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Linking neighbors' fertility:

Third births in Norwegian neighborhoods

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Abstract:
The aim of this paper is to gain more insight on the drivers behind geographical variations in family sizes by pointing out the role of neighborhoods and neighbors for two-child couples' transitions to third births. Couples' decisions about fertility behavior are influenced by their social context where immediate neighborhoods and neighbors may play a significant role. Furthermore, as neighborhoods are important contexts of childrearing, couples may sort geographically based on their fertility preferences. Using detailed geo-data from Norwegian administrative registers to locate couples in flexible ego-centered neighborhoods, this paper introduces a new dimension of spatial fertility variations. Results from regression models show that the family size of neighbors is positively related to each other. That is, the likelihood that two-child couples have a third child increases with the share of families with three or more children in the neighborhood. This relationship remains significant also after controlling for a range of couple characteristics, housing, neighboring women's educational level and time-constant characteristics of neighborhoods. It is also consistent for various neighborhood definitions which in this study range from the 12 to the 500 nearest neighbors. However, the strength of the association between neighbors' fertility increases with the number of neighbors, providing evidence that residential sorting is a dominant driver.

Keywords: spatial fertility; k-nearest neighbors; fertility diffusion; family size; third births

JEL classification: J11, J12, J13, R20, R23

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Sammendrag

Formålet med denne artikkelen er å få mer innsikt i drivkreftene bak geografiske variasjoner i barnetall ved å peke på rollen nabolag og naboer spiller for sannsynligheten for at foreldre med to barn får et tredje barn. Pars beslutninger om familieliv er preget av deres sosiale omgivelser der umiddelbare nabolag og naboer kan være av betydning. Samtidig er nabolag viktig i familiehverdagen og oppveksten slik at par kan tenkes å velge bosted i tråd med familieønsker.

Artikkelen benytter detaljerte geokodete norske registerdata for å konstruere fleksible individ-sentrerte nabolag og innfører dermed en tilleggsdimensjon sammenliknet med tidligere studier: Nabolagsvariasjoner i barnetall. Resultater fra regresjonsanalysene viser at naboers barnetall er positivt korrelert med hverandre. Det vil si at sannsynligheten for at to-barns foreldre får et tredje barn øker med andelen familier med tre eller flere barn i nabolaget. Denne assosiasjonen forblir signifikant også etter kontroll for en rekke kjennetegn ved par, deres bolig, nabokvinners utdanningsnivå og andre tidskonstante trekk ved nabolag. Sammenhengen består for ulike nabolagdefinisjoner som i denne studien spenner fra de 12 til de 500 nærmeste naboene. Sammenhengen mellom naboers barnetall øker imidlertid med nabolagsstørrelse, noe som kan vise til at selektiv bosetting er en dominerende mekansime.

1. Introduction

Declining family sizes, and especially fewer women having a third child, contribute substantially to overall fertility decline worldwide (Zeman, Beaujouan, Brzozowska, & Sobotka, 2018). This link between the declining number of three-child-families and declining total fertility rates has traditionally been considered important in Norway (Kravdal, 1992), and research on higher parity progressions is regaining attention in several countries today, such as France (Breton & Prioux, 2005), Germany (Diabaté & Ruckdeschel, 2016) and Turkey (Greulich, Dasre, & Inan, 2016). Similarly, strong regional variations in couples' number of children raise the interest in the spatial distribution of parity progressions. The spatial diffusion of fertility behavior is an inherent part of demographic transition theories (Bongaarts & Watkins, 1996; Lesthaeghe & Neels, 2002), and the importance of compositional and contextual factors in shaping fertility variation in Norway has already been shown for the spread of childbearing within cohabitation (Vitali, Aassve, & Lappegård, 2015).

Geographical variations in fertility are well recognized at the level of regions, nation states and along the urban-rural dimension. For instance, they are documented for all Nordic countries (Kulu, Vikat, & Andersson, 2007), the Netherlands (De Beer & Deerenberg, 2007), Austria, Switzerland and Germany (Basten, Huinink, & Klüsener, 2011), Italy (Vitali & Billari, 2015), Great Britain (Fiori, Graham, & Feng, 2014) and Australia (Gray & Evans, 2017). Still, there is little research that considers the importance of different geographical scales (Logan, 2012) or pays attention to couples' *immediate* residential context, and research on spatial correlations of fertility at small geographical scales is to date largely lacking.

The aim of this paper is to provide insight into spatial variations in family sizes by analyzing third births in a neighborhood context. Using unique geo-data drawn from Norwegian registers, I will test whether neighbors' family sizes relate to a couple's probability of having a larger family. Following the call to pay more attention to the dimensionality and complexity of neighborhood definitions (Sharkey & Faber, 2014), I will also analyze how the relation varies with the chosen neighborhood scale. In this paper, neighborhoods are defined as networks of neighbors using k-nearest neighbor measures and are couple-centered and scalable (Östh, Clark, & Malmberg, 2015).

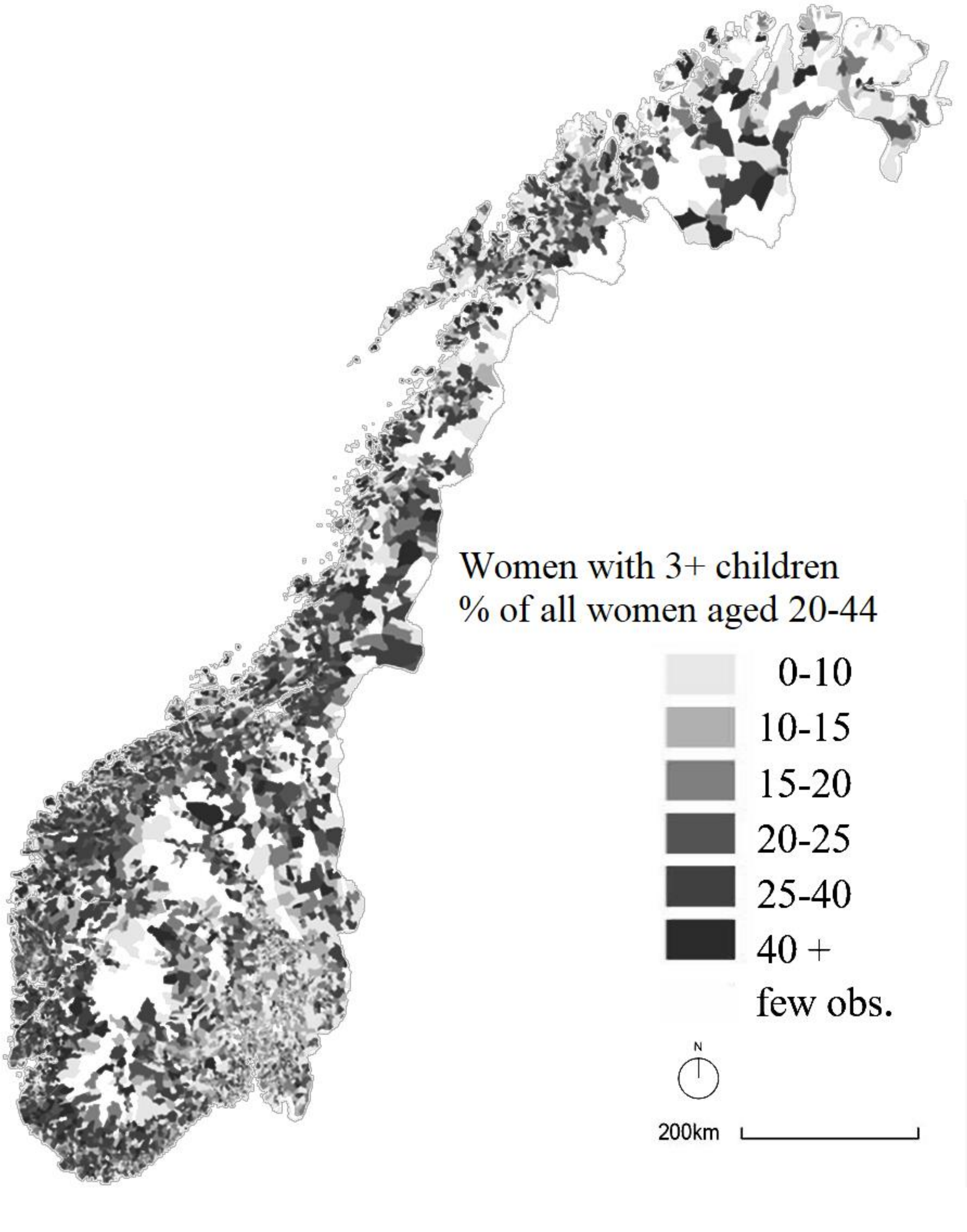
Social networks may influence fertility behavior in various ways (Bernardi & Klarner, 2014), and studies have shown that neighbors become more important for couples when entering parenthood (Kalmijn, 2012). At the same time, family transitions and residential relocations remain interrelated (Kulu & Steele, 2013; Wagner & Mulder, 2015). This means that geographical clustering of fertility, even net of many important confounders, may reflect both residential sorting and social interaction (Manski, 1993). The present analyses use detailed longitudinal data from Norway (2000-2014), covering inhabitants' residential address, their housing and family situation and fixed effects for statistical tracts, thus accounting for central sorting mechanisms related to housing and sorting into urban districts or villages. The questions posed are: (i) Are couples who live among many large families more likely to also have a third child? (ii) At what neighborhood scale do we observe the strongest association? (iii) To what degree is the association attenuated when controls for confounders are included?

2. Background

In the European low-fertility context Norway is part of the Nordic countries, which are known for relatively high birth-rates. In 2014, the last year of observation in the following study, the Norwegian total fertility rate (TFR) was 1.76, but it has since declined to 1.62. As in many European countries there seems to be a two-child family ideal (Frejka, 2008), and 40 percent of all Norwegian women above the age of 45 had given birth to two children (Dommermuth, Hart, Lappegård, Rønsen, & Wiik, 2015). Largely in contrast to other European countries, a deviation from the two-child norm results in more than two children rather than fewer. In 2014, 14 percent of all women aged 45 were childless, another 14 percent had one child and 32 percent had three or more children (Dommermuth et al., 2015). However, across Norway this pattern is not evenly distributed geographically.

Figure 1 illustrates the distribution of large families across Norway in 2014, by plotting the proportion of women aged 20-44 with three or more children. Primarily, an east-west divide regarding family sizes is visible. Women in the southwestern parts of Norway, also called the Norwegian bible-belt, are more often having at least three children compared to women in the more metropolitan southeast. This finding aligns with regional variations that have been documented for previous decades (Lappegård, 1999), and reveals persisting regional fertility cultures. Besides these regional patterns, fertility rates differ also between neighborhoods. For example, within the capital city of Oslo, the difference in total fertility rates between urban districts was at 0.8 children in 2015 (TFR of 2.08 in Bjerke versus 1.29 in St. Hanshaugen) (Syse, Hart, & Aase, 2016). In contrast, the difference between counties is at 0.3 children (Syse et al., 2016). While the association between sociodemographic characteristics and third births in Norway is relatively well studied (Hart, Rønsen, & Syse, 2015; Kravdal & Rindfuss, 2008), the origin of the uneven spatial distribution of large families is less explored.

Figure 1: Map of regional variations in third births in Norway. 2014. Basic statistical units (N=14,000).



Third births: why should the context matter?

As for all parity transitions, having a third child depends on having the resources, the partner and the ability to continue childbearing. Whereas the importance of a woman's education, her labor market attachment and couples' economic resources is ambiguous when it comes to *completed* fertility, becoming a mother at a later age is well known to lower a woman's probability of having many children (Breton & Prioux, 2005; Kravdal, 1990). Beyond such preconditions and sociodemographic correlates, evidence on why couples in post-transitional societies have more than two children is rare and not coherent either.[1] The experience of being a parent is gained with the first child and a sibling for the firstborn is provided at second birth (Sobotka & Beaujouan, 2014). Opting for a third child might therefore seem a matter of taste and lifestyle. In line with this, couples alter their family size intentions during the life course due to changing circumstances, new information, reference groups and perceived norms (Clay & Zuiches, 1980; Iacovou & Tavares, 2011; Liefbroer, 2009; Thomson, 2015).

To the extent that tastes and lifestyle preferences drive third birth probabilities, one may expect to see geographical clusters of large families. This could emerge because neighbors sort residentially by lifestyle and fertility preferences, and/or because neighbors influence each other's fertility preferences. Empirically, several studies corroborate such geographical clustering, e.g. Meggiolaro's (2011) study of Milanese neighborhoods. Further, fertility intentions have been shown to vary with regional fertility contexts in Europe (Testa & Grilli, 2006). However, planning or having many children is also often linked to intergenerational transmission and rather stable religious values (Adsera, 2006; Cools & Hart, 2017). These are factors known to be unevenly distributed across space (Mönkediek, Rotering, & Bras, 2017). At the same time, early internalized family values and religious orientations are less likely to change with contemporary living contexts, or if so, rather slowly.

So, why might we observe similar fertility behavior among neighbors? Correlated fertility behavior within neighborhoods and variations in the number of children between neighborhoods may emerge through similar channels as for other geographical aggregates. Theoretical divisions are often made between explanations focusing on (i) Population composition and residential sorting; (ii) Contextual effects; and (iii) Social diffusion or multiplication, although these often prove difficult to distinguish empirically.

(i) Population composition and residential sorting

National, regional and local fertility dynamics can, in part, be understood through changes in compositions of the inhabitants and the residential sorting of individuals into places (Dribe, Juárez, & Scalone, 2017; Hank, 2002). In line with this, one typical notion is that cities have a TFR below the national TFR because of the overrepresentation of highly educated women in urban areas, who are more likely to remain childless (Kulu & Washbrook, 2014). However, this relation could likewise emerge from a so-called contextual effect if the cities' universities and labor markets not only attract highly educated individuals but also foster a career-oriented culture – also resulting in lower fertility rates, not only for highly educated women. Consequently, in most cases, population composition alone is not a sufficient explanation for spatial patterns in fertility (Basten et al., 2011; De Beer & Deerenberg, 2007; Fiori et al., 2014; Gray & Evans, 2017; Kulu & Boyle, 2009; Kulu et al., 2007; Kulu & Washbrook, 2014).

(ii) Contextual factors

Different places provide unique economic and social conditions for families which may influence childbearing patterns and may be particularly salient and important to families with many children. In the Norwegian context the propensity of having a third child has previously been associated with contextual factors such as settlement size or opportunity structures for families in a municipality. For instance, living in a rural area or smaller town gives a higher probability for third births than living in larger cities (Kulu et al., 2007) whereas aggregate unemployment lowers the number of higher order births (Kravdal, 2002). Child-care availability has shown significant positive effects on all parities (Rindfuss, Guilkey, Morgan, & Kravdal, 2010), highlighting opportunities for having a large family as an important contextual factor. Within neighborhoods, proper and affordable housing is another crucial aspect (Clark, 2012). Usually, homeownership and/or living in a single-family house is seen as the best option for families, but what is perceived as proper housing varies within and between countries (Mulder, 2013). In addition to a family-friendly infrastructure and housing opportunities, broader cultural differences related to place-specific traditions or local social norms may play a role for the existence and persistence of local fertility patterns (De Beer & Deerenberg, 2007; Fulda, 2015). Several studies examine the relation between local social norms (or their absence) and fertility, including linkages between neighborhood disadvantage and early childbearing versus living in elite neighborhoods and late childbearing (Malmberg & Andersson, 2019).

Importantly, families do not move at random, and couples who intend to have many (more than two) children may tend to favor the same residential areas. Hence, residential sorting tends to be empirically difficult to disentangle from contextual effects.

(iii) Diffusion and social multiplication

The pace and spread of new fertility behaviors, as for instance nonmarital births, has led to the recognition of fertility diffusion as an important mechanism (Bongaarts & Watkins, 1996; Casterline, 2001). Such diffusion of fertility behavior between neighboring *regions* has been documented in several European contexts, for instance in France, Belgium and Switzerland (Lesthaeghe & Neels, 2002), Italy (Vitali & Billari, 2015), historical Prussia (Goldstein & Klüsener, 2014) and Norway (Vitali et al., 2015). As family dynamics are found to spread across regions, it can be expected that neighborhoods may have an even greater impact on family decisions. Neighborhoods can form arenas where neighbors interact and influence each other's childbearing behavior through mechanisms such as emotional contagion, social learning and social pressure (Bernardi & Klarner, 2014). This may be especially true for parents, as couples' networks have been shown to shift to more local ties after becoming parents (Kalmijn, 2012; Rözer, Poortman, & Mollenhorst, 2017). Parents have many opportunities to interact with neighbors in a similar family situation and such interaction might be particularly relevant. In line with this, results from a Swiss panel study show that after having a child, respondents feel closer to more neighbors and report more neighborly contact and support than before the childbirth (Kalmijn, 2012).

Neighboring families may influence each other's fertility through similar channels as other networks (Bernardi & Klarner, 2014). They may share knowledge, provide information and behavioral examples, and we may observe social multiplication. Social multiplication among neighbors has been documented among, for instance, welfare recipients (Markussen & Røed, 2015; Mood, 2010). Previous studies find fertility contagion among friends (Balbo & Barban, 2014), siblings (Lyngstad & Prskawetz, 2010) and colleagues (Pink, Leopold, & Engelhardt, 2014), though these tend to be potentially confounded by self-selection and contextual effects. Further, becoming a parent has been found more likely among individuals where many network members have young children (Lois & Becker, 2014). Drawing on similar mechanisms, neighbors' fertility (ideals) have been associated with family sizes and fertility limitation in several high-fertility contexts, for example in Nepal (Axinn & Yabiku, 2001; Jennings & Barber, 2013) and Kairo (Weeks, Getis, Hill, Gadalla, & Rashed, 2004). Still, in low-fertility countries the neighborhood dimension appears understudied when it comes to fertility behavior.

In summary, geographical variations in family size might be rooted in diverse opportunity structures of places, but they may also reflect local culture and/or norms. These contextual drivers may influence local fertility patterns through attracting certain couples or through influencing those already living there. Above that, social multiplication may reinforce existing patterns. Hence, the phenomenon that couples with many children tend to live in similar neighborhoods may emerge due to a combination of compositional effects, specific characteristics of the residential context, and possibly social multiplication.

3. Hypotheses and empirical strategy

Based on the theoretical background and previous research, I expect to find a strong association between the share of neighbors with more than two children and two-child couples' probability to have another child (Hypothesis 1). However, because of residential sorting I also expect that this relation is moderated and in part explained by individual characteristics of couples (Hypothesis 2a) and by enduring observed and unobserved characteristics of the residential context (Hypothesis 2b). More specifically, I consider the following individual characteristics: Age, global region of birth, union status, education, employment and income. Furthermore, housing, time since last move and neighborhood characteristics as the share of highly educated women, centrality and region are also considered. Lastly, unobserved characteristics of the residential context are captured using fixed effects for statistical tracts.

Next, I expect to find that the relation between neighbors' family sizes and a couple's probability to have another child depends on and varies with the chosen scale of the neighborhood fertility measure (Hypothesis 3). The question is not only *whether* neighbors' fertility behavior is related (Sharkey & Faber, 2014), but also *at what scale* neighborhoods are relevant. In previous studies, regions, municipalities and census tracts have most commonly been examined as fertility contexts beyond the nation state (Petrović, Manley, & Ham, 2018). Spatial analysis always suffers from the modifiable areal unit problem (MAUP) where decisions about unit scaling and zoning influence the results one obtains (Openshaw, 1984). Weeks (2004: 389) says: "The only real solution to both aspects of the MAUP is to begin with individual level data that are geocoded to specific locations, and thus, be able to aggregate the data to any scale that the researcher desires, and delimit any set of boundaries that the researcher believes is appropriate to the data."

The scales that this study considers range from the closest 12 to the closest 500 households and may represent families' local activity spaces. Andersson and Musterd (2010) argue that a grid of 100 x 100 meters, comprising on average 30-40 neighbors is most relevant if social interaction among neighbors is of interest. Further, it is common to attribute correlated behavior at small scales to social interaction among neighbors (e.g. Andersson & Musterd, 2010) while the influence of unmeasured confounding characteristics and self-selection grows with neighborhood scale. Hence, comparing the association at different scales might also indicate the relative importance of social interaction versus other contextual effects. In the models where statistical tract fixed effects are implemented, associations at lower scales will be better identified.[2]

4. Data and measures

This study uses high-quality data from several Norwegian administrative registers covering the whole population of Norway in the years 2000 to 2014. Using universal personal identification numbers and detailed address codes, time series on individual information from registers were linked and connected to individuals' residential information, the nationwide housing stock and other geocoded information. Geographical coordinates for each inhabitant's place of residence were used to find couples' (k-)nearest neighbors each year of observation.

The study sample consists of 295,846 married and unmarried co-residential couples. To identify them, I used information from Norwegian birth registers and selected women who gave birth to their second child in the study period, restricted to those who were aged 20 to 44 at second childbirth and lived in the same household as the child's father. I relied on the woman's parity since she is most involved with childbearing and -rearing. For almost 10 percent of couples her second childbirth was the couples' first joint child. Whether he or she had children from previous partners was included as a control variable.

Outcome: The event under study is a woman's third childbirth, backdated to the start of pregnancy.[3]

A range of *individual and couple characteristics* that are known to impact childbearing and that are unevenly distributed across neighborhoods were included as control variables in the models. They were measured yearly and for both partners, if relevant. All couples in the study sample were registered at the same address and hence co-residential. Whether they were married is included as a time-varying measure for their *union status*. *Stepchildren* were documented using the following categories: (i) No children from previous partners; (ii) Both partners had children from previous partners; (iii) Only the woman had children previously; (iv) Only the man had children with previous partners; and lastly (v) Couples had more complicated prehistories or missing information. *Global region of birth* was measured for both partners, distinguishing between those born in Asia, Africa, South and Central America, and those born in any other region, including Norway. Further, both partners' *age* when entering the risk set was included.

Next, a *woman's employment status* was defined as active if her annual income exceeds the social security base income. *Educational enrollment* was documented for both partners using a yearly updated dummy measure. Each partner's *highest educational level* was measured using the following categories: (i) Primary education (≤10 years); (ii) Secondary education (11-13 years); (iii) Short university education (14–17 years); and (iv) Long university education (≥18 years). Further, the annual *household income* from wages and salaries (inflation-adjusted to 2013-NOK) was included using five categories: (i) No income; (ii) < 600,000 NOK; (iii) 600,000-800,000 NOK; (iv) 800,000-1,000,000 NOK; and (v) > 1,000,000 NOK.

Housing: To indicate whether couples' current housing had room for another child, I used a variable combining number of rooms and dwelling type in six different categories. I distinguished between single-family houses, terraced/row houses and apartments, and contrast if each house type had up to 4 rooms versus 5 or more.

Residential relocations: Addresses and dates on residential relocations exist for the whole study period and couples were followed also after moving. When the couple moved to the current neighborhood was measured as a time-varying covariate with the following categories: (i) Moved to the neighborhood during the last year; (ii) Lived in the neighborhood up to 5 years; (iii) Up to 10 years; or (iv) More than 10 years.

Neighborhood definition: The geographical coordinates of a couple's residential address form the center of their individual neighborhood. Through calculating straight-line distances to surrounding residents the geographically nearest neighbors were picked up to the desired number (K= 12, 25, 50, 100, 250 and 500). Since population density varies across Norway and perceptions of personal neighborhoods are spatially limited, maximum distances between neighbors were defined (15, 20, 25, 50, 50 and 100 km, respectively, see Appendix A). Consequently, couples residing in remote places were given smaller numbers of potential neighboring peers. Neighborhoods were defined at 31st of December for each study year.

Neighborhood fertility context: I used the percentage of female neighbors with at least three children out of all female neighbors aged 20-44 as a measure of the neighborhood fertility context. The neighbor's number of children was obtained from individual-level birth registers and for each year aggregated at the defined scales. Clear over- or underrepresentation of large families in the neighborhood may have had greater impact on couples' further childbearing. To detect such non-linearity or thresholds, the measure was divided into five categories: (i) < 10%; (ii) 10 up to 15%; (iii) 15 up to 20%; (iv) 20 up to 25%; (v) ≥ 25%.

Neighboring women's educational level: Using the same strategy, the percentage of neighboring women with university education was calculated for each study year and included as a continuous control variable.

Municipal centrality: The centrality of a couple's residential municipality was included in the models without fixed effects since the rural, urban and suburban dimensions have been emphasized in previous studies. Centrality describes a municipality's geographical position in relation to urban settlements and these settlements' population size (see Statistics Norway Standard Classification of Centrality at http://stabas.ssb.no/, 2014 classifications). I used the following five categories: (i) Municipality with a regional center; (ii) Municipality within 35 minutes commuting time to a regional center; (iii) Municipality within 36 to 75 minutes commuting time to a regional center; (iv) Somewhat central municipalities; and (v) Less and least central municipalities.

Regions: To catch dynamics at higher spatial levels ('regional cultures'), I included dummies for the seven main regions in Norway. These are: Oslo and Akershus (Capital region), South Eastern Norway, Hedmark and Oppland, Agder and Rogaland, Western Norway, Trøndelag, and Northern Norway.

5. Statistical models

I implemented linear regression models with robust standard errors, adjusting for the correlation of observations over time within couples.[4,5] Quarters of years are the time units, and process time (time since second birth) was included in the models using linear and quadratic terms. Couples were censored when they moved abroad, one partner died, the woman turned 44 or observation time exceeded 10 years. As periods in which couples did not share an address were excluded, permanent separation also led to exit from the risk set. Thus, in the regression analysis 5,413,880 couple-quarter observations were included.

Shared unmeasured confounders among neighbors remained even when very small neighborhood scales were used, and a range of traits could be observed and included as covariates in the models. I therefore included additional models with fixed effects based on administrative neighborhood boundaries. Including such fixed effects further reduced the risk that the main estimates capture other unmeasured neighborhood characteristics which influence predominant family sizes. Importantly, only enduring characteristics at the level of the chosen administrative unit (or higher levels) were held constant. As we deal with data for the whole country – containing both densely populated cities and sparsely populated rural regions – the chosen administrative unit was statistical tracts, representing a level between the smallest statistical unit and municipalities. There are around 1,550 statistical tracts in Norway, and these were constructed to comprise naturally coherent units of communication and space. In urban areas these tracts ideally compriseabout 3,000-6,000 inhabitants, while tracts in rural areas have about 1,000-3,000 inhabitants.

Fixed effects take account of all time-constant features of these tracts, which may be the built environment, economic circumstances, childcare opportunities and other opportunity structures for families that were shared at this neighborhood level and that remained constant over the observation period, including relatively time-stable values or norms. To the extent that geographical patterns are found, these capture how individual neighborhoods deviate from the statistical tract wherein the couple lived.

6. Descriptive statistics

In total, 27.5 percent of the 295,846 couples in the study sample had a third child during the years 2000 to 2014. Table 1 shows characteristics of the study sample divided by outcome with couple-quarters as the unit. We notice that the average spacing between a second childbirth and a pregnancy resulting in the birth of a third child was 10.6 quarters of years, which corresponds to 2.7 years; other couples were on average observed for 3.3 years. Further, men and women in couples who conceived their third child were on average 1.6 years younger at second childbirth, more often foreign-born, more often married (78 versus 72 percent), and the women were less often in education (7 versus 8 percent) or employed (88 versus 91 percent) than those in other two-child couples or observed at other time points. For the level of education, results confirm that couples with university education who already have two children more often had a third child than parents with secondary education. Further, couples more often had another child, when the woman's first child was from a previous relationship.

Table 2 gives descriptive statistics about couples' residential contexts, again divided by outcome with couple-quarters as unit. We see that among two-child families in Norway, it was most common to live in relatively spacious single-family houses, regardless if awaiting another child or not. Forty percent of all observations were on couples who lived in a single-family house with 5 rooms or more. Further, during the observation period, most of the families (52 and 3 percent, respectively) had lived in their respective neighborhood for one to five years, with couples awaiting a third child having shorter residencies in their present neighborhood than other couples. As previously shown (Figure 1), descriptive statistics confirm that couples who had a third child more often lived in the least central municipalities and were overrepresented in certain regions of Norway. Also, the share of neighboring women with university education was somewhat lower among women expecting their third child.

Table 1: Descriptive statistics of individual control variables, couple-observations by outcome

Having a 3rd child	*Yes*	*No*
Process time: quarters of years (Ø)		
(max. 40)	10.6	13.1
Age at 2nd childbirth (Ø)		
woman (min. 20, max. 44)	29.4	31.0
man (min. 17, max. 77)	32.3	33.9
Country of birth: Asia, Africa, South or Central America (%)		
female partner	10.5	7.7
male partner	9.9	6.2
Marital status (% married)	78.3	72.2
Children from previous partners (%)		
none of the partners	80.1	82.3
both partners	2.4	2.4
only woman	10.5	5.6
only man	5.0	8.1
complex/ missing	2.0	1.6
Highest education, woman (%)		
Compulsory or unknown	16.8	14.5
High school	28.6	34.6
Short university	42.5	40.0
Long university	12.0	10.9
Highest education, man (%)		
Compulsory or unknown	16.1	15.5
High school	42.4	46.3
Short university	26.5	25.5
Long university	15.0	12.7
Women in education (%)	6.8	7.8
Man in education (%)	5.4	4.2
Woman in labor force† (%)	87.5	90.8
Annual household income‡ (%)		
None	0.8	0.5
up to 600,000 NOK	23.5	18.8
600,000 – 800,000 NOK	27.0	26.2
800,000 – 1,000,000 NOK	23.4	24.7
1,000,000 + NOK	25.4	29.8
Couple-quarter observations	75,846	5,338,037
Couples	75,846	295,846

Note: Data from Norwegian registers on a quarterly/yearly basis 2000-2014. Means (Ø) are given for continuous measures, percentages are given for categories.

†*Defined as active if annual income exceeds social security base income.*

‡*From wages and salaries, inflation adjusted to 2013-NOK, NOK 1000 ~ € 135 (in 2013).*

Table 2: Descriptive statistics of residential context variables, couple-observations by outcome.

Having a 3rd child	*Yes*	*No*
Dwelling type and number of rooms	%	%
single-family house, 5 rooms +	40.3	40.3
single-family house, 4 rooms or less	26.5	28.2
terraced/row house, 5 rooms +	3.9	4.5
terraced/row house, 4 rooms or less	7.0	7.7
apartment, 5 rooms or more	0.7	0.7
apartment, 4 rooms or less	8.7	7.9
missing housing information	12.9	10.8
Residential time in current neighborhood		
moved during the last year	22.0	16.4
last relocation up to 5 years ago	51.7	42.8
last relocation up to 10 years ago	23.1	30.1
last relocation more than 10 years ago	3.2	10.7
Neighbor women with university education		
% of 500 nearest neighbors	39.2	40.5
250 nearest neighbors	39.1	40.3
100 nearest neighbors	39.2	40.5
50 nearest neighbors	39.4	40.8
25 nearest neighbors	39.5	41.0
12 nearest neighbors	39.7	41.3
Centrality of residential municipality		
municipality with regional center	25.8	25.8
travel time to regional center < 36 min	25.1	27.0
travel time to regional center 36-75 min	15.8	17.6
somewhat central	16.3	16.5
less and least central	17.0	13.1
Region of Norway		
Oslo and Akershus (Capital region)	21.2	24.9
Hedmark and Oppland	5.9	7.2
South Eastern Norway	14.9	19.4
Agder and Rogaland	19.0	14.8
Western Norway	21.2	16.5
Trøndelag	8.8	8.8
Northern Norway	9.0	8.4
Couple-quarter observations	75,846	5,338,037

Note: Data from Norwegian registers on a quarterly/yearly basis 2000-2014.

Looking at neighbors' family sizes, we see from Table 3 that among couples awaiting a third child on average 18 to 19 percent of neighbors had 3 or more children. The average for all other observations was 16 to 17 percent. This is the case irrespective of whether the average of the 12 or 500 nearest neighbors is taken and aligns with the first hypothesis claiming that there is a positive relation between the percentage of neighbors with more than two children and two-child couples' probability to have another child.

Table 3: Descriptive statistics of the neighborhood fertility measure, couple-observations by outcome

Couples having a 3rd child	*Yes*		*No*		*Range*
Neighbors with at least 3 children	*Ø*	*SD*	*Ø*	*SD*	*%*
% of 500 nearest neighbors	17.8	6.6	16.3	5.9	0-43
250 nearest neighbors	18.1	7.0	16.6	6.3	0-48
100 nearest neighbors	18.3	7.9	16.8	7.3	0-56
50 nearest neighbors	18.5	9.0	16.9	8.4	0-67
25 nearest neighbors	18.8	10.8	17.0	10.2	0-80
12 nearest neighbors	19.0	13.9	17.2	13.1	0-100
Couple-quarter observations	75,846		5,338,037		

Note: Data from Norwegian registers on a quarterly basis from 2000-2014. Neighbors updated yearly. Table shows means (Ø) and standard deviations (SD).

7. Results from the regression models

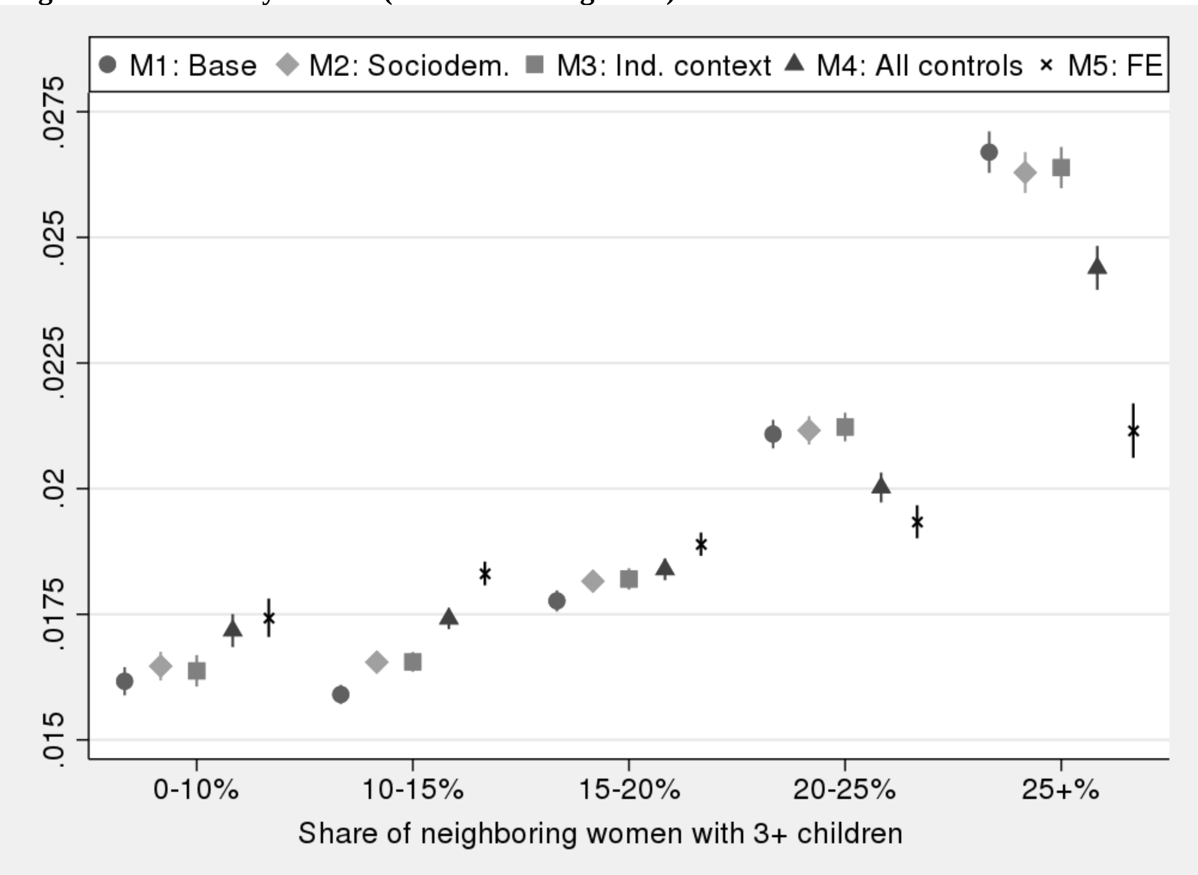
To address the first research question and to test the previously posed hypotheses, I estimated several regression models where the outcome is a third birth and the predictor of interest is the share of women with three or more children among each couple's 250 nearest neighbors. First, I will show a basic model including the neighborhood fertility measure and process time (model 1). Then, individual demographic and socioeconomic characteristics of couples are included (model 2). Next, a model with individual characteristics of couples' residential contexts, as for example housing (model 3) and a model including other observed context characteristics is shown (model 4), before unobserved neighborhood characteristics at the level of statistical tracts are held constant (model 5). Finally, to analyze the impact of neighborhood scaling (MAUP) and to test hypothesis 3, models 4 and 5 are compared using neighborhood measures comprising couples' 12, 25, 50, 100 and 500 nearest neighbors.

Stepwise models

Results from the first models with stepwise inclusion of individual, couple-context and other context variables, as well as fixed effects, are shown in Table 4 and illustrated in Figure 2. As seen in the first baseline model, including only the neighborhood fertility measure and process time, having a third child was most likely among couples who lived in neighborhoods with many other large families. Conversely, couples who lived in neighborhoods with less large families than the average 15-20 percent, were significantly less likely to have a third child. This is in accordance with hypothesis 1.

However, Hypothesis 2a states that this association partly or fully exists because couples with initially different probabilities of giving birth to a third child sort into different neighborhoods. Comparing couples living in different neighborhoods, while controlling for partners' age, global region of origin, union status, the presence of stepchildren, his and her level of education and educational enrolment, the woman's labor force participation and household income (model 2), the positive association between neighbors' family sizes and a couple's likelihood of having another child persisted. In fact, the main estimates (see Table 4) and predicted probabilities (see Figure 2) do not appear substantially different from the previous model.

Figure 2: Model comparison using predicted probabilities with 95% CIs for being in the 1st trimester of pregnancy with the later live born 3rd child at the time the 2nd child is 3 years old, by neighborhood fertility context (250 nearest neighbors)



Surprisingly, adding individual characteristics of the residential context, such as couples' dwelling type and size, residential time in the neighborhood and the share of neighboring women with university education (model 3), did not impact the main coefficients either. Usually housing as well as women's average education represent important sorting dimensions and are assumed to explain much spatial correlation of fertility behavior (e.g. (Kulu & Boyle, 2009). Indeed, families who lived in apartments or row houses or in houses with four rooms or less were less likely to increase their family size than couples who lived in spacious single-family houses. It is further evident, that couples who had remained in place for a while were less likely to have a third child than couples who had relocated during the last year. Hence, the data confirm that anticipatory moves and appropriate housing were important predictors for third births. However, including these variables did not alter the relationship between neighbors' family size and third births. Taken together, results from model 2 and 3 therefore consolidate Hypothesis 1 but provide only limited support forHypothesis 2a, claiming that parts of the association between neighbors' family sizes are moderated and explained by individual characteristics of couples that were included in these models.

The main estimates appeared noticeably different first when indicators for the centrality of couples' municipality and country region dummies were added (model 4). This can beread from column 4 in Table 4. When traits describing couples' broader residential context were accounted for, the probability of having a third birth varied less along the share of neighboring women with three or more children (see Figure 2). Consequently, results from the fourth model support hypothesis 2b, stating that parts of the association between neighbors' family sizes and a couple's probability to have another child were moderated and explained by other characteristics of the residential context. However, note that broader context variables had more impact on the relation of interest than individual measures as housing and couples nearest neighbors' education. Further, the characteristics that could be included in model 4 were limited to those available in the dataset. Introducing neighborhood fixed effects at the level of statistical tracts in the fifth model, I control for unobserved variation between these tracts. Results are provided in the last column of Table 4.

The model with fixed effects replaces the controls for municipal centrality and region with a fixed term that captures all time-constant features at the level of statistical tracts and higher levels. Consequently, residential sorting at larger scales, into regions and larger 'neighborhoods', is accounted for, and the main estimates capture remaining variation in third birth probabilities between the smaller individual neighborhoods. When applying these fixed effects, the probability of having a third child for couples living among many large families (25+ percent) was significantly reduced. Generally, the remaining variation between the different neighborhood categories was lower, especially compared to estimates from models that did not account for other contextual characteristics (see Table 4 and Figure 2). Hence, also the fifth model supports hypothesis 2b and shows that parts of the association between neighbors' family sizes and a couples' probability to have another child were explained by unobserved characteristics of the residential context.

Table 4: Stepwise OLS regression models for having a third child. 2000-2014

	M1: baseline	*M2: + ind. sociodem.*	*M3: +ind. context*	*M4: + other context*	*M5: + tract fixed effects*
Neighbors with at least 3 children					
0-10% of 250 nearest	-0.0016***	-0.0017***	-0.0018***	-0.0012***	-0.0015***
10-15% of 250 nearest	-0.0019***	-0.0016***	-0.0017***	-0.0010***	-0.0006***
15-20% of 250 nearest	ref.	ref.	ref.	ref.	ref.
20-25% of 250 nearest	0.0033***	0.0030***	0.0030***	0.0016***	0.0004*
25+% of 250 nearest	0.0089***	0.0081***	0.0082***	0.0060***	0.0023***
Process time (quarters of years)	0.0011***	0.0012***	0.0013***	0.0013***	0.0014***
Process time ^{2}	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
Dwelling type and number of rooms					
single-family house, 5 rooms +			ref.	ref.	ref.
single-family house, 4 rooms or less			-0.0012***	-0.0012***	-0.0011***
terraced/row house, 5 rooms +			-0.0018***	-0.0020***	-0.0017***
terraced/row house, 4 rooms or less			-0.0021***	-0.0024***	-0.0022***
apartment, 5 rooms or more			-0.0001	-0.0001	-0.0011
apartment, 4 rooms or less			-0.0007**	-0.0010***	-0.0019***
missing housing information			0.0006**	0.0004*	0.0001
Residential time in current neighborhood					
moved during the last year			ref.	ref.	ref.
last relocation up to 5 years ago			-0.0009***	-0.0009***	-0.0010***
last relocation up to 10 years ago			-0.0045***	-0.0045***	-0.0045***
last relocation > 10 years ago			-0.0041***	-0.0042***	-0.0043***
Neighboring women w/university education					
% of 250 nearest neighbors			0.0000***	0.0000	-0.0002***
Centrality of residential municipality					
municipality with regional center				-0.0024***	-
travel time to regional center < 36 min				-0.0030***	-
travel time to regional center 36-75 min				-0.0030***	-
somewhat central				-0.0028***	-
less and least central				ref.	-
Region of Norway					
Oslo and Akershus (Capital region)				ref.	-
Hedmark and Oppland				-0.0003	-
South Eastern Norway				-0.0014***	-
Agder and Rogaland				0.0021***	-
Western Norway				0.0024***	-
Trøndelag				-0.0006**	-
Northern Norway				-0.0001	-
Individual and couple covariates	No	Yes	Yes	Yes	Yes
Fixed effects for statistical tracts	No	No	No	No	Yes
Couple-quarter observations					5,413,880

*Note: Table shows B-coefficients and significance levels: * p<0.05; ** p<0.01; *** p<0.001. Covariates included in models 2 to 5 are: both partners' age at start, global region of birth, union status, stepchildren, both partners' educational attainment and enrolment, woman's employment status, and household income.*

Nonetheless, results from the regression models using neighborhoods consisting of couples' 250 nearest neighbors still support the first hypothesis claiming that the family size of neighbors was positively related to a couple's propensity of having a third child. Parts of this relation were (slightly) moderated by individual characteristics of couples and their housing situation, but even more by observed and unobserved characteristics of the broader residential context. These findings support especially hypothesis 2b and indicate that residential sorting at larger spatial scales is important for the spatial clustering of fertility. However, the relationship of interest remained significant also after controlling for these characteristics of couples and their larger neighborhoods and was hence relatively consistent. Next, I will test how sensitive the results are for the scaling of the individual neighborhoods.

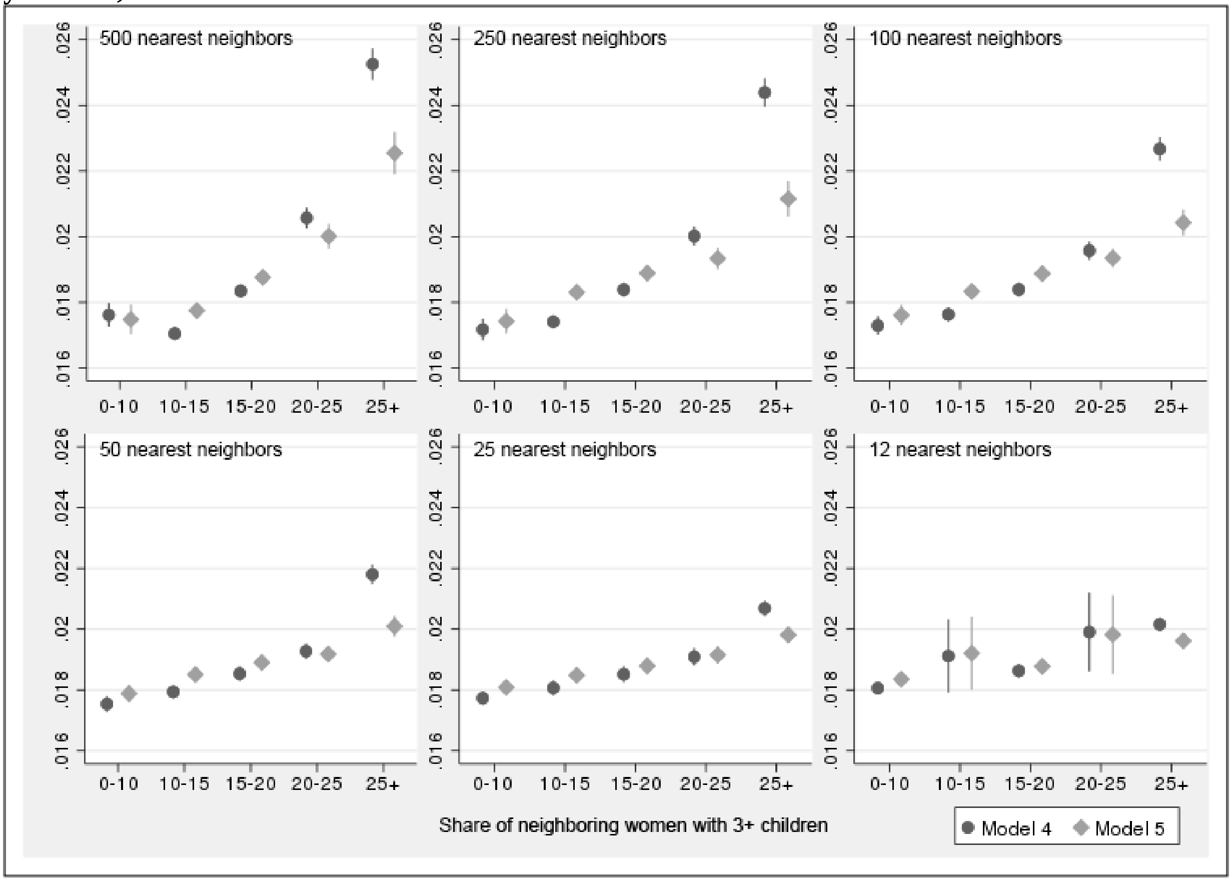
Scale comparison

In this part, I set out to investigate whether the association between the share of neighbors with more than two children and two-child couples' probability to have another child varied with and depended on the chosen scale of the neighborhood fertility measure (Hypothesis 3). Results for neighborhood measures consisting of a couple's nearest 12, 25, 50, 100, 250 and 500 neighbors are given in Figure 3 and Table 5. The main coefficients of models 4 and 5 are provided for all scales.[6]

Primarily, results seem to show that the less neighbors I included in the fertility context measure, the weaker the relation to couple's continued childbearing appeared. This was especially true for the probability of third births among couples who were surrounded by a high percentage of large families (25+ percent). On the other hand, for couples living in neighborhoods where large families were scarce (0-10 percent) the probabilities for third births were relatively similar regardless how many neighbors I included in the measure.

From Figure 3 we further notice that the estimates with increasing neighborhood scale also differ more between model 4, including all previously mentioned control variables, and model 5, using fixed effects for statistical tracts. This confirms that the influence of unmeasured confounding neighborhood characteristics grows with neighborhood scale. Meanwhile, when decreasing the included number of neighbors, the variation in third birth probabilities by neighborhood fertility context generally decreased. In model 5 for example, coefficients for the categories right below (10-15 percent) and right above (20-25 percent) the reference category (15-20 percent) are for the most part not significantly different from the reference when looking at 50 neighbors or less. However, having very few (0-10 percent) or really many (25+ percent) neighboring families with many (3+) children was still significantly correlated with a couple's transition to have a third child, even if only the twelve nearest neighbors were considered.

Figure 3: Neighborhood scale comparison using predicted probabilities with 95% CIs for being in the 1st trimester of pregnancy with the later live born 3rd child at the time the 2nd child is 3 years old, models 4 and 5



Given the observed variation, my results confirm the previously discussed MAUP and thus support the third hypothesis, stating that (the strength of) the relation between neighbors' family sizes and a couple's probability of having another child varies with the chosen scale of the neighborhood measure. That the strength of the relation between neighbors' fertility increased with neighborhood scale might emphasize the relative importance of other contextual effects over social interaction effects. But again, even though the dimensions varied through the scales, we nevertheless see quite consistent significant relationships between couple's continued childbearing and neighbors' family sizes at both the highest (25+ percent) and lowest ends (0-10 percent) of the neighborhood composition measure.

Table 5: Comparing different neighborhood scales. OLS regression models for having a third child. 2000-2014

Model 4 with covariates						
	k=12†	*k=25*	*k=50*	*k=100*	*k= 250*	*k=500*
Neighbors with 3+ children						
0-10 %	-0.0006***	-0.0008***	-0.0010***	-0.0011***	-0.0012***	-0.0007***
10-15 %	0.0005	-0.0004**	-0.0006***	-0.0008***	-0.0010***	-0.0013***
15-20 %	ref.	ref.	ref.	ref.	ref.	ref.
20-25 %	0.0013	0.0006**	0.0007***	0.0012***	0.0016***	0.0022***
25 + %	0.0015***	0.0022***	0.0033***	0.0043***	0.0060***	0.0069***
Model 5 with tract fixed effects						
	k=12†	*k=25*	*k=50*	*k=100*	*k= 250*	*k=500*
Neighbors with 3+ children						
0-10 %	-0.0004***	-0.0007***	-0.0010***	-0.0013***	-0.0015***	-0.0013***
10-15 %	0.0004	-0.0003	-0.0004**	-0.0005***	-0.0006***	-0.0010***
15-20 %	ref.	ref.	ref.	ref.	ref.	ref.
20-25 %	0.0010	0.0004*	0.0003	0.0005**	0.0004*	0.0012***
25 + %	0.0008***	0.0010***	0.0012***	0.0016***	0.0023***	0.0038***
Couple-quarter observations						5,413,880

*Note: Table shows B-coefficients and significance levels: * p<0.05; ** p<0.01; *** p<0.001. Covariates included but not shown are: process time, both partners' age at start, global region of birth, union status, stepchildren, both partners' educational attainment and enrolment, woman's employment status, household income, housing, residential time, neighbors' education, centrality and region (last two only in model 4).*
† *For k=12, few observations fell in the categories 10-15 and 20-25 percent. For details see Appendix A.*

8. Summary and discussion

The aim of this paper was to gain more insight into spatial variations in family sizes by teasing out the relative importance of the family behavior of couples' nearest neighbors to those of other neighborhood characteristics. By defining individual neighborhoods of different sizes, this study introduced a new dimension of spatial fertility variation and has thus contributed to spatially motivated research, especially to an emerging awareness of scale sensitivity. Previous research has found that couples' decisions about fertility behavior are influenced by their social context where also immediate neighborhoods and neighbors may play a significant role. Neighborhoods are important contexts of childrearing. Hence, families may sort geographically based on their fertility preferences, but they may also increasingly interact with neighboring families (Kalmijn, 2012). Still, with few exceptions (e.g. Malmberg & Andersson, 2019), neighborhoods and neighbor networks have to date been severely understudied in fertility research.

The focus of this study was third births, representing the transition to a typically larger family in Norway. While the link between the three-child-family and total fertility rates traditionally has been considered important in Norway (Kravdal, 1992), the origin of the uneven spatial distribution of large families has been less explored. In this paper, I analyzed three research questions: (i) Are couples who live among many large families more likely to also have a third child? (ii) At what neighborhood scale do we observe the strongest association? and (iii) To what degree is the association attenuated when controls for confounders are included?

The analyses showed that two-child couples who lived in neighborhoods with a higher share of families with more than two children were indeedmore likely to have a third child than other two-child couples. Conversely, two-child couples who lived in neighborhoods where families with at least three children were scarce were less likely to have a third child than two-child couples living in 'average' neighborhoods. Because of the selection of family-oriented couples into family-compatible neighborhoods, couple characteristics, housing and contextual factors as the neighborhoods' centrality, as well as fixed effects at the level of statistical tracts, were included in a stepwise manner into the models.

Results confirmed that observed and unobserved characteristics of the residential context, and to a lesser degree the included individual characteristics of couples, moderated and partly explained the relation between the neighborhood fertility context and a couple's probability of continued childbearing. Surprisingly, the comparison between the different models revealed that adding broader context variables had more impact on the relation of interest than including individual context measures such as housing and couples nearest neighbors' education. This indicates that residential sorting at *larger* spatial scales is important for the spatial clustering of fertility, aligns well with regional variations that have been documented for previous decades (Lappegård, 1999), and underlines the persistent regional fertility cultures. Moreover, the results also confirmed previous findings that the propensity to have many children is highest among couples living in spacious single-family houses in rural regions. But beyond these characteristics the local fertility context thus also seems to matter. This correlation has never been shown at such a small scale.

With an open approach towards measuring 'neighborhoods', I also asked at which local scale the strongest association emerged. The scales that were considered here range from the nearest 12 to the 500 nearest neighbors andmay all reasonably represent families' everyday activity spaces. Still,the more neighbors I included in the neighborhood measure, the stronger the correlation between neighbors' family size and couples continued childbearing became. This was especially true for couples living in neighborhoods where large families were overrepresented. The scale comparison also revealed that the influence of unmeasured confounding neighborhood characteristics grows with neighborhood scale. In sum, these results might emphasize the relative importance of other contextual effects and selection over social interaction effects.

Family events and residential relocations are in addition highly intertwined processes. The positive association that was found between third births and recent residential relocations may point towards selective or anticipatory relocations, perhaps towards new neighborhoods and neighbors stimulating couples' child desires. While the latter is not completely unlikely if one assumes that desired family size is subject to change (Thomson, 2015), the mechanisms cannot be distinguished empirically.

Limitations and strenghts

It is notoriously difficult to distinguish between self-selection into neighborhoods and causal effects of neighborhood contexts, and studies rarely manage to do so. Importantly, families do not move at random, and couples who intend to have many (3+) children may tend to favor the same residential areas. Even if very small neighborhood scales were used and a range of traits and fixed effects could be included in the models, shared unmeasured confounders among neighbors are likely to remain.

In future studies it could be interesting to elaborate further on the impact of residential segregation by other dimension, as country of origin and socioeconomic status. Such segregation is especially prevalent in larger cities and is most likely important because contact with neighbors might depend on further commonalities than only sharing the kids' playground.

The study was also limited to current neighborhoods and did thereby not fully address couples' neighborhood histories. There could for example be cumulative (or contradictory) effects over the life course, which call for an inclusion of time lags, the upbringing context and the family of origin in future studies (Miltenburg & van der Meer, 2016). To test whether there are any discrepancies or changes over the life course, it would also be interesting to analyze how fertility ideals, and not only actual fertility behavior, are interrelated among neighbors and within neighborhoods. Unfortunately, such data are not available for Norway.

Still, this study brought together both the spatial and social context by introducing small-scale neighborhoods using k-nearest neighbor measures. The correlation between neighbors' fertility behavior could be shown even at the very small scale of the 12 closest neighbors. As such, this paper contributes to widen spatial and network thinking in fertility research to neighborhoods and neighbors.

Above all, I have shown that neighborhoods and neighbors matter – either by attracting couples and inducing selective moves, or because neighbors influence each other's behavior.

Conclusion

To conclude, while the evidence on why couples in post-transitional societies want more than two children is rare, this study indicates that transitions to third birth are strongly sociogeographically situated through mechanisms of residential segregation or social interaction effects among neighbors.

Notes

1. In the contemporary Norwegian context, there is broad access to contraception and early medical abortion. Unintended pregnancies are therefore assumed to be a minor issue and are not discussed further in this paper. Also, I make no strict distinction between the desired or intended versus actual number of children, because desires and intentions are interrelated and subsequently revised to match possibilities and constraints (e.g. Iacovou & Tavares, 2011).

2. In some cases, especially rural regions, statistical tracts may overlap with a neighborhood size of 500 neighbors, leaving us with more estimable variation from metropolitan regions (see chapter 5 for more details about statistical tracts).

3. Originally, the event of interest is a couple's decision to have a third child. Because I do not know when that decision was taken, I use the first trimester of the pregnancy leading to the live birth of the female partner's third child. It is operationalized this way because the decision to have another child is taken at the latest when a pregnancy is accepted. In the analyses I thus capture individual and neighborhood circumstances at the time the female partner gets pregnant with her third child. Note that abortions and miscarriages are not captured by these data.

4. Results from discrete-time hazard regression models give similar conclusions and are reported in Appendix B. Because coefficients from such models cannot be readily compared across models they are not presented in the main text.

5. As couples in addition are nested in neighborhoods, one could consider additional clustering at a higher level. With the (k-)nearest neighbor approach it is however not obvious what the unit of clustering should be. The neighborhoods are ego-centered and thus, in essence, a characteristic of the couple.

6. Because the fixed effects are at the level of statistical tracts regardless of the scale for the individual neighborhood, they might overlap and impact individual neighborhoods differently, as discussed earlier (e.g. note 1). Hence, it may not be the optimal model for a scale comparison. However, because the fixed effect model still is a stronger model than model 4, both are presented.

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Appendix A

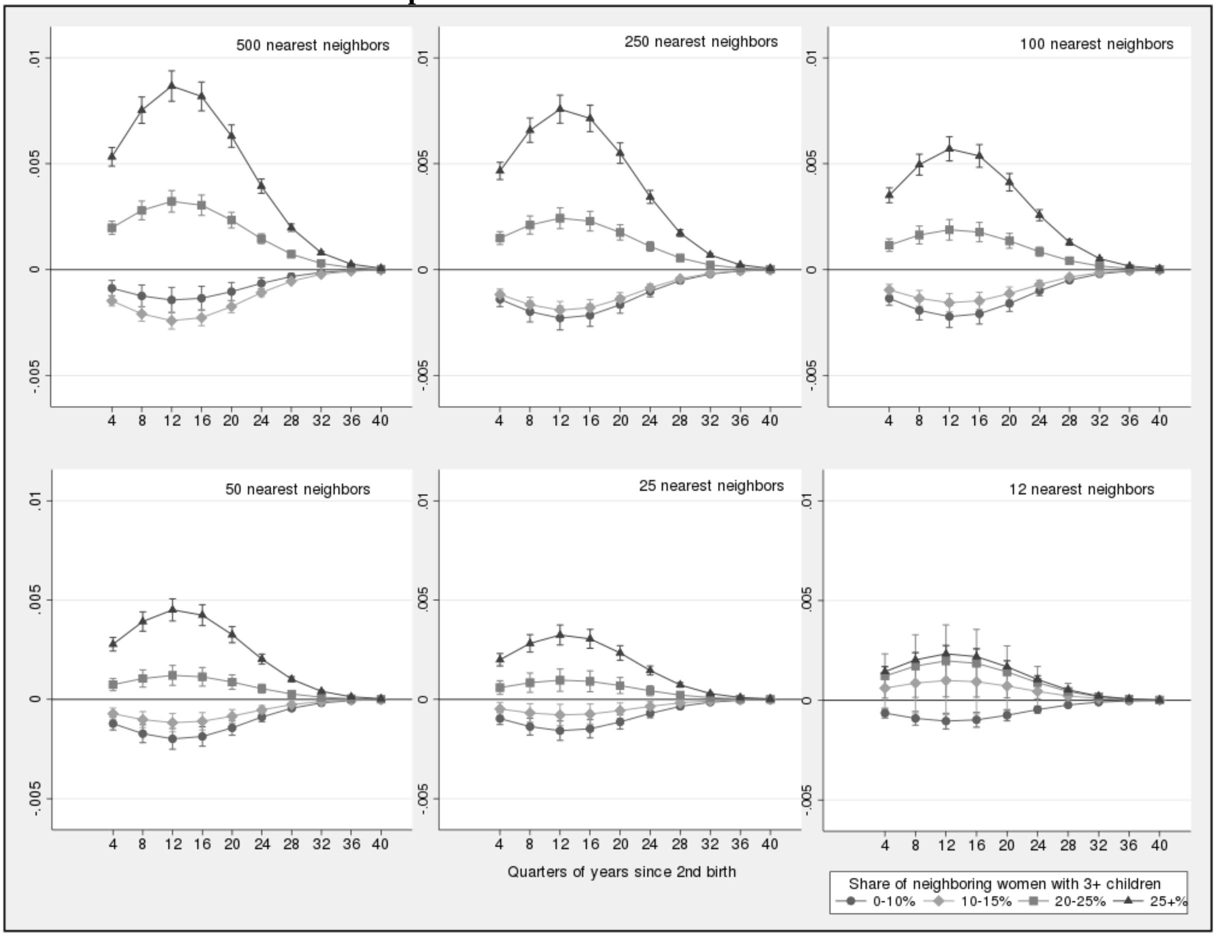
Distances and number of neighbors included after different choices of neighborhood size

		Defined neighborhood size *(k-nearest neighbors)***:**					
	k=	*500*	*250*	*100*	*50*	*25*	*12*
Number of neighbors actually included †							
	Minimum	499	66	66	1	1	1
	Maximum	890	645	500	416	416	416
	Mean	500	250	100	50	25	12
	SD	3	3	3	3	3	3
Max.-distance to a neighbor (meter)							
	Defined max.	100000	50000	50000	25000	20000	15000
	Final max.	98830	50000	49978	25000	19999	14980
	Mean	3497	2154	1149	710	444	265
	SD	6237	3888	2266	1474	988	614
Median distance to neighbors (meter)							
	Mean	2077	1349	721	457	290	177
	SD	3840	2579	1513	1008	670	426

† *Values exceeding the defined 'k' are due to housing block coordinates making it impossible to identify exactly the desired number of nearest neighbors. Values below the defined 'k' stem from the distance cut-off.*

Appendix B

Results from discrete-time hazard regression models for being in the 1st trimester of pregnancy with the later live born 3rd child. Neighborhood scale comparison using average marginal effects with 95% CIs at all observation points. 2000-2014



Note: Neighborhoods with 15-20% neighboring women with 3+ children serve as reference. Covariates included are: Both partners' age at start, global region of birth, union status, stepchildren, both partners' educational attainment and enrolment, woman's employment status, household income, housing, residential time, neighbors' education, centrality and region. Comparable to OLS regression model 4.