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ABSTRACT

Sorting out Neighbourhood Effects Using Sibling Data

Previous research has reported evidence of intergenerational transmission of both neighbourhood status and social and economic outcomes later in life; parents influence where their children live as adults and how well they do later in life in terms of their income. However, interactions between the individual, the childhood family and neighbourhood context and the neighbourhood experiences after leaving the parental home are often overlooked which might bias estimates of neighbourhood effects. It is likely that part of the effects attributed to neighbourhoods, are actually effects of the family in which someone was brought up. This study uses a sibling design to disentangle family and neighbourhood effects on income, and synthetic sibling pairs are used as a control group. The sibling design allows us to separate the effects of childhood family and neighbourhood contexts, but also between childhood neighbourhood effects and effects of the adult neighbourhood experiences. Using data from Swedish registers we show that the neighbourhood effect from both childhood and adult neighbourhood exposure is biased upwards by the influence of the family context. This leads to the conclusion that part of what appeared to be a neighbourhood effect was in fact a lasting family effect. Interestingly, we find that there is a long lasting effect of the family context on income later in life, and that this effect is strong regardless the individual neighbourhood pathway later in life.

JEL Classification: I30, J60, R23

Keywords: neighbourhood effects, non-random sorting, siblings, family, income, longitudinal data

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Introduction

There is an emerging body of literature that highlights the importance of taking into account the neighbourhood in which an individual grew up as a means to understanding their later life trajectories. Empirical evidence suggests that neighbourhood disadvantage is partly inherited across generations and that individuals who spend their childhood in poor areas are more likely to live in such areas also as adults (de Vuijst et al 2015; Gustafson et al 2017; Sharkey 2008; 2013; van Ham et al 2014; Vartanian et al 2007). Childhood neighbourhood disadvantage not only restricts socio-spatial mobility later in life, but it also affects the socio-economic status of adults. Hedman and colleagues (2015) found that living in a deprived neighbourhood as a child has a negative effect in income as an adult later in life, and that this effect persisted over a very long period of time. So the "the long arm of childhood" (see Tambupolon 2015) stretches well into adulthood, having deleterious effects on individuals growing up in poorer areas.

The need to better understand the influence of childhood neighbourhood exposure and how it affects later-in-life outcomes is one of the most important challenges facing research on neighbourhood effects (van Ham and Manley 2012). Better understanding childhood neighbourhood effects could be the missing link in neighbourhood effects research, where outcomes for adults are often sketchy. Also, if the childhood is such a determining factor for people, than more policy efforts should be directed towards children living in deprived neighbourhoods, helping them to get a better start in life. However, off course neighbourhoods are not the sole influence on children as they grow up. The household environment is crucial for the daily experiences of a child. In a speech in 2014 the then British Prime Minister David Cameron stated "[i]t's family that brings up children, teaches values, passes on knowledge, instils in us all the responsibility to be good citizens and to live in harmony with others" (Cameron 2014). This was not an isolated speech and the importance of the family unit has been repeatedly identified as being central in ensuring that children enjoy the best start. The family in which an individual grows up will affect, among other things, his/her genetic composition, abilities, attitudes and norms and values, and may also function as a source of potential assistance (or lack thereof). This assistance may consist of homework supervision at a young age or labour market networks or financing an apartment or higher education at older ages. A vast literature has repeatedly found strong correlations between, for instance, educational achievement, labour market outcomes, and earnings of parents and children (see d'Addio 2007; Solon 1999 for overviews).

There is thus evidence of intergenerational transmission of both neighbourhood status and social and economic outcomes later in life. In other words, parents may (directly or indirectly) exercise influence on both where their children live as adults and how well they do later in life. With some exceptions, most studies modelling intergenerational neighbourhood effects fail to recognize the interactions that may occur between the individual, the childhood family context and the residential neighbourhood context (see van Ham et al 2014). As a result, conclusions based on the importance of the residential environment (or the household) may be biased. The aim of this paper is, therefore, to measure neighbourhood effects on income for adults, while controlling for the childhood family influence.

We are specifically interested in the effects of adulthood neighbourhood context on individual income, and we argue that childhood "family effects" and the effects of childhood neighbourhood context may linger on well into adulthood, hence biasing estimates of the impact of the adult residential environment. In addition, and in line with Hedman and colleagues (2015) and others, we argue that effects of the childhood neighbourhood environment may still have an independent effect on adult outcomes later in life. The way this study tries to disentangle the effects of childhood family, childhood neighbourhood and adult neighbourhood contexts on adult income, is by using data on siblings and by comparing their outcomes. Full siblings share a substantial part of their gene pool, and are assumingly, if born relatively close in time, raised under similar circumstances and crucially, by the same parents. By coming from the same family, they share childhood residential histories and parental motivations for moving to certain neighbourhoods, meaning that any potential selection

effects related to the family's entry into the childhood neighbourhood are effectively removed by comparing siblings. The data used for this study are derived from GeoSweden, a Swedish longitudinal micro-database from register data, which contains the entire Swedish population from 1990.

Contexts of Influence: neighbourhood and family

As children grow up they experience many sites of influence, such as sports clubs, cultural associations and religious institutions as well as the more obvious nursery and schooling environments. The two most encompassing sites of influence, which hold a critical position as they provide the access to all of the other sites, are the neighbourhood and the household.

The neighbourhood context represents a space in which a set of critical exposures may take place, including exposure to people and institutions. For example, young children often make friends among neighbours, go to local schools and many spare-time activities are organized at the local level. Although the neighbourhood does not represent the full range of exposures that an individual will experience across their life course (see Kwan 2008) it acts very much like an access point through which other contextual spaces is accessed. Hence, geographic variation in the local spatial opportunity structure (Galster and Sharkey 2017) does not only concern the neighbourhood itself but also the higher geographic levels the neighbourhood is situated in (school attachment area, city district, municipality etc.). The key hypothesis in the neighbourhood effect literature is that the spatial opportunity structure has a causal effect on individual life opportunities. Galster (2012) provides a list of 17 potential mechanisms, categorized into four groups. The first group contains social-interactive mechanisms, which include, among other, socialization, peer pressure, role models, and parental mediation. The latter describes how the neighbourhood may affect parents' physical and mental health and resources, hence having an indirect impact on child development. The second group is environmental mechanisms and contains factors related to the physical and social environment, including pollution and noise, physical conditions of the built environment and exposure to violence. Geographic mechanisms refer to the relative location of the neighbourhood and important institutions, public services and labour markets, as well as the opportunities to access those. Finally, institutional mechanisms include the quality of local institutions, such as school and health care facilities.

The (quantitative) literature can often not distinguish among these potential mechanisms and evidence on the strength and nature of neighbourhood effects is far from conclusive. But there is evidence that people who have spent longer periods of time in poorer areas are more negatively affected by their neighbourhood contexts than those with a shorter exposure time (Musterd et al 2012) and there is evidence that effects from the childhood neighbourhood linger on after an individual has left the neighbourhood (Sampson et al 2008; Wheaton and Clarke 2003). There is even evidence from the U.S. and Swedish contexts of neighbourhood effects being transmitted over generations, in the sense that children experience negative consequences from their parents' exposure to poverty (Hedman et al 2015; Sharkey and Elwert 2011). These findings have fueled the call for more neighbourhood effect research taking childhood exposure into account when analyzing adult outcomes and neighbourhood exposures (see e.g. van Ham and Manley 2012). In addition to affecting adult outcomes, childhood neighbourhood context may also influence the residential choices children make when they embark on their own residential careers as adults. The literature on intergenerational transmission has shown clear correlations between childhood and adult neighbourhood contexts (e.g. de Vuijst et al 2015; Gustafson et al 2017; Sharkey 2008; van Ham et al 2014) and has even found evidence of intergenerational transmission of neighbourhood over multiple generations (Sharkey 2013, Hedman et al, 2017).

The literature on intergenerational transmission of neighbourhood context clearly shows that individuals who grow up in disadvantaged areas face a higher risk of living in such area types over long periods of time. However, most studies do not address to what extent these outcomes are due to

neighbourhood or family factors. Manley and colleagues (2017) use data from Sweden and find that the residential careers of siblings show a stronger degree of similarity than the careers of unrelated individuals originating from the same neighbourhood background. Hence they conclude that family has an independent effect on residential outcomes long after leaving the parental home. Whereas relatively few studies have investigated intergenerational transmission of neighbourhood status, there is an extensive literature on intergenerational socio-economic mobility. This literature generally finds clear correlations between the family you grow up in and outcomes later in life, especially regarding income and level of education (see Black and Deveraux 2011; d'Addio 2007; Solon 1999 for overviews). Parental level of education and income affect the resources of a household, and therefore their freedom to choose a residential neighbourhood and school for their children, but also parental attitudes towards education and health. Other factors affecting child (socio-economic) development and future opportunities are, according to d'Addio (2007), cognitive abilities and personality traits, which are at least partially associated with genes and therefore partially inherited from parents (Anger and Heineck 2010, Grönqvist et al 2016).

Also the household and social environment a child grows up in – including family structure, parental style and norms and values – affects outcomes later in life. A large literature has reported correlations between family size and composition and socio-economic outcomes. For example, living in a single-parent household or in a large family is associated with school drop-out and future unemployment (e.g. Björklund et al 2004; Black et al 2005; McLanahan and Sandefur 1994). There is also empirical evidence of norm diffusion within families. For example, Cunningham (2001) has compared attitudes towards gender roles among mothers, at age 15, and their children, at age 18, and found substantial correlations. However, none of these processes occur in isolation. The social context in which the household is embedded may affect children's outcome both directly and indirectly, through effects on household economic circumstances, parenting style or family norms. Hence, disentangling the respective role of the family and the neighbourhood (representing one of many social contexts) is a difficult task both in theory and practice. The childhood family context may affect adult outcomes both directly (socio-economic transmission) and indirectly via the childhood neighbourhood and by transmission of neighbourhood status into adulthood.

The usage of siblings to separate family and neighbourhood effects

A quasi-experimental family design could be used to identify unbiased causal influence of the adult neighbourhood context on individual outcomes while controlling for childhood family context. Within pairs of genetically related individuals (twins, full siblings) who also share a similar family background, many of the unmeasured influences on individual outcomes can be controlled. For instance, full biological siblings have a very similar genetic inheritance compared to two non-related individuals. If the siblings are sufficiently close in age, their childhood household and neighbourhood contexts will also be similar and it can be assumed that they have been exposed to the same family norms, values and attitudes. They will also have similar childhood neighbourhood experiences, at least in terms of residential location. The high intra-familial correlation of full siblings provides an opportunity to distinguish adult neighbourhood exposure, where the siblings follow separate tracks, from measured and unmeasured family and childhood related exposures. By using a sibling design, we are able to identify what can be thought of as a "family effect", and separate it from effects related to childhood neighbourhood context.

The potential of sibling studies has not been fully explored by studies investigating neighbourhood effects. Most of the earlier neighbourhood effect studies using siblings have mainly been concerned with removing bias due to non-random neighbourhood selection, generally by using a family fixed-effects model. By looking at variation within rather than between families, the model keeps all family-related unobservable characteristics "fixed", theoretically removing all bias that is due to correlations between family and neighbourhood sorting processes and the outcome of choice. Examples of (U.S.

based) studies using this approach, often in comparison to a standard OLS model, are Aaronson (1998), Levy and Duncan (2000), Plotnick and Hoffman (1995; 1999) and Vartanian and Walker Buck (2005). A problem related to this design, which is acknowledged by all authors, is that it requires a certain amount of difference in neighbourhood exposure between siblings, which is why they must be sufficiently separated by age. This requirement jeopardizes the notion of siblings' similar family experiences.

Another problem with the fixed-effects approach is that it does not report what amount of variation is due to the neighbourhood compared to the family level. The issue of context versus family has been central in more recent research on intergenerational mobility where the question of causality has become increasingly central (Black and Deveraux, 2011). Siblings are often used as controls for the family aspect since they are assumed to share substantial genetic material and family background and could hence be compared with two random individuals originating in the same neighbourhood. Using a sample of 687 individuals from 379 families from the PSID (US data) Solon and colleagues (2000) find sibling correlations in years of education to be larger than correlations among children living in the same neighbourhood, controlling for family characteristics. Hence, they conclude that family differences are more important to explain variations in children's education attainment than differences among neighbourhoods where the children grow up. Also working with U.S. data, Duncan and colleagues (2001) and Page and Solon (2003) confirm a greater degree of similarity in vocabulary test scores and delinquency, and income, respectively, among siblings/brothers than among neighbours or peers. In the U.K., Nicoletti and Rabe (2013) adopt a multilevel model approach and find sibling and neighbourhood correlations on pupils' test scores of 0.61 and 0.14, respectively. It is clear from these correlations that the family context (as represented by the sibling correlation) is more important that the neighborhood context. A similar model was applied by Lindahl (2011) who used Swedish data encompassing 13,000 individuals born in 1953 to estimate the relative importance of family and childhood neighbourhood for school performance, educational attainment and income. Like the previous studies, she finds sibling correlations to be substantially larger than neighbourhood correlations. Whereas sibling correlations take on values on between 0.17 (income, females) and 0.43 (education, females), the highest neighbourhood correlation, unadjusted for parental background characteristics, were below 0.08 (education, males). Adjusted for parental background characteristics, numbers dropped to below 0.03. This is well below the results reported in the U.S. and U.K. Equally weak neighbourhood correlations have also been reported for Norway (Raaum et al 2006), and for Toronto, Canada (Oreopoulos 2003). Hence, the conclusion from these studies is that family indeed matters more than neighbourhood for individual performances, and that although the impact of the neighbourhood naturally varies among different contexts, it is very small in the Scandinavian countries.

The conclusion of weak (sometimes very weak) neighbourhood correlations once family background characteristics are controlled for is important for the field of neighbourhood effect studies. We argue that one of the most important challenges for this field is to better understand the relative importance of family and neighbourhood and sort out potential family bias. In this paper we take up that challenge by analyzing the impact of adult neighbourhood experiences and childhood neighbourhood and family context on adult income 14 years after having left the parental home. We adopt an analytical strategy similar to Merlo and colleagues (2013) who follow a sample of about 416,000 Swedish-born full brothers in 184,000 families and analyze the relationship between their (adult) neighbourhood exposure during 13 years and the risk of ischemic heart disease. They calculate the brothers' average exposure to low-income neighbourhoods, as well as how each of them departs from this overall family mean. These two variables capture a joint family effect (the average exposure) and the individual trajectory (the individual departure from that joint exposure). Both these variables are then used to estimate the relative impact of family and adult neighbourhood trajectory using a multilevel modelling strategy. The authors conclude that the intra-family correlation is much higher than the intra-neighbourhood correlation. In fact, they find that the latter is very small, in the order of 1.5%. They also show that the neighbourhood effect is much smaller taking the experiences of the full brother into

account. In the present study, we use a similar strategy but unlike Merlo and colleagues, we use both male and female siblings as well as a younger sample, and start our follow-up once the siblings leave their parental home. In this way, we get estimates of the effects of both adult neighbourhood experiences and a proxy for the childhood environment, and are thus able to distinguish not only between the effects of family and neighbourhood context, but also between childhood neighbourhood effects and effects of the adult neighbourhood career. The above literature review leads to three hypotheses:

Hypothesis 1: *Adult income is not only affected by adult neighbourhood experiences, but also by childhood neighbourhood and family context.*

Hypothesis 2: *The family environment during childhood has a stronger effect than childhood and present neighbourhood context on adult income.*

Hypothesis 3: *Estimates of causal effects of the adulthood neighbourhood will be biased upwards if the family environment during childhood is not taken into account.*

Data and methods

The data used for this study are derived from GeoSweden, a longitudinal micro-database owned by the Institute for Housing and Urban Research, Uppsala University, which contains the entire Swedish population tracked from 1990 to 2010. The database is constructed from a number of different annual administrative registers including, among other, demographic, geographic, socio-economic and real estate data for each individual living in Sweden each particular year. For each person in the dataset it is possible to identify their parents and siblings, who are defined as two individuals who have the same mother *and* father. Since we want to obtain information about the childhood neighbourhood environment, at least one of the siblings must live with their parents in 1990 (the first year for which we have data).

It is crucial for this study that the siblings have as similar family experiences as possible. To ensure this, we select sibling pairs that are close in age and leave the parental home not too long apart. For simplicity, we have restricted the analysis to two siblings per family. Our criteria for selection are: i) both siblings are aged 15-21 in 1990; ii) siblings are born no more than three years apart; iii) at least one of the siblings lives in the parental home in 1990; vi) at least one of the sibling pair leaves the parental home between 1991 and 1993; v) the other sibling leaves the parental home within four years after the first sibling. The parental home could be either the mother's or the father's home, as long as both siblings live in the same home. In case of multiple sibling pairs within the same family that fulfil the above criteria, we have selected the sibling pair closest in age to maximise similarity of exposure. If there are several potential sibling pairs of the same age range, we have selected pairs according to: 1) data availability, 2) same gender; 3) age, where we have kept the oldest pair. These restrictions have left us with 98,326 individuals, or 49,163 sibling pairs.

The dependent variable in this study is (logged) pre-tax income from work, including work-related transferences[1]. We estimate individual income 14 years after leaving the parental home. Since the calendar year of this event varies among individuals, we have adjusted income for inflation with 1990 as a base year. Income from work is also the variable upon which our definition of poverty neighbourhoods is based. Neighbourhoods are defined according to the SAMS (Small Area Market Statistics) classification scheme, made by Statistics Sweden in collaboration with each respective municipality. SAMS are constructed so that they are relatively homogenous areas in terms of housing type, tenure and construction period. Although the usage of administrative areas in neighbourhood

[1]Income from work represents the sum of cash salary payments, income from active businesses, and tax-based benefits that employees accrue as terms of their employment (sick or parental leave, work-related injury or illness compensation, daily payments for temporary military service, or giving assistance to a handicapped relative).

effect studies has received criticism, we argue that SAMS areas capture the *physical structure* of the surrounding environment quite well. More importantly we needed fixed neighbourhood boundaries to create a control group, our synthetic sibling pairs that are described later in this section. Our main neighbourhood variable is the share of low income individuals in the neighbourhood. We define low income as belonging to the three lowest income deciles on the basis of the national income distribution. For each year in the data, we categorise all neighbourhoods with at least 30 inhabitants in working ages (20-64) into deciles on the basis on their share of low income inhabitants. Decile 1 represents the neighbourhoods with the lowest share of low incomes and decile 10 those with the highest.

Neighbourhood exposure is measured in two different variables, each reflecting different time periods in the sibling pairs' lives. The first neighbourhood exposure variable represents the childhood environment and is hence the same for both siblings. It is measured the year before the first sibling leaves the parental home. For modelling reasons, we have categorised the variable into four categories; decile 1-4, decile 5-7, decile 8-9 and decile 10. The categorisation is partly derived from the data (we have experimented with different categorisations), and partly from a wish to get isolated measures of the poorest neighbourhood category. The second neighbourhood variable represents the cumulative exposure to neighbourhood types for the 13 years after leaving the parental home and is therefore mostly different within sibling pairs. The variable is the sum of all neighbourhood income deciles an individual has experienced and takes values ranging from 13 (only ever lived in the least deprived decile) to 130 (only ever lived in decile 10). We estimate the effect of long-term exposure to poverty neighbourhoods on income later in life because income from work tends to fluctuate heavily during the early adult years when unemployment spells, short-term contracts and periods of study are common. By estimating income later in life, 14 years after having left the parental home (one year later than all independent variables to avoid problems of reverse causality), we are more likely to capture a reflection of an individual's more permanent income status.

Our data contains three different levels: individual, family and neighbourhood. To account for the relative influence of each level, and to obtain measures of the variation of each of these levels, we estimate a multilevel model. The data contains two measures of neighbourhood: childhood neighbourhood and adult neighbourhood exposure. For all the models we chose to cluster individuals according to parental neighbourhood occupied immediately prior to leaving the parental home. This acknowledges that the hierarchy of location is based on the initial experiences gathered during childhood rather than later exposures gained during their independent housing career. We adopted this approach given the stickiness of neighbourhoods (see Glass and Bilal 2016) to recognise the clustering of the starting neighbourhood within a family. This gives us a strictly hierarchical model with each level nested in the next, se Eq.1. The multilevel model provides us with a tool to separate variation on the family level from variation on the (childhood) neighbourhood level. Hence, the model setup allows us to take a first step towards identifying a neighbourhood effect that is not affected by family context.

$$ln(inc_{ijk}) = \alpha + \beta 1 X_{ijk} + \beta 2 N_{ijk} + \beta 3 C_k + v_k + \mu_{jk} + e_{ijk} \qquad \text{Eq.1}$$

Where:

$ln(inc_{ijk})$ = logged income from work, including work-related benefits, measured 14 years after the child leaves the parental home

X_{ijk}= a range of individual control variables, all measured 13 years after the child leaves the parental home

N_{ijk}= Individual cumulative neighbourhood exposure, measured over the period from leaving the parental home and 13 years onward

C_k= Characteristics of childhood neighbourhood, measured the year leaving the parental home

v_k= variation at the childhood neighbourhood level

μ_{jk}= variation at the family level

e_{ijk}= an individual error term

However, in order to fully explore the sibling-setup of our data, we adopt the strategy of Merlo and colleagues (2013) and compare the above described "standard model" measuring neighbourhood exposure on the individual level to a model where this individual estimate is replaced by two variables of which the first is estimated on the family level: *family mean of cumulative neighbourhood exposure* and *individual departure from the family mean*. The family mean represents the average of adult neighbourhood exposures of the two siblings. Like with individual exposure, it varies from 13 to 130. Given that the variable takes the neighbourhood pathways of both siblings into account, it implicitly contains familial background aspects shared by both siblings. The second variable, individual departure from family mean, is obtained by subtracting the family mean from the individual exposure. A positive value means that the individual has a higher exposed to low income neighbourhoods over the last 13 years than his/her sibling. This variable estimates the neighbourhood path of an individual that is not shared by his/her sibling. We argue that by replacing individual neighbourhood exposure by these two variables, familial mean and individual departure from the family mean, we are able to distinguish the family influence from the "true" (or perhaps more clearly a truer) neighbourhood effect. To the extent that the "family effect" is shared by both siblings, any remaining effects that influence neighbourhood paths and income, and hence bias estimates of neighbourhood effects, are captured by the familial mean whereas the individual departure from the family mean provides a measure of a neighbourhood effect free from family influence. Our model using these two variables is written as:

$$ln(inc_{ijk}) = \alpha + \beta 1 X_{ijk} + \beta 3 C_k + \beta 4 F_{jk} + \beta 5 I_{ijk} + v_k + \mu_{jk} + e_{ijk} \qquad \text{Eq.2}$$

In Eq.2, individual cumulative neighbourhood exposure N_{ijk} has been replaced by the two variables family mean of cumulative neighbourhood exposure F_{jk} and individual departure from the family mean I_{ijk}

To control for individual characteristics we identify the usual demographic characteristics, notably age, sex, family composition (whether having a partner and whether having children), level of education (less than 12 years, 12 years, 13-14 years, or greater or equal to 14 years), and tenure (home ownership, tenant-owned cooperative, private and public rental). We also include data on fathers' country of birth (Sweden, West, Eastern Europe incl. Russia or Non-western countries). We have chosen to define this variable based on the father's status, partly because many children bear their father's family name which is a strong marker of ethnicity. All control variables are measured 13 years after leaving the parental home, i.e. one year before estimating the dependent variable. Descriptive statistics of all variables included in the analysis is shown in table 1.

****Table 1 about here****

In addition to our sibling sample, we also constructed a control group. This control sample consists of a set of what we term 'synthetic sibling pairs', created to be as similar to the real siblings as possible. Thus, a synthetic sibling pair comes from the same neighbourhood and have fathers belonging to the same income level and country category. The main difference between them and a real sibling pair is that they do not share parents (neither mother nor father) and hence their upbringing, gene pool and everything else that is related to family must differ. For comparability the other criteria used for the siblings remains such that the synthetic pairs are created by selecting all individuals in the same age range (15-21 in 1990) and ordered randomly by neighbourhood of origin, father's country background and father's income level. We then subject the synthetic pairs to the same restrictions as our real

siblings: 1) they should be born no more than three years apart; 2) at least one should leave the parental home between 1991 and 1993; 3) they should leave home maximum four years apart. All pairs not fulfilling these criteria are deleted. We also delete any real sibling pairs, deriving from either the father or the mother. The randomly paired up individuals are much fewer than the real pairs: 8,300 individuals in 4,150 pairs. All models run in this paper are re-run using the control group. However, since the results of these models are mainly interesting in relation to those obtained using the "real" sibling pairs, they are mainly used for comparison and are not described at length in the text. Results from the models are found in the Appendices.

Results

Table 2 shows results from our "standard models" to estimate logged income from work (including transferences) for siblings (both included in the model), 14 year after leaving the parental home. Model I includes individual cumulative neighbourhood exposure, in Model II we include childhood neighbourhood, and in Model III, we interact childhood neighbourhood with adult neighbourhood exposure. In model I, we find a negative effect of the independent neighbourhood career after having left the parental home. Whilst the coefficient may appear small, the values for this variable can range from 13 up to 130. So for an individual who has experienced the maximum exposure to poverty this equates to a coefficient of -0.377 which is of a similar magnitude to having a father from a non-western country. All the control variables behave as expected. Income increases with age and education level, is slightly higher for those with children and those with partner, and is substantially higher for individuals who are actually working. Being female, having an immigrant fathers from especially non-western countries, and living in a rented home all have negative effects on income.

The random effects part of the model shows that only a small part of the variation in income can be attributed to childhood neighbourhood whereas family is comparatively more important (0.005 compared with 0.019 in model I) although still low. Most of the variation in income among individuals is however still unexplained. Although the explanatory power of the childhood neighbourhood is low, this is not surprising as we estimate income 14 years after having left the childhood neighbourhood and childhood household. Considering this, it is interesting to see that even after 14 years of independent residential life course the childhood family and neighbourhood still have effects, reinforcing the notion of the long arm of home in later life (see Glass and Bilal 2016 on the 'stickinesss' of childhood neighbourhood over time).

In model II we included childhood neighbourhood characteristics. We find that having lived in the poorest neighbourhoods (a decile 10 neighbourhood) the year before leaving the family home results in an income penalty, still 14 years later in life. This result is in line with previous studies and signals again to the lasting effects of the childhood environment. (Very) small negative effects are also found for having lived in neighbourhood deciles 1-7 or 8-9 as a child. Including childhood neighbourhood in Model II reduces the variance on the childhood neighbourhood level further.

In model III, table 2, we include a set of interactions between childhood neighbourhood category and adult neighbourhood experiences of the individual. The main effect for childhood neighbourhood almost disappears in this model, while the negative effect of the cumulative adult neighbourhood rank remains similar to Models I and II. The interaction effects are the most interesting in Model III and show that there is a strong correlation between growing up in a decile 10 neighbourhood (poorest neighbourhoods) and the cumulative exposure to poverty neighbourhoods later in life. For someone who grew up in a decile 10 neighbourhood and has a cumulative exposure of 13 later in life (so only the best neighbourhoods) the interaction effect is -0.027, while for someone who grew up in a similar neighbourhood and has a later-in-life cumulative exposure of 130 (all poverty neighbourhoods) the interaction effect is -0.269, about ten times as large. So the negative effect of growing up in a poor neighbourhood on income is reinforced by adulthood experiences of living in poor neighbourhoods.

The main message from the individual models I and II is thus that although childhood exposure only explains a very small part of the variation in income among individuals, growing up in poverty has long lasting effects where those who remain in poverty neighbourhoods also as adults experience the strongest income penalties. These results are well in line with previous literature. However, in order to better distinguish neighbourhood effects from family-related influence, we now move to our family model.

****Table 2 about here****

In the family models (IV-VI), presented in table 3, individual cumulative neighbourhood exposure has been replaced by the two variables 'family mean in neighbourhood exposure' and 'individual departure from the family mean'. The family mean takes the neighbourhood paths of both the individual and his/her sibling into account and thus represent the two siblings' joint neighbourhood exposure. We argue that this variable captures family-related features or events that affect the neighbourhood paths of both siblings. Such features may include, among other things, genetic composition, abilities, temperament, upbringing, norms and values, attitudes, parental guidance, (monetary) support or other tangible and intangible items shared by siblings but not by unrelated individuals. The individual departure from the family mean represents the individual's own path, after having left the family home. Crucially, this pathway is measured not absolutely but *in relation to the pathway of the sibling.* Hence, it shows the extent to which the deviation in neighbourhood paths explain the individual's income, given everything that is shared by the two siblings.

In model IV, Table 3, the family mean is more important than the corresponding value for individual cumulative exposure seen in Model I (-0.004, instead of -0.003). The variable capturing individual departure from the family mean is also negative but smaller (-0.002) than the individual estimate from model I. We argue that the individual departure variable captures a neighbourhood effect free of family influence. Such a conclusion provides evidence that the effect in model I, as expected from the literature review, was biased upwards by family influence.

In model V, we add childhood neighbourhood decile to the predictor variables but only find very minor effects on income of childhood neighbourhood deciles 1-9. The value for decile 10 is substantially larger and shows that there is an additional income penalty for individuals who lived in the poorest neighbourhoods before leaving the parental home. In comparison to model II, the coefficient for decile 10 childhood is slightly lower in the family setup (-0.090 vs. -0.103 in model II). Hence, it appears that the coefficient for childhood neighbourhood was biased upwards by the "family effect".

In model VI, table 3, we repeat the interaction setup of model III and interact family mean with childhood neighbourhood. As in model III, the independent effect of the childhood neighbourhood for decile 8-9 and 10 becomes positive but are replaced by negative values for the interaction terms. For a child growing up in decile 10, a negative effect arises when the family mean exceeds a value of 20 (which must be considered very low given that the variables ranges from 13 to 130). These results mean that children who grew up with their parents in deciles 8-9 and 10 experience a negative effect on their income later in life unless their joint exposure to poverty after having left the parental neighbourhood is very low. In addition, the negative effect gets stronger as the family mean cumulative neighbourhood rank gets stronger. The combination of the family mean and the interaction effect is substantially higher compared to model II and thus demonstrates that growing up in a poor area and being exposed to a negative family-effect, reflected by a high family mean exposure to poverty for the sibling, together yields a strong negative effect on future incomes. This effect is even stronger for individuals who spend a larger proportion of their individual housing career in poverty areas compared to his/hr sibling (the individual departure from the family mean effect) but even if the individual does fairly well, he or she suffers an income penalty related to the (childhood) neighbourhood and family background.

****Table 3 about here****

We argue that our combined results confirm that the neighbourhood effect on income, from both childhood and adult neighbourhood exposure, were biased upwards in the individual model by the influence of the family context. After controlling for family, using our sibling setup, the estimates of the impact of both childhood and adulthood neighbourhood pathways become smaller. However, the coefficient for family mean is larger than the coefficient for individual exposure, signalling that there is a long lasting and important impact of the family context that is resilient to the ameliorative effects of individual neighbourhood experiences later in life. This larger effect is due to capturing also direct inter-generational transfer of socio-economic status.

In order to illustrate the family effect on income, and how it varies with the cumulative neighbourhood exposure of the individual sibling, we have calculated the logged income for a hypothetical individual who is a Swedish-born male, age 33 (sample mean), single without children, with 13-14 years of schooling, employed and living in a tenant-owned cooperative housing segment, and who lived as child in a decile 10 neighbourhood. We calculated the income for this hypothetical person, using model II (the individual model) and using model V (the family-model)[2] with three different sibling scenarios where the sibling has: lowest possible exposure to low-income neighbours (13), mid exposure (72) or maximum exposure (130). The results for varying levels of own exposure to poverty neighbourhoods are shown in the *solid* lines of Fig. 1. The lightest line represents estimates from the individual model, whereas the darker lines represent the different sibling scenarios. The figure clearly shows that incomes get lower as the level of own exposure to poverty increases individuals, but also that those whose siblings perform worse on the housing market, i.e. have a higher exposure to low-income neighbours, do worse in terms of individual income compared to those whose siblings have a lower exposure to poverty. For example, the predicted income of an individual who has spent the entire independent housing career in poverty neighbourhoods (own total exposure of 130) but has a sibling with a low exposure to poverty, has the same predicted income as someone who has a total exposure of 90 but a sibling with an exposure of 130.

Comparing results from the family model to the individual model (the light-grey line) predicted incomes are basically identical to someone having a sibling with a medium exposure of poverty up until an own exposure of about 50. Then the lines start to divide and differences are growing the level of own exposure increases. Hence, the family model predicts higher incomes than the individual model for high exposures to poverty, if the sibling does fairly well (generally better than the individual). We interpret these results as signs of a family effect – having a sibling that performs better than oneself signals a positive influence from the family in relation to the own performance. This could be due to “positive” norms, “beneficial” genes, parents who are able or willing to help or something else that provides an advantage to the individual and reduces the neighbourhood penalty on her income.

In order to test whether our sibling setup indeed captures family effects the way we expect, we re-estimated all our models on a set of “synthetic siblings”. The results can be found in Appendix 1 (individual models) and 2 (family models). Note that the models run for the synthetic sample all include childhood neighbourhood and hence correspond to, in order, models II, III, V and VI. Rather than discussing the actual coefficients, we illustrate the results by calculating predicted income for the same hypothetical individual described above, using equivalent models. Results are shown in the *dotted* lines in Fig. 1. These four dotted lines, representing results from the individual model and the family model using the three different sibling exposures, are clustered together to a much higher extent than the solid lines representing the real sibling pairs. Hence, for our set of synthetic pairs, the “family effect” is much smaller and it matters little how the “sibling” performs – the predicted income is the same regardless of “sibling” exposure (or the lack thereof using the individual model) and varies only by own exposure to poverty. This makes sense as these are synthetic pairs, so there should not be a family effect. In other words, we find that the income levels of two unrelated individuals coming from the same neighbourhood and having a similar ethnic and income background are not influenced

[22] We choose to solve the equation using the models without interactions since the interaction terms were insignificant for the synthetic sample, see Appendix 1.

by any sort of joint background, unlike for the real siblings. We can hence conclude that the effect we found for the real siblings indeed was a family effect. That we found substantial differences in the family mean variable between results for the two samples (-0.0033 for real siblings, -0.0018 for the synthetic sample, see table 3, model V, and Appendix 2, model III) whereas the coefficient for the individual departure from the family mean was identical up to fifth decimal (-0.001597 for real siblings, -0.00154 for the synthetic sample) suggest that this measure is robust and free from family influence.

****Fig. 1 about here****

Discussion and conclusions

This paper set out to disentangle the effects of the family you grew up in and the effects of the neighbourhoods you lived in on individual income later in life. The problem in investigating neighbourhood effects on income is that your parental family context affects both your income later in life, but also your neighbourhood outcomes. In addition, there might also be an independent effect of the childhood neighbourhood on income later in life. As a result, the family effect might bias estimates of independent causal effects on income of the adult neighbourhood experiences. Whereas the neighbourhood effect literature has placed much effort in reducing selection bias, there has been very little attention for potential family bias. In this study we have used a sibling design, with synthetic sibling pairs as controls, to get more insight in family bias on neighbourhood effects.

Our results confirm that there is a strong and lasting parental family effect on income. At the start of this paper we proposed three hypotheses: 1) *Adult income is not only affected by adult neighbourhood experiences, but also by childhood neighbourhood and family context;* 2) *(The family environment during childhood has a stronger effect than childhood and present neighbourhood context on adult income;* 3) *Estimates of causal effects of the adulthood neighbourhood will be biased upwards if the family environment during childhood is not taken into account.* In summary, we can conclude that all three hypotheses were confirmed. Both childhood neighbourhood and childhood family had a lasting effect on income well into adulthood. This finding is striking in itself given that we estimated income 14 years after leaving the parental home. In other words, even when individuals are well into adulthood there remains an effect of the childhood family: the long arm of childhood (Tambupolon 2015). The effect of the childhood family context on adult income is evident when siblings are compared. Individuals with a sibling who does well in terms of (adult) neighbourhood path (i.e. has a low cumulative exposure to low-income neighbourhoods), have a higher predicted income compared to individuals with a similar adult neighbourhood path but a sibling with a high exposure to low-income neighbourhoods. We interpret this as a family effect. Those with siblings in low income neighbourhoods are assumed to come from a less resourceful or advantageous family (either in terms of finances, time investments or other unmeasurable but important traits such as genetics), whereas individuals whose siblings live in better neighbourhoods are assumed to benefit from a more positive family background. This conclusion is confirmed by our tests using synthetic pairs. Our overall conclusion, therefore, is that the childhood family context has a lasting effect on adult income, even when taking both childhood and adult neighbourhood path into account. If we deliberately omitted family context from our models we found that estimates of the effect of both childhood and adult neighbourhood were stronger than in our family model. This leads us to conclude that part of what appeared to be a neighbourhood effect was in fact a lasting “family effect”. It is clear that, when possible, models of neighbourhood effects should control for the childhood family context to avoid bias in estimates.

This study contributes to the current debates in the neighbourhood effects literature on differential impacts of similar neighbourhood environments on different people (see, e.g. Sharkey and Faber 2014). We add to the discussion of individual heterogeneity by arguing that the overall effect may differ among individuals depending on the characteristics of their family background and former

neighbourhood experiences. Although the family is not deterministic in any sense – for instance, individuals may indeed perform well despite coming from a less advantageous family background, or do relatively badly in terms of neighbourhood path despite having a resourceful family – the childhood family context generally has a lasting effect on individual income later in life. These results were acquired using data from Sweden, a country that provides relatively good opportunities for individuals to "move up" on the social ladder in terms of both income and neighbourhood path. Although there indeed is a link between family background and individual performance (see, e.g., Lindahl 2011, on socio-economic status; van Ham et al 2014, on neighbourhood status), internationally comparative analyses have shown that it is easier to undertake upward social mobility in terms of neighbourhood status in equal counties such as Sweden than in more liberal welfare regimes (Nieuwenhuis et al, 2017). Hence, it is likely that the "family effects" found in this paper are stronger in other types of societies.

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Table 1. Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
Dependent variable, measured 14 years after having left the parental home					
Logged income from work (adjusted for inflation, value of 1990)	97,968	6.874	1.996	0	11.036
Independent variables, measured 13 years after having left the parental home					
Childhood neighbourhood rank	97,968	76.670	24.784	1	10
Adult cumulative neighbourhood rank	97,968	76.670	24.784	13	130
Family mean in adult cumulative nbd rank	97,968	76.670	20.481	13	130
Individual departure from family mean	97,968	0	13.956	-57	57
Sex (1 = male, 2 = female)	97,968	1.530	0.499	1	2
Age	97,968	32.852	1.592	27	40
Father's country of birth (1 = Sweden, 4 = Non-Western)	97,968	1.151	0.521	1	4
Living with partner (1=yes)	97,968	0.642	0.479	0	1
Children in household (1 = yes)	97,968	0.664	0.472	0	1
Education level (1= >12yrs, 4 = >14yrs)	97,968	2.295	1.213	1	4
Employment status (1 = employed)	97,968	0.876	0.329	0	1
Tenure (1=home ownership, 4 = public rental)	93,124	1.805	1.069	1	4

Table 2. Results from individual model, using own cumulative exposure. Dependent variable = logged income from work, including work-related transferences, 14 years after having left the parental home, measured in the monetary value of 1990

		Model I		Model II		Model III	
		Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Predictor variables							
Rank of childhood nbd (ref = category 1-4)	category 5-7			-0.020	0.012	0.009	0.038
	category 8-9			-0.028	0.013	0.108	0.046
	category 10			-0.103	0.025	0.077	0.089
Cumulative neighbourhood rank		-0.003	0.000	-0.003	0.000	-0.002	0.000
Interaction childhood nbd*cum nbd rank	childhd nbd cat 5-7					-0.000	0.000
	childhd nbd cat 8-9					-0.002	0.001
	childhd nbd cat 10					-0.002	0.001
Age		0.015	0.003	0.014	0.003	0.014	0.003
Female (ref = male)		-0.433	0.010	-0.432	0.010	-0.433	0.010
Father's country of birth (ref = Sweden)	West	-0.026	0.019	-0.021	0.019	-0.020	0.019
	East	-0.165	0.040	-0.156	0.041	-0.151	0.041
	Non-west	-0.364	0.036	-0.341	0.036	-0.328	0.037
Live with partner (ref = single)		0.022	0.016	0.021	0.016	0.021	0.016
Children in household (ref = no))		0.053	0.016	0.055	0.016	0.056	0.016
Education level (ref = LT12yrs)	12yrs	0.199	0.013	0.196	0.013	0.195	0.013
	13-14yrs	0.356	0.015	0.351	0.015	0.350	0.015
	15+yrs	0.529	0.013	0.522	0.013	0.519	0.013
Employed (ref = not employed)		3.806	0.015	3.805	0.015	3.803	0.015
Tenure (ref = home ownership)	tenant-based coop	0.034	0.014	0.031	0.014	0.030	0.014
	private rental	-0.105	0.015	-0.107	0.015	-0.108	0.015
	public rental	-0.163	0.017	-0.164	0.017	-0.163	0.017
Constant		3.271	0.106	3.286	0.107	3.247	0.108

Random effects parametres						
Childhood neighbourhood variance	0.005	0.002	0.005	0.002	0.005	0.002
Family variance	0.020	0.010	0.020	0.010	0.020	0.010
Residual	2.040	0.014	2.040	0.014	2.040	0.014
N	93124		93124		93124	
Log Likelihood	-165902.9		-165893.49		-165887.08	

Table 3. Results from family model, using family mean and individual departure from family mean. Dependent variable = logged income from work, including work-related transferences, 14 years after having left the parental home, measured in the money value of 1990

		Model IV		Model V		Model VI	
		Coef.	**Std0. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Predictor variables							
Rank of childhood nbd (ref = category 1-4)	category 5-7			-0.016	0.012	-0.005	0.046
	category 8-9			-0.019	0.014	0.122	0.056
	category 10			-0.090	0.025	0.113	0.107
Family mean in cumulative nbd rank		-0.004	0.000	-0.003	0.000	-0.003	0.000
Interaction childhood nbd*family mean	childhd nbd cat 5-7					-0.000	0.001
	childhd nbd cat 8-9					-0.002	0.001
	childhd nbd cat 10					-0.002	0.001
Individual departure from family mean		-0.002	0.000	-0.002	0.000	-0.002	0.000
Age		0.014	0.003	0.014	0.003	0.014	0.003
Female (ref = male)		-0.433	0.010	-0.432	0.010	-0.432	0.010
Father's country of birth (ref = Sweden)	West	-0.023	0.019	-0.020	0.019	-0.019	0.019
	East	-0.158	0.040	-0.151	0.041	-0.146	0.041
	Non-west	-0.349	0.036	-0.330	0.036	-0.315	0.036
Live with partner (ref = single)		0.022	0.016	0.021	0.016	0.021	0.016
Children in household (ref = no))		0.055	0.016	0.055	0.016	0.057	0.016
Education level (ref = LT12yrs)	12yrs	0.198	0.013	0.196	0.013	0.195	0.013
	13-14yrs	0.356	0.015	0.352	0.015	0.351	0.015
	15+yrs	0.529	0.013	0.524	0.013	0.521	0.013
Employed (ref = not employed)		3.804	0.015	3.803	0.015	3.802	0.015
Tenure (ref = home ownership)	tenant-based coop	0.033	0.014	0.031	0.014	0.030	0.014
	private rental	-0.106	0.015	-0.107	0.015	-0.108	0.015
	public rental	-0.164	0.017	-0.164	0.017	-0.163	0.017

Constant	3.328	0.107	3.332	0.107	3.295	0.109
Random effects parametres						
Childhood neighbourhood variance	0.005	0.002	0.005	0.002	0.005	0.002
Family variance	0.020	0.010	0.020	0.010	0.020	0.010
Residual	2.040	0.014	2.040	0.014	2.040	0.014
N	93124		93124		93124	
Log Likelihood	-165892.06		-165885.31		-165880.31	

Appendix 1. Results from individual model using *synthetic siblings*. Dependent variable = logged income from work, including work-related transferences, 14 years after having left the parental home, measured in the monetary value of 1990. Models correspond to table 2, model II (model I) and III (model II).

		Model I			Model II		
		Coef.	**Std. Err.**	**Sign.**	**Coef.**	**Std. Err.**	**Sign.**
Predictor variables							
Rank of childhood nbd (ref = category 1-4)	category 5-7	-0.039	0.016	*	-0.083	0.052	
	category 8-9	-0.080	0.019	***	-0.153	0.066	*
	category 10	-0.139	0.039	***	-0.014	0.144	
Cumulative neighbourhood rank		-0.002	0.000	***	-0.002	0.000	***
Interaction childhood nbd*cum nbd rank	childhd nbd cat 5-7				0.001	0.001	
	childhd nbd cat 8-9				0.001	0.001	
	childhd nbd cat 10				-0.001	0.001	
Age		0.027	0.004	***	0.027	0.004	''
Female (ref = male)		-0.386	0.014	''	-0.386	0.014	***
Father's country of birth (ref = Sweden)	West	0.056	0.035		0.054	0.035	
	East	0.124	0.085		0.121	0.085	
	Non-west	-0.063	0.072		-0.059	0.072	
Live with partner (ref = single)		-0.020	0.024		-0.019	0.024	
Children in household (ref = no))		-0.024	0.024		-0.024	0.024	
Education level (ref = LT12yrs)	12yrs	0.036	0.019		0.035	0.019	
	13-14yrs	0.147	0.021	***	0.147	0.021	***
	15+yrs	0.296	0.018	***	0.296	0.018	***
Employed (ref = not employed)		1.305	0.028	''	1.305	0.023	***
Tenure (ref = home ownership)	tenant-based coop	0.034	0.021		0.034	0.021	
	private rental	-0.060	0.023	**	-0.059	0.023	**
	public rental	-0.090	0.025	***	-0.090	0.025	***
Constant		5.60	0.147	***	5.62	0.149	***

Random effects parametres				
Childhood neighbourhood variance	0.000	0.003	0.000	0.003
Family variance	3.47e-09	2.55e-09	1.10e-08	7.58e-09
Residual	0.354	0.006	0.354	0.006
N	7899		7899	
Log Likelihood	-7113.8328		-7112.4075	

Appendix 2. Results from family model using *synthetic siblings*. Dependent variable = logged income from work, including work-related transferences, 14 years after having left the parental home, measured in the monetary value of 1990. Models correspond to table3, model V (model III) and VI (model IV).

		Model III			Model IV		
		Coef.	**Std. Err.**	**Sign.**	**Coef.**	**Std. Err.**	**Sign.**
Predictor variables							
Rank of childhood nbd (ref = category 1-4)	category 5-7	-0.038	0.016	*	-0.155	0.067	*
	category 8-9	-0.079	0.019	***	-0.196	0.085	*
	category 10	-0.137	0.039	**	-0.010	0.178	
Family mean in cumulative nbd rank		-0.002	0.000	***	-0.003	0.001	***
Interaction childhood nbd*family mean	childhd nbd cat 5-7				0.002	0.001	
	childhd nbd cat 8-9				0.002	0.001	
	childhd nbd cat 10				-0.001	0.002	
Individual departure from family mean		-0.002	0.000	**	-0.002	0.000	**
Age		0.027	0.004	***	0.027	0.004	***
Female (ref = male)		-0.386	0.014	***	-0.386	0.014	***
Father's country of birth (ref = Sweden)	West	0.056	0.035		0.052	0.035	
	East	0.125	0.085		0.121	0.085	
	Non-west	-0.060	0.072		-0.057	0.073	
Live with partner (ref = single)		-0.020	0.024		-0.020	0.024	
Children in household (ref = no))		-0.024	0.024		-0.025	0.024	
Education level (ref = LT12yrs)	12yrs	0.036	0.019		0.035	0.019	
	13-14yrs	0.147	0.021	***	0.146	0.021	*''
	15+yrs	0.296	0.018	***	0.296	0.018	''
Employed (ref = not employed)		1.305	0.028	***	1.305	0.028	''
Tenure (ref = home ownership)	tenant-based coop	0.033	0.021		0.033	0.021	
	private rental	-0.060	0.023	**	-0.060	0.023	**
	public rental	-0.091	0.025	***	-0.092	0.025	***

Constant	5.613	0.148	***	5.666	0.152	***
Random effects parametres						
Childhood neighbourhood variance	0.000	0.003		0.000	0.003	
Family variance	1.99e-10	1.54e-10		4.25e-10	3.41e-10	
Residual	0.354	0.006		0.354	0.006	
N	7899			7899		
Log Likelihood	-7113.7123			7111.1054		

Fig. 1. Predicted (logged) income 14 years after having left he parental home, measured in money value of 1990, for a hypothetical Swedish-born male, age 33, single, no children, 13-14 years of schooling, employed, live in tenant-owned cooperative, grew up in a decile 10 neighbourhood. Solid lines symbolize real sibling pairs, dotted lines a sample of synthetic sibling pairs. Based on results from table 2, model II (individual model) and table 3, V (family model) for real sibling pairs, and corresponding models I (individual model) and III (family model), both in Appendix 1, for synthetic pairs.