032**
			(0.012)	(0.012)
Log likelihood	29962.3	29959.8	582584.5	582585.6

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (two-tailed test)

Figures

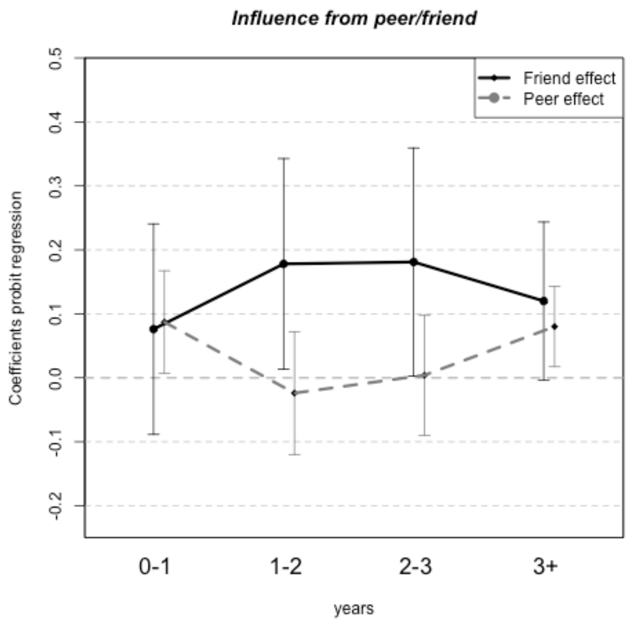

Figure 1. Estimates from a discrete model of the friend/peer's childbearing effect on the individual's risk of becoming a mother in the four years after the friend/peer's childbearing.

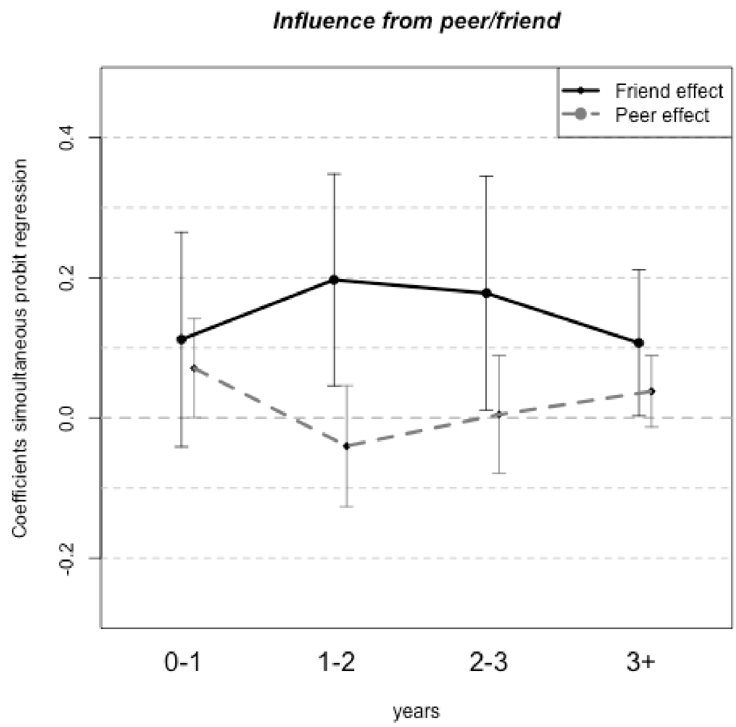

Figure 2. Estimates from a simultaneous equation model of the friend/peer's childbearing effect on the individual's risk of becoming a mother in the four years after the friend/peer's childbearing.

Appendix A1

Algorithm generating probable friends at Wave III

Probable friends were chosen based on two types of information: the attribute similarity of ego and alter and the relative network position of ego and alter. The predicted probability is based on the dyad-level logistic regression model below:

Y_{ij}=b_1 (out - degree) +b_2 (in - degree) +b_3 (reciprocity) +b_4 (popularity difference) +b_5(Pop Direction) +b_6 (Transitive return) + b_7 (Intransitive return) + b_8(Transitivity *Same - grade) +b_9 (Intransitivity *Same - grade) + b_{10} (Same Grade) + b_{11} (Same Gender) + b_{12}(Number of Same Clubs) +b_{13} (Same Race) +b_{14} (Both been in fights) +b_{15} (Skip School) + b_{16} (Same School Crowd) +e_{ij}

Where Y_{ij}=1 if ego nominates alter, and 0 if not.

The first 3 measures capture simple network involvement properties: out-degree is the number of people ego nominates and in-degree is the number of people who nominate alter. Reciprocity = 1 if alter nominates ego, zero otherwise. The two popularity coefficients capture simple popularity difference (ego in degree minus alter in degree, both not counting any nominations from the other) and the direction of the difference (Pop Direction = 1 if ego is less popular than alter). The transitivity and intransitivity coefficients capture balance processes within the school friendship network. A triad is balanced if, whenever ego sends to alter and alter sends to a third, ego also sends to the third. If ego does not send to the third, then the triad is intransitive. The transitivity measures (b_6, b_7, b_8, and b_9) capture how many transitive and intransitive triples would be created if ego nominated alter as a friend, differentiated by those within and between grade level. The next coefficients capture whether ego and alter are the same grade, same gender, how many clubs they both belong to, whether they are the same race (coded in 5 categories), two measures of delinquent activity (fighting and skipping school), and an indicator for whether they are members of the same school crowd, as identified by a cluster analysis of the friendship networks.

The model predicts friendships based on the in-school network and behavior characteristics. All predicted friends, however, are also in the in-home survey. As probable friends of ego were indeed chosen the most likely people who were also selected for an in-home interview. Thus, there is a wide variance in the observed probability that ALTER*n* is a friend, because each of ego's observed friends may not have been selected for an in-home interview.

Appendix A2

Robustness checks: permutation test

To test the assumption of independence of dyads, we engaged in a permutation test in which we compared the actual coefficients estimates with the effect we would have obtained if friends were assigned randomly. The correlation between dyads may reduce the standard errors of the estimates and affect the statistical tests leading to make the type II error. In this way, we would have overestimated the effect of friendship influence on fertility because we would not take into account the actual network structure and the correlation between dyads. To check the robustness of our coefficients estimates we simulated 1,000 datasets in which we randomly assigned friends to the respondents. The permutation is stratified by the total number of friends, in order to shuffle respondents with the same friendship network size.

For each of the π simulated dataset we re-estimated the model and we saved the new coefficient estimates $\hat{\beta}^{\pi}$. We then compared the estimates $\hat{\beta}$ of the original model with the distribution of the estimates obtained in the simulated models. This allowed us to assess the significance value p^{π} without any assumptions on the distribution of β.

The significance value was calculated as it follows:. $p^{\pi} = \dfrac{\left(\# \quad of \quad \hat{\beta}^{\pi} \geq \left|\hat{\beta}\right| \right)}{\left(\# \quad of \quad \hat{\beta}^{\pi} \right)}$ In this way, we could compare the actual coefficient with the null hypothesis H_0: β=0. As in other statistical tests, *a priori* significance level of 0.05 is used for interpreting the significance of the results.

Our robustness checks provided results that are consistent with the analysis provided in the text. In the model without piecewise effects, the childbearing of a friend *j* significantly influences the probability for individual *i* of becoming a mother. Conversely, the effect of a peer does not significantly differ from zero.

The permutation tests in the model with piecewise covariates indicate that an individual's risk of having a child significantly increases one year later the childbearing of a friend. Peers effects are statistically not significant in the first 3 years and become not negligible in the long run. The p-value of the permutation tests are reported in table A1. Figures A1 and A2 illustrate the distribution of the estimates under the null hypothesis of network independence.

Table A1. Permutation tests of Friends and Peer effects of discrete time hazard models

Coefficient	p-value
Models 1 and 2 (see Table 3 in the text)	
Friend becomes mother (β_3)	0.041
Peer becomes mother (β_4)	0.763
Models 5 and 6 (see Table 4 in the text)	
Friend effect (0-11 months)	0.181
Friend effect (12-23 months)	0.045
Friend effect (24-35 months)	0.028
Friend effect (36+ months)	0.026
Peer effect (0-11 months)	0.145
Peer effect (12-23 months)	0.425
Peer effect (24-35 months)	0.292
Peer effect (36+ months)	0.015

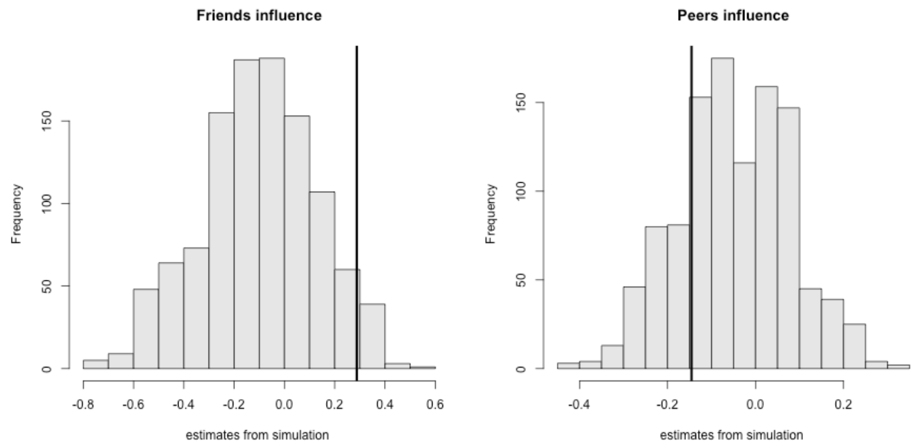

Figure A1. Distribution of simulated coefficients under random dyads assignments (null hypothesis). Actual estimates in solid line. Cross-friends model with piecewise effects.

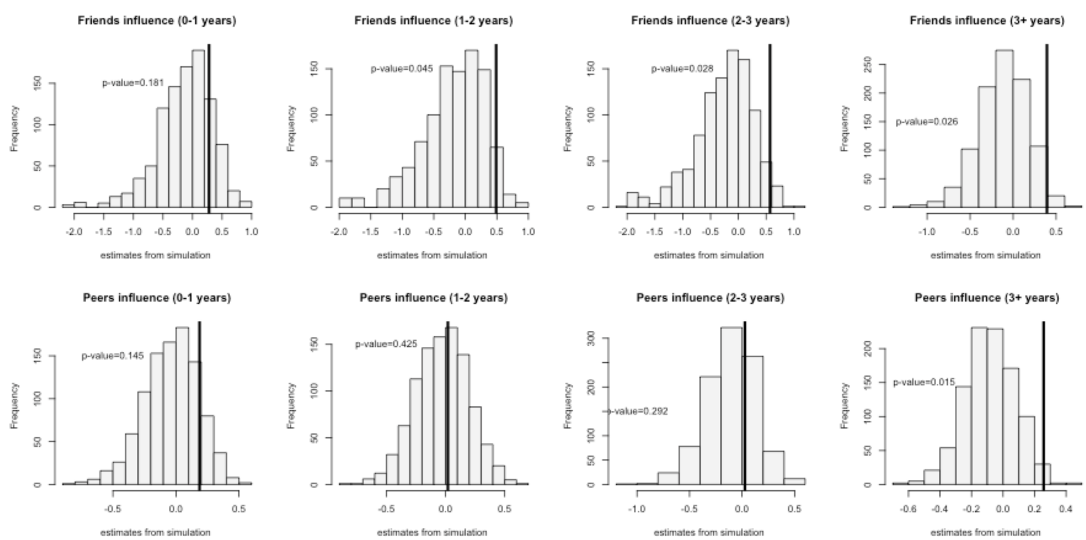

Figure A2. Distribution of simulated coefficients under random dyads assignments (null hypothesis). Actual estimates in solid line. Cross-friends model with piecewise effects.