The Effects of Birth Order on Adult Outcomes: Evidence from Australia

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Abstract

This paper investigates how birth order affects education, labour market outcomes, health, personality traits, in-vivo transfers and inheritance of Australians. We find that later born children have lower educational attainment, though we cannot find a detrimental effect on health, personality or parental financial transfers. Sibship size is related to inheritance in a way consistent with the financial dilution hypothesis, but its causal effect cannot be identified with confidence.

JEL: I20, I30, J13, J24

Keywords: family size, sibship size, birth order, education, wages, health, personality

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1. Introduction

This paper studies the effect of birth order and sibship size (the total number of children in a family) on several measures of human capital and parental financial transfers using representative data for Australia. In particular, we investigate the effect of birth order on educational attainment, health, personality and financial transfers received from living parents or as inheritance. Sibship size is available as a control in our regressions but, as we shall see, it is not easy to interpret causally.

Any effects of birth order and sibship size will be both relentless and ubiquitous, since birth order and sibship size are an economically important feature of the biological family, which is a robust institution across time and culture. That is, with the relatively rare exception of multiple births, children come to their parents in a specific order, with the possibility of differential attention. Furthermore, parental resource constraints imply that the sibship size will affect the resources devoted to each child if the resources are rival in consumption. This is called the *dilution* effect of sibship size. Naturally, a birth order effect needs more than one child to operate, so there is a sense in which birth order is a sibship size effect, but in this paper we take advantage of well-established econometric techniques to measure the independent effects of birth order.

Relentless and ubiquitous family effects are relevant for the current debates on inequality. For example, if children with high birth orders are relatively disadvantaged, either because of their birth order or because they come from a large family which is financially challenged, cohorts with relatively large numbers of children will sow the seeds of disadvantage into the next generation. On this note, there is good evidence that since the industrial revolution it is the rich who have had fewer surviving children than the poor, the direct opposite of the situation prior to the industrial revolution (Brennan, Menzies and Munger, 2012). In such a world, significant birth order and sibship size effects on human capital will see the poor sow seeds of disadvantage into their children's lives in an historically new way, since it is the poor that have larger families with higher birth order children.

To estimate birth order and sibship size effects on human capital stocks of Australians we rely on a nationally representative panel survey of Australian households, the Household Income Labour Dynamics survey in Australia (HILDA). HILDA contains very rich information at the household and individual levels, covering demographics, family background, economic, health, and environmental conditions. We use data from wave 8 (survey year 2008) in which an extensive

array of information about respondents' parents and siblings was collected. These data are used to construct birth order and family background variables for the respondents, and the effects of these variables on educational attainment, labour market outcomes, health, personality traits and financial transfers from parents are estimated in this paper.

The results can be summarised as follows. We find that birth order negatively affects adult educational outcomes. For example, in a family of two children second borns have about 0.4 years less of education than first borns, and their probability of attaining university degree is lower by 7 percentage points. However, we do not find substantial birth-order differences in financial transfers from parents. Instead, the internationally widespread convention of equal inheritance transfers from parents (Piketty, 2014) is consistent with both no birth order effects and our weak evidence for dilution, measured as a negative sibship size coefficient on inheritance and transfers. From the point of view of minimizing inequality the equal sharing convention is welcome, but any hope that inheritance or in-vivo transfers could be used to compensate later born children for their unfortunate birth order does not find support in our analysis.

Labour market outcomes such as probability of being employed and hourly wages are also negatively affected by birth order, but these effects are to a large extent driven by the generally lower educational attainment of individuals with higher birth order. We also consider the effect of family composition on health, Big Five personality traits and locus of control, and find that these characteristics is largely unaffected by birth order (with a notable exception of openness being negatively related to birth order). In contrast, even when controlling for own education, sibship size has a negative correlation with hourly earnings, and those from larger families have a greater tendency to believe that outside events impact their lives more than their own actions do. However, we are unable to use instrumental variables in our regressions, so these sibship coefficients are a fragile basis for making causal assertions.

2. Literature Review

One of the earliest studies on birth order and human capital is Galton (1874) which demonstrates that the first born are over-represented in a cohort of successful scientists. More recently Caceres-Delpiano (2006), Conley and Glauber (2006), Kantarevic and Mechoulan (2006), Booth and Kee (2009), Black et al. (2005) and Black et al. (2011) document a negative relationship between birth order and IQ, educational attainment and adult earnings in developed countries, though Erjnaes and Portner (2004) and De Haan et al. (2014) find that later born children fare better in developing countries.

Theoretical explanations of birth order and sibship size effects on human capital are to be found in: 1. *The parental time dilution hypothesis* (Blake, 1981) which asserts that earlier born children have access to more parental time and hence acquire more human capital. Downey (1995) and Steelman and Powell (1989) proposes a corresponding financial dilution hypothesis; 2. *The optimal stopping rule* which asserts that parents curtail fertility when their last child turns out to be a "bad draw"- viz., a difficult-to-raise child. Hence, last born children are more likely to be of 'worse' quality than earlier born children; 3. *The advanced maternal age hypothesis* which asserts a worse genetic endowment of later born children; 4. *The "confluence" hypothesis* (Zajonc 1976) which asserts that earlier born children benefit from teaching their younger siblings who themselves do not have an opportunity to enhance their human capital this way. On the other hand, later born children may benefit from more experienced parents with latter-career incomes; and 5. *In developing countries* a positive effect of birth order can be explained by household reliance on labour of older children. However, this is largely irrelevant for Australian data, and so we do not consider it further.

Several empirical studies directly test these theories. Price (2008) finds evidence that older children enjoy more of a cumulative quality time with their parents because of parents' tendency to split their time equally among existing children. De Haan (2010) shows that parents spend less financial resources on later born children. Pavan (2015) estimates a structural model in which birth order effects can originate as a results of resource dilution or an optimal stopping rule. He finds that parental inputs explain between 20% and 40% of the cognitive gap between first born and later born children. Lehmann et al. (2014) document very early childhood difference in cognitive development by birth order and show that changes in maternal behaviour can account for most of the cognitive birth order gap. Hotz and Pantano (2011), on the other hand, find evidence that parents choose parental style endogenously being more permissive with younger siblings. This paper does not attempt to differentiate between these alternative explanations. Instead we provide additional evidence on the negative birth order effects on educational outcomes in Australia, a wealthy developed country with high-quality public education system and a relatively accessible tertiary education, to indicate differential early parental investments in children's human capital as an important likely cause of birth order disadvantage in this context.

There are also recent studies investigating the effects of birth order on intermediate inputs into human capital. Lehmann et al. (2014) study the effects of birth order on birth weight and actually find that later born children on average have higher birth weight. Barclay and Kolk (2015) and Modin (2002) find that mortality risk in adulthood increases with birth order using population

register data from Sweden. Hatton and Martin (2010) document a negative relationship between height and birth order in Interwar Britain. In contrast, Black et al. (2016) use a large population data from Norway and do not find a clear first-born advantage in health as measured by obesity, high blood pressure and high triglycerides, though later-borns were more likely to smoke. Our results for Australia are consistent with these findings.

While education and health have been presumed to be the major determinants of human capital, starting from Mincer (1958), Becker (1962) and Grossman (1972), personality characteristics and other non-cognitive skills have recently started receiving recognition alongside education and health as important determinants of lifetime economic success. For example, Almlund et al. (2011) and Heckman et al. (2006) incorporate psychological characteristics into models of economic behaviour by allowing these characteristics to directly affect individuals' preferences, expectations and constraints, and Cunha et al. (2010) show that personality characteristics explain 12% of the variance in educational attainment (compared to 16% explained by cognitive ability measures).

Personality characteristics most commonly used to study personality in social science include Big Five personality traits and Locus of Control. The 'Big Five" personality traits are: (1) extraversion – a tendency of an individual to be talkative, assertive and energetic; (2) emotional stability; (3) openness- the tendency to be imaginative, curious and intelligent; (4) conscientiousness- the tendency to be organized, responsible, and thorough and (5) agreeableness- the tendency to be cooperative, sympathetic and friendly. In recent studies, conscientiousness is found to be positively associated with educational attainment, wages and job performance (Almlund et al. (2011) , Nyhus and Pons (2005), Salgado (1997), and Hogan and Holland (2003)) while neuroticism, extraversion, and agreeableness are found to be negatively correlated with educational attainment (e.g. Goldberg et al. (1998)). Fletcher (2013) shows that extraversion is positively associated with earnings in a model that controls for family and genetic background via siblings fixed effects.

Locus of control (LoC) refers to beliefs about an individual's control of events that affect her life. Individuals with an external LoC believe that their lives are largely determined by external factors, while economic and educational benefits have been observed for individuals with an internal LoC, who instead believe they have a lot of control over their lives (see Semykina and Linz, 2007; Heineck and Anger, 2010; Coleman and Deleire, 2003 and Baron and Cobb-Clark, 2010).

The effect of birth order on personality traits has interested psychologists for a long time. However, until recently studies in psychology tended to find mixed evidence in part due to often small sample sizes and failure to control for family background characteristics (see Hughes (2005) and Rohrer et al. (2015) and references therein). To date, there have been only a few large-scale studies examining this relationship, with Rohrer et al. (2015) being a notable contribution. This study used large datasets from three countries (US, UK and Germany) to demonstrate absence of birth order effects on Big Five personality traits (they did not analyse LoC). With respect to the effects of birth order on LoC, some psychologists believe that first born children have more external LoC because they receive more direct parental attention than their later born siblings (Lasko, 1954; Sears, 1950). Our study includes LoC among the personality traits. Similarly to Rohrer et al. (2015) we find little effect of birth order on most personality traits, with the exception of Openness to Experience which is negatively affected by birth order in our data.

To the best of our knowledge there is very little work explicitly focusing on the effect of birth order on parental transfers in developed countries, with the exception of Mechoulan and Wolff (2015). They show that in modern France first born children not only enjoy advantage in educational and occupational outcomes over later born children, but they also receive more in-vivo transfers from their parents (the paper does not study the effect of birth order on bequests due to data limitations). We provide a new evidence of the effects of birth order on in-vivo parental transfers and inheritance. In contrast to Mechoulan and Wolff (2015), we find no relationship between the probability or amount of these transfers and birth order in Australia.

In summary, our study contributes to Australian economics literature by providing the first evidence of birth order effects in Australia. We also contribute to international literature by providing a new comprehensive evidence of birth order effects on a large array of important outcomes.

3. Data

Wooden and Watson (2007) and Watson and Wooden (2012) provide a good discussion of HILDA, Australia's first nationally representative household panel survey. Our sample is based on HILDA wave 8 (HILDA 8). Our analysis requires detailed information on respondent's family background. Starting from wave 8, every four years respondents were asked detailed questions about the history and status of their parents and siblings. At the time this paper is written we have two waves of HILDA where detailed parent and siblings information is available (waves 8 and 12). Unfortunately, in wave 12 some relevant questions about parental background such as age and type (birth, step or adoptive) are only asked if at least one of the parents is still living. In contrast, in wave 8 all respondents were asked these questions.

The population of interest in our study is individuals aged between 28 and 55 years. We focussed on this age group since they are most likely to have their education completed and at the same time to be fully attached to the labour force. The list of dependent variables measuring human capital casts a wide net so as to include all its likely ingredients broadly conceived (education, health, personality traits) and labour market success (indicator for being employed full-time, and, hourly wages). The following educational outcomes are included in the analysis: (1) an indicator for completing year 12 of high school or a higher qualification; (2) an indicator of attaining bachelor's or a higher degree and (3) years of education[1]. Health status is measured by self-assessed health (an indicator for having a fair or poor health currently or at age 15), presence of a long term health condition, height and mental well-being.[2]

[1] HILDA collects data on highest education level achieved by respondent (edhigh1 variable), with the possible levels being year 11 or below, year 12, Certificate III or IV, Advanced Diploma or Diploma, Bachelor or honours, Graduate Diploma or graduate certificate, Postgraduate degree – masters or doctorate. Information about total years of education completed is not collected by HILDA. Allocating years of schooling based on highest level of education may create measurement error problems, as some people may have several degrees of the same level (e.g. two bachelor's degrees in different fields of study). Nevertheless, previous studies used this approach (e.g. Leigh and Ryan (2008)), so we also explore the relationship between family composition variables and years of education coded as in Leigh and Ryan (2008). Another alternative is to work with the edhigh1 variable directly by modelling it using the ordered probit model. However, there are a few problems with this approach as well: (1) higher levels of education such as doctoral or masters are often acquired later in life and are less dependent on family background; (2) It is not clear how lower-level educational outcomes should be ranked. For example, Certificate III and IV do not necessarily correspond to higher human capital attainment compared to completion of high school only. There are pathways to certificate courses for high school drop outs, and these courses can be less than a year in duration, so a certificate holder can have less than 12 years of schooling completed.

[2] To construct a mental well-being measure we use the mental health part of the SF-36 instrument administered by HILDA in every survey wave. Our measure is based on 5 questions as to whether in the last 4 weeks the respondent has been a nervous person, feeling so down that nothing could cheer her up, feeling calm and peaceful, felt down, and been a happy person. He/she rates his/her experiences on each of the questions on a 6-point scale, capturing the dimension of "none of the time" to "all the time". Based on this, the HILDA team constructs a 0-100 score reflecting

Personality characteristics that we analyse include "Big Five" personality traits and LoC. HILDA administers a Big Five personality inventory based on Saucier (1994) every four years starting from 2005. In particular, as a part of the Self-Completion Questionnaire (SCQ) the respondents indicate how well each of different 36 words describes them (e.g. talkative, moody, philosophical, etc.). These responses are then factor-analysed to extract five factors corresponding to the Big Five personality traits. The closest wave with personality questions is wave 9, so we merge respondents' personality traits recorded in wave 9 with the information from wave 8. Information about LoC in HILDA is also collected as a part of the SCQ. In particular, in years 2003, 2004, 2007 and 2012 the respondents were asked 7 questions about how strongly they agree with statements about their perception of personal control in their lives, with two questions probing for internal control and five questions probing for external control. We merge HILDA wave 8 data with respondents' LoC answers in year 2012. We follow Cobb-Clark and Schurer (2013) in the construction of their external LoC index. Big five personality traits and LoC have been shown to be stable across time within working-age individuals (Cobb-Clark and Schurer, 2012 and 2013) which mitigates our concerns about not using contemporaneous values of these characteristics.

For the parental financial transfer variables we use HILDA questions about last financial year transfers from parents and any inheritance/bequests received by the respondent. These questions are asked in each wave of HILDA, however the probability of receiving any of these transfers are very small per year (e.g. 0.015 for inheritance and 0.019 for financial transfers from parents in wave 8). To increase variation in these dependent variables we redefine them as parental transfers and inheritance received in the last 4 years. We apply appropriate CPI figures to obtain the cumulative amounts of transfers measured in current 2008 dollars.

The explanatory variables of interest are the respondent's birth order, and sibship size. Starting from wave 8 every four years HILDA administers a detailed set of questions related to the characteristics and status of respondents' parents and siblings. Of particular interest to this survey are questions about the number and age and sex of siblings and their type (full, half, step, adopted or foster). We use this information to compute the number of siblings and birth order for each respondent.

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the state of the mental wellness according to an established guideline (Ware et al., 2000). A higher score reflects better mental health.

In all our models we include extensive controls for family background characteristics. These include age of father and mother at the time of respondent's birth, educational attainment of parents (schooling and the highest degree completed), labour force status of parents during childhood (i.e., an indicator for father being unemployed for 6 months or more when the respondent was growing up, and indicator for mother being in paid employment when the respondent was 14 years old) and occupational attainment of parents (coded up to 1-digit ANZSCO 2006 classification). We include an indicator for respondent's living with birth mother and father when they were 14 years old. We also include a set of respondents' yearly birth cohort dummies and indicators for father, mother or respondent being foreign-born. Finally, we include dummy variables flagging respondents who grew up with either non-birth mother or father, and who reports having at least one non-full sibling (i.e. half, step, foster, adopted).[3]

Our sample is constructed in the following steps. First, we keep respondents who are between 28 and 55 years of age during the wave 8 interview (6134). In the next step we also remove those who were a members of a twin pair (98 obs) and where age, sex and type for at least one of the siblings was missing (150). This leaves us with 5886 observations. Among these 118 respondents have mother's age missing for various reasons (e.g. "don't know", "refuse", etc.), we flag them with a dummy variable. But we drop 35 observations where the reported mother's age at birth is less than 15 years old. The father's age is missing for 179 observations, which we flag with a dummy variable. We delete 13 observations where father's age at birth is less than 15. We also delete 59 observations with missing data on explanatory variables. The final sample with non-missing information on educational and labour market outcomes, sibship size and birth order and family background is 5779.

Several dependent variables (such as self-assessed current health and personality) are constructed using responses to a self-completed questionnaire (SQC) which respondents fill out themselves and mail back to the HILDA managers. The response rate to the SCQ is usually lower, which reduces the number of observations further when the variables derived from the SCQ are analysed.

All Tables are available in an online appendix.[4] Tables 1 and 2 show the sample means of the explanatory and dependent variables, respectively. We show Table 2 in the paper (as well as in the online appendix) because we use the inheritance figure later. Table 3 shows the distribution of

[3] The results are robust to excluding these groups of observations from the estimation sample.
[4] See the corresponding author's webpage.

birth order, conditional on sibship size. It is reassuring that our sample selects a proportion approximately equal to 1/n of each birth order of sibship size n. Finally, Table 4 shows the sample means of the dependent variables by birth order. There is a negative relationship between birth order and many adults outcomes, but this negative relationship can also be generated by sibship size which is positively correlated with birth order. In the next section we discuss how we isolate the independent effect of the birth order on the outcomes of interest.

4. Methodology

We face two major technical challenges in our research. First, birth order is highly correlated with sibship size for the mechanical reason that high birth orders can only be exhibited for high sibship size, the latter being a cap on the former. Indeed, in our actual data the correlation between the sibship size and birth order is 0.71. One way to get around this problem of multicollinearity is to use birth order information to construct a birth order index in a way that reduces the correlation with the sibship size, e.g. by normalisation that is related to sibship size. The index constructed by Booth and Kee (2009) is one possibility. Their index by construction has close to zero correlation with the sibship size. Another is the index of Erjnaes and Portner (2004), which is more strongly correlated with the sibship size than the Booth and Kee (2009) index. We will use Booth and Kee index (BK) as our primary measure of birth order but will check if the results are robust to using birth order dummies.

The BK index is constructed as follows. Let N denote the sibship size in respondent's family, and φ denote the absolute birth order of the respondent (φ=1 for the only child and for first born, φ=2 for second born, and so on). Let A denote average birth order in the respondent's family: A=(N+1)/2. The BK index is defined as BK= φ/A. In our data BK is between 0.167 and 1.857. The within family mean of BK is 1 for all family types.

Our second technical challenge is that because of data limitations we cannot perform instrumental variable estimation of the effects of sibship size, so the effects of sibship size that we report do not have causal interpretation. In our data sibling ages are measured in years (date of birth is not reported) so precise identification of twin pairs to be used as an IV for sibship size (as in Black et al. (2005)) is not possible. Using sex composition of older siblings as an IV for sibship size (as in Angrist and Schlosser (2010)) resulted in weak IVs and the IV estimates from these regressions suggest that any effect of sibship size on education is close to zero. In what follows we treat sibship size as a control variable when we interpret birth order, but our interpretation of the sibship coefficients themselves is offered in a tentative way.

Our estimating equation for educational attainment (Tables 5 to 8, and Table 10) is:

$$E_i = \gamma X_i + \alpha N_i + \beta B_i + \varepsilon_i$$

where E denotes educational attainment; X is the respondent's demographic characteristics (yearly birth cohort dummies, gender and immigrant status) and family background characteristics (parental age at respondent's birth, parents' immigrant status, education, labour force attachment and occupation, indicators for having non-birth mother, non-birth father, not full siblings, not living in their full family at the age of 14, and an indicator for father's being unemployed for 6 months during respondent's childhood). We use N to denote sibship size (dummy variables or linear functional), and B to denote birth order (dummy variables or BK functional form).

Our estimating equation for non-educational outcomes (Table 9) is:

$$y_i = \gamma X_i + \mu DE_i + \alpha N_i + \beta B_i + \varepsilon_i$$

where y can represent labour force status, health, personality or transfers/inheritance, and E denotes educational attainment. We investigate whether effects of sibship size and birth order are mediated by educational attainment by switching the value of the indicator variable D from zero to unity and observing the change in statistical and economic significance of sibship size and birth order.

Results

Tables 5 to 8 present the estimated impact of sibship size and birth order on educational attainment. We focus on the impacts of birth order and sibship size on the years of education, so Table 5 appears below, while Tables 6 and 7 are relegated to the online appendix. Table 5 presents the results of the linear regression (with robust standard errors) on years of education. Models (1) and (2) only have controls for own age, mother's age and parents' foreign born status, Models (3) and (4) add socio-economic family background characteristics such as; the father's age at the respondent's birth (in 5 year band dummies), the education and occupation of both parents, and dummies for non-birth father, non-birth mother, non-full sibling, living with birth father and mother at age 14, and the father's being unemployed for more than 6 month when respondent was growing up. Models (5)-(8) add birth order variables in the BK birth order index and dummy variable forms. Table 6 and 7 present the same specifications for indicators of high school and Bachelor's degree completion, respectively

The results in Tables (5) – (7) suggest that the effects of a sibship size is negative, statistically significant and decreases in magnitude as socio-economic family background are included in the model. Interestingly, the sibship size effect does not change once the BK birth order index is added to the model, as is expected from the low sample correlation between the two variables. The effect of the BK index is negative and statistically significant, and is stronger for the university completion probability. The coefficient on the BK index is difficult to interpret though, as a given increase corresponds to a different birth order change, depending on the sibship size. To get a better understanding of the economic significance of the birth order we estimate models (7) and (8) where the BK index is replaced with the birth order dummies. These specifications point to a strong first born advantage – up to the fifth child, higher birth order siblings have at least 0.3 less years of education. We compare these results to the high school and bachelors completion probability in the online appendix (Tables 6 and 7). Again up to the fifth child, later born children are at least 3 percentage points less likely to complete high school and at least 7 percentage points less likely to complete Bachelor's degree. For very large families some of the birth order coefficients are insignificant, but they are generally negative, and sometimes indicate that disadvantage is increasing with the birth order.

Table 8, which appears below, presents the effects of birth order in the models estimated for different sibship sizes, to better control for the family size. The results support the earlier finding - in the family of two children the second born on average has less than 0.4 years of education, and is 7 percentage points less likely to complete Bachelor's degree. In the family of three children the second and third borns on average have 0.6 and 0.8 less years of education, respectively, are 4 and 8 percentage points less likely to complete high school, and are 13 and 17 percentage points less likely to complete Bachelor's degree than the first born. The coefficients on birth order dummies in families of four and five siblings are not all statistically significant, but many are negative.

We also examine the effects of the sibship size and birth order on labour market outcomes, health, personality and parental transfers. For all these dependent variables we estimate specification (5) (with full family background characteristics, linear sibship size and BK birth order index).[5] We also augment this specification with highest educational attainment dummies to see if any of the birth order or sibship size effects are mediated by educational attainment. The coefficients on sibship size and birth order for models with different dependent variables are

[5] We report models with BK birth index for brevity only. We also estimate specifications with a full set of birth order dummies and find qualitatively similar results. These results are available from authors upon request.

presented in Table 9. Birth order is found to decrease log hourly wages among employed but this effect is explained by higher educational attainment of lower birth order individuals. Birth order is also found to decrease agreeableness (marginally statistically significant effect) and openness to experience. The negative relationship between birth order and openness to experience has been documented in Rohrer et al. (2015). Openness is correlated with IQ, and Rohrer et al. show that the IQ component of openness is giving rise to the negative correlation of this trait with birth order. We do not find any statistically significant coefficients for parental transfers, in contrast to Mechoulan and Wolff (2015) who find that first born are more likely to receive in-vivo transfers from parents in France.

Results in Table 9 suggest that the health status measures that we use are largely unaffected by birth order.

Table 9 also shows that sibship size, with own education controls in place, is negatively correlated with the wage (the hourly wage being nearly 1 per cent lower), the mental health score and locus of control. The most pronounced effect of sibship size occurs on received in-vivo transfers and inheritance. It is not straightforward to interpret the inheritance and in-vivo transfer figures in Table 2 ($80,000 and $20,000 among recipients). Inheritance might be either a one-off payment associated with the death of both parents or a two-off payment coming as each parent dies, and in-vivo transfers are in principle ongoing. Furthermore, as we have flagged, the estimated coefficients on sibship size may suffer from endogeneity bias. Nevertheless, we offer the following two observations as conjectures.

First, the probability of receiving parental transfers or inheritance is small, at around 6 per cent over four years (Table 2). However, for those fortunate enough to receive inheritance, the amounts involved (around $80,000 from Table 2) are around half the net present value of undertaking a university degree which, according to the OECD (2014), is approximately $200,000 for men and $150,000 for women (using a $US0.75 exchange rate).

Second, financial dilution is consistent with the data, as can be seen in the second last column of Table 9. This is hardly surprising, especially for inheritance, given the social norm in Australia of equal sharing of resources among children. On average, each additional child ‘costs’ $15,000 for existing children via dilution, though under the equal sharing hypothesis the average hides a high deal of volatility, since dilution decreases non-linearly with sibship size. For example, the second child reduces the first child’s inheritance by 50 percentage points, but the fifth child reduces the

first four children's inheritance by only 5 percentage points, from 25 per cent to 20 per cent.[6] The convention of equal sharing is good news for inequality relative to past practice, for there was a time when early birth order advantage was reinforced by preference for the first born (if male). However, there is no evidence in our data for parental compensation for later birth order, as would be the case if we had observed higher inheritance for higher birth order children.

Given the magnitudes of inheritance received in HILDA, we wonder if inheritance creates a small 'university-degree-sized' tendency towards inequality which cannot be justified on the grounds of creating favourable incentives. The fortuitous circumstances of either receiving in-vivo transfers/inheritance in the first place, or having fewer siblings to have to share it with cannot be created by one's own efforts, at least not ethically. We offer the conjecture that the more financial capital creation *truly* lies outside of the locus of control of an individual, the more the *perceived* locus of control turns outwards too. Thus, our evidence for dilution may explain the significant negative impact of sibship size in the LoC regression in Table 9.

All that said, a caveat remains over the last two paragraphs that the sibship size coefficients should be interpreted with caution because we have not been able to deal effectively with endogeneity.

Table 10 examines heterogenenity of the birth order effects on education along various dimensions. We find that females are more disadvantages by birth order effects than males, and that children of lower educated, non-working and non-immigrant mothers experience stronger negative birth order effects. Interestingly, respondents who grew up with non-birth siblings experience no birth order effect, as do immigrant respondents. Existing studies of birth order in developing countries point to a positive relationship between birth order and academic achievement. If immigrant respondents originate from a mix of developed and developing countries, the relationship between birth order and education can be of any sign in this subsample, so finding a zero relationship is not surprising. Unfortunately the sample size is not large enough to enable estimation of the relationship for different countries of origin.

[6] $d/dn\ (1/n) = -1/n^2$.

5. Conclusion

We have succeeded in establishing that birth order has a significant effect on adult outcomes, using a high quality Australian dataset. We find that later born children and children from large families have lower educational attainment, but when the birth order and sibship size measures are made independent, the birth order effects dominate. We find little effect of birth order on health, personality or parental financial transfers, making us doubt whether parents compensate later born children for the disadvantages of being later born. Sibship size is related to inheritance in a way consistent with the financial dilution hypothesis, and the amounts involved for those fortunate enough to receive inheritance are around half of the NPV of undertaking a degree. However, sibship size coefficients should be interpreted with caution because we have not been able to deal effectively with endogeneity.

The size of the effects of sibship size and birth order on educational attainment we found in Australian data are comparable with those found in other countries. For example, Black et al. (2005) in a comparable specification (their Table IV, col.3) find that an extra sibling is associated with the decrease in years of education by 0.09 in their US data, while Angrist et al. (2010) show that in their Israeli data an extra sibling is associated with the 0.145 decrease in the highest grade completed.[7] Booth and Kee show in their British data that an extra sibling is associated with the 1.2% decline in the years of education, and our results suggest a 0.7% decline at the mean educational attainment.

The size of birth order effects that we find are also of the same order of magnitude found in other countries. For example, Black et al. (2005) show that a second child's educational attainment is less by 0.34 years than that of a first child, and a third child's education is less by 0.54. Booth and Key show that a unit increase in their birth order index decreases education attainment is their British data by 3.4%, and our results imply the effect of 3.9% at the mean educational attainment.

Our findings regarding the relationship between family background and personality characteristics are also consistent with the earlier literature. For example, Rohrer et al. (2015) study find little effect of birth order on personality, except for the Openness for which the relationship is driven by the IQ component of Openness. Lehmann et al. (2014) do not find the effect of birth order on behavioural problems among children in NLSY. We also do not find any effect of birth order on health. To the best of our knowledge Black et al. (2016) is the only

[7]Black et al (2005) and Angrist et al . (2010) show that these effects found in the OLS specifications disappear when twin birth is used as an instrument for family size.

comparable study to ours of the relationship between birth order and health in their measurement of health (other existing studies focus on mortality). Black et al. (2016) find a negative relationship between birth order and self-reported physical and mental health in the Norwegian population.

We are among the very few papers that examine the relationship between parental transfers and birth order. As we have just noted, parents do not attempt to compensate their later born children for their birth order disadvantage, but at least in Australia this disadvantage is not amplified by differential in-vivo transfers as appear to be the case in France (Mechoulan and Wolff (2015))

How important these Australian results prove to be for society in general, or inequality in particular, depends considerably on what other economy-wide forces are at play. Our results suggest that the impacts of birth order on adult outcomes are both significant and economically important. Furthermore, they originate in the family, an institution that exhibits significant stability across time and sub-cultures. Even modest effects, when widespread and enduring, can become important over decades.

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Table 2. Dependent variable means

	(1) Females mean	(2) Males mean	(3) Total mean
Edu: Years	12.568	12.566	12.567
Edu: Postgrad - masters or doctorate	0.049	0.062	0.055
Edu: Grad diploma, grad certificate	0.087	0.060	0.075
Edu: Bachelor or honours	0.182	0.148	0.166
Edu: Adv diploma, diploma	0.114	0.102	0.108
Edu: Cert III or IV	0.160	0.318	0.234
Edu: Year 12	0.137	0.109	0.124
Edu: Year 11 and below	0.270	0.203	0.238
employed	0.764	0.916	0.835
lwage_hourly	3.178	3.296	3.238
Bad health	0.125	0.117	0.121
NR_health	0.117	0.145	0.130
chronic_disease	0.202	0.186	0.194
Bad health in childhood	0.060	0.045	0.053
Health in childhood NR	0.038	0.047	0.042
Height in centimetres	164.4	178.3	170.9
Height_NR	0.143	0.163	0.153
Mental health	73.015	74.785	73.833
Mental health _NR	0.119	0.149	0.133
Personality scale - Agreeableness	0.271	-0.309	0.002
Agreeableness _NR	0.146	0.172	0.158
Personality scale - Conscientiousness	0.104	-0.115	0.002
Conscientiousness _NR	0.146	0.172	0.158
Personality scale - Emotional stability	0.039	-0.040	0.003
Emotional stability _NR	0.146	0.172	0.158
Personality scale - Extraversion	0.125	-0.146	-0.000
Extraversion _NR	0.146	0.172	0.158
Personality scale - Openness to experience	-0.037	0.043	-0.000
Openness _NR	0.147	0.172	0.159
Locus of Control	0.024	-0.025	0.001
Locus of Control _NR	0.152	0.169	0.160
Received transfer from parents over last four years	0.070	0.057	0.064
Amount of transfer from parents in AUD (among those who received)	17,892	15,381	16,859
Received inheritance/bequest over last four years	0.060	0.049	0.055
Amount of inheritance/bequest in AUD (among those who received)	68,992	88,329	77,061
Observations	3060	2719	5779

Table 5. Effects of Sibship Size and Birth Order on Years of Education

	No S.D. controls[8]		S. D. controls		S.D. and Birth Order controls			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SibshipSize	-0.163***		-0.095***		-0.095***		-0.044**	
	(0.015)		(0.015)		(0.015)		(0.022)	
SibshipSizeS=2		0.169		0.047		0.08		0.259
		(0.175)		(0.165)		(0.165)		(0.169)
SibshipSizeS=3		0.016		-0.105		-0.075		0.239
		(0.174)		(0.165)		(0.165)		(0.172)
SibshipSizeS=4		-0.107		-0.135		-0.107		0.268
		(0.176)		(0.168)		(0.168)		(0.179)
SibshipSizeS=5		-0.460**		-0.387**		-0.355**		0.081
		(0.185)		(0.177)		(0.177)		(0.191)
SibshipSizeS=6		-0.545***		-0.378**		-0.349*		0.132
		(0.201)		(0.189)		(0.189)		(0.208)
SibshipSizeS=7		-0.448*		-0.326		-0.299		0.205
		(0.237)		(0.222)		(0.221)		(0.244)
SibshipSizeS=8		-1.118***		-0.786***		-0.79***		-0.358
		(0.266)		(0.251)		(0.251)		(0.276)
SibshipSizeS=9		-1.261***		-0.790***		-0.75***		-0.319
		(0.218)		(0.208)		(0.209)		(0.265)
Booth and Kee Birth order Index					-0.50***	-0.505***		
					(0.078)	(0.078)		
birth_orderS1=2							-0.359***	-0.394***
							(0.068)	(0.070)
birth_orderS1=3							-0.555***	-0.604***
							(0.090)	(0.094)
birth_orderS1=4							-0.506***	-0.559***
							(0.118)	(0.121)
birth_orderS1=5							-0.683***	-0.689***
							(0.153)	(0.157)
birth_orderS1=6							-0.753***	-0.749***
							(0.216)	(0.221)
birth_orderS1=7							-0.652**	-0.605**
							(0.287)	(0.289)
birth_orderS1=8							-0.461	-0.211
							(0.326)	(0.338)
birth_orderS1=9							-0.768**	-0.611*
							(0.315)	(0.330)
Observations	5779	5779	5779	5779	5779	5779	5779	5779
Adjusted R^2	0.062	0.063	0.211	0.211	0.216	0.217	0.217	0.218

Robust standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All models include yearly birth cohort dummies, sex, indicator for being foreign born, mother's and father's age at respondent's birth (in 5 year band dummies), parental indicators for being foreign born, mother's and father's education and occupation, indicators for non-birth father, non-birth mother, non-full sibling, indicator for living with birth father and mother at age 14, indicator for father's being unemployed for more than 6 month when respondent was growing up.

[8] Socio-demographic (S.D.) variable as described under 'Data' or in the online appendix.

Table 8. Effects of Birth Order on Educational Outcomes by Sibship Size

	(1) N=2	(2) N=3	(3) N=4	(4) N=5
	I. Effects of birth order on years of education			
birth_orderS1=2	-0.379***	-0.589***	-0.269	-0.112
	(0.122)	(0.125)	(0.166)	(0.266)
birth_orderS1=3		-0.839***	-0.274	-0.269
		(0.146)	(0.195)	(0.306)
birth_orderS1=4			-0.224	-0.292
			(0.222)	(0.306)
birth_orderS1=5				-0.897***
				(0.334)
Adjusted R^2	0.191	0.204	0.188	0.177
	II. Effects of birth order on probability of high school completion			
birth_orderS1=2	-0.016	-0.044*	-0.035	-0.113*
	(0.023)	(0.025)	(0.032)	(0.059)
birth_orderS1=3		-0.078***	-0.120***	-0.104*
		(0.028)	(0.037)	(0.062)
birth_orderS1=4			-0.078*	-0.193***
			(0.043)	(0.064)
birth_orderS1=5				-0.295***
				(0.073)
Adjusted R^2	0.113	0.102	0.138	0.106
	III. Effects of birth order on probability of university degree			
birth_orderS1=2	-0.072***	-0.134***	-0.063*	0.015
	(0.027)	(0.027)	(0.035)	(0.057)
birth_orderS1=3		-0.175***	-0.024	-0.004
		(0.031)	(0.040)	(0.061)
birth_orderS1=4			-0.031	-0.007
			(0.047)	(0.064)
birth_orderS1=5				-0.086
				(0.067)
Adjusted R^2	0.156	0.177	0.155	0.119
Observations	1275	1637	1190	621

In panel I coefficients from the linear regression models are presented. In panels II and III coefficients from linear probability models are presented.
Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
All models include yearly birth cohort dummies, sex, indicator for being foreign born, mother's and father's age at respondent's birth (in 5 year band dummies), parental indicators for being foreign born, mother's and father's education and occupation, indicators for non-birth father, non-birth mother, non-full sibling, indicator for living with birth father and mother at age 14, indicator for father's being unemployed for more than 6 month when respondent was growing up.

Table 9. Effects of Sibship Size and Birth Order on Non-Educational Outcomes

	Without own education controls		With own education controls	
Dep var	SibshipSize	BK	SibshipSize	BK
Employed full time (N obs=5,779)	-0.001 (0.003)	0.000 (0.017)	0.002 (0.003)	0.016 (0.017)
log hourly wage if employed full time (N obs=3,140)	-0.015*** (0.004)	-0.055** (0.024)	-0.007* (0.004)	-0.013 (0.022)
Reports bad health (Nobs =4,861)	0.004 (0.003)	0.019 (0.015)	0.003 (0.003)	0.012 (0.015)
Reports chronic health condition	-0.000 (0.003)	0.015 (0.017)	-0.002 (0.003)	0.006 (0.017)
Bad health in childhood	0.000 (0.002)	0.001 (0.010)	NA[a]	NA[a]
Height in cm	-0.271*** (0.063)	-0.478 (0.324)	NA[a]	NA[a]
Mental health score	-0.017** (0.009)	0.005 (0.044)	-0.016* (0.009)	0.020 (0.044)
Agreeableness (N obs =4,862)	0.000 (0.008)	-0.079* (0.041)	0.000 (0.008)	-0.076* (0.041)
Conscientiousness	-0.009 (0.008)	-0.066 (0.042)	-0.005 (0.008)	-0.040 (0.042)
Emotional Stability	0.011 (0.008)	-0.029 (0.043)	0.013 (0.008)	-0.008 (0.043)
Extraversion	0.011 (0.007)	-0.015 (0.042)	0.012 (0.007)	-0.013 (0.042)
Openness to Experience	-0.017** (0.008)	-0.179*** (0.043)	-0.011 (0.007)	-0.129*** (0.043)
Locus of Control	0.019** (0.009)	-0.009 (0.043)	0.016* (0.009)	-0.028 (0.043)
Received in-vivo transfer over last four years (N obs=5,020)	-.005*** (0.001)	-0.013 (0.009)	-.005*** (0.002)	-0.013 (0.01)
Amount in-vivo among those who received (N obs= 316)	-3157.6 (1925.3)	-7474.6 (7666.2)	-3958.9* (2099.5)	-11276.9 (8028.6)
Received inheritance over last four years (N obs=5,020)	-.003* (0.001)	0.009 (0.009)	-.003* (0.001)	0.009 (0.009)
Amount inheritance among those who received (N obs=266)	-14,806*** (4652.4)	32,058 (30110.8)	-13,729*** (4764.54)	34,526 (30139.68)

Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

All models include yearly birth cohort dummies, sex, indicator for being foreign born, mother's and father's age at respondent's birth (in 5 year band dummies), parental indicators for being foreign born, mother's and father's education and occupation, indicators for non-birth father, non-birth mother, non-full sibling, indicator for living with birth father and mother at age 14, indicator for father's being unemployed for more than 6 month when respondent was growing up.

The coefficients come from a range of models with varying sample sizes due to number of responses on SCQ . Full results are available upon request.

[a] We do not include results from the models with educational controls as it seems unlikely that adult height and health in childhood would be mediated by own educational attainment

Table 10. Heterogeneous Effects of Birth Order on Education

	Edu: years	Edu: years	High school	High School	University degree	University degree
			By sex			
	Male	Female	Male	Female	Male	Female
Booth and Kee Birth order Index	-0.307*** (0.112)	-0.683*** (0.109)	-0.033 (0.022)	-0.105*** (0.022)	-0.068*** (0.023)	-0.109*** (0.023)
Observations	2719	3060	2719	3060	2719	3060
Adjusted R^2	0.192	0.242	0.114	0.144	0.155	0.182
			By mother's years of schooling			
	<12	>=12	<12	>=12	<12	>=12
Booth and Kee Birth order Index	-0.552*** (0.097)	-0.359** (0.162)	-0.074*** (0.020)	-0.066*** (0.023)	-0.102*** (0.020)	-0.038 (0.038)
Observations	3812	1379	3812	1379	3812	1379
Adjusted R^2	0.151	0.170	0.089	0.074	0.119	0.157
			By mother's birth year			
	<=1939	>1939	<=1939	>1939	<=1939	>1939
Booth and Kee Birth order Index	-0.457*** (0.117)	-0.532*** (0.105)	-0.081*** (0.023)	-0.060*** (0.022)	-0.082*** (0.023)	-0.093*** (0.022)
Observations	2916	2863	2916	2863	2916	2863
Adjusted R^2	0.209	0.235	0.127	0.137	0.165	0.183
			By mother's labour force status			
	No work at 14y.o.	Work at 14y.o.	No work at 14y.o.	Work at 14y.o.	No work at 14y.o.	Work at 14y.o.
Booth and Kee Birth order Index	-0.600*** (0.117)	-0.415*** (0.106)	-0.091*** (0.024)	-0.054*** (0.020)	-0.102*** (0.024)	-0.076*** (0.022)
Observations	2655	3124	2655	3124	2655	3124
Adjusted R^2	0.230	0.197	0.137	0.122	0.170	0.162

Robust standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
All models include yearly birth cohort dummies, sex, indicator for being foreign born, mother's and father's age at respondent's birth (in 5 year band dummies), parental indicators for being foreign born, mother's and father's education and occupation, indicators for non-birth father, non-birth mother, non-full sibling, indicator for living with birth father and mother at age 14, indicator for father's being unemployed for more than 6 month when respondent was growing up.

Table 10, Cont. Heterogeneous Effects of Birth Order on Education

	Edu: years	Edu: years	High school	High School	University degree	University degree
	By family type					
	Intact[a]	Non full sibs[b]	Intact	Non full sibs	Intact	Non full sibs
Booth and Kee Birth order Index	-0.605***	-0.049	-0.092***	0.044	-0.106***	-0.025
	(0.090)	(0.194)	(0.017)	(0.042)	(0.019)	(0.038)
Observations	4312	893	4312	893	4312	893
Adjusted R^2	0.218	0.203	0.126	0.115	0.172	0.169
[a] In this column we restrict the sample to individuals with birth father and mother and full siblings only						
[b] In this column we restrict the sample to individuals reporting at least one non-full sibling						
By mother's immigrant status (Yes = Immigrant)						
	No	Yes	No	Yes	No	Yes
Booth and Kee Birth order Index	-0.539***	-0.401***	-0.080***	-0.051*	-0.107***	-0.049*
	(0.093)	(0.142)	(0.019)	(0.026)	(0.019)	(0.030)
Observations	3864	1915	3864	1915	3864	1915
Adjusted R^2	0.219	0.186	0.143	0.088	0.166	0.153
By respondent's immigrant status (Yes = Immigrant)						
	No	Yes	No	Yes	No	Yes
Booth and Kee Birth order Index	-0.613***	-0.043	-0.085***	-0.025	-0.120***	0.042
	(0.086)	(0.184)	(0.018)	(0.033)	(0.018)	(0.039)
Observations	4587	1192	4587	1192	4587	1192
Adjusted R^2	0.208	0.202	0.136	0.098	0.160	0.166

Robust standard errors are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All models include yearly birth cohort dummies, sex, indicator for being foreign born, mother's and father's age at respondent's birth (in 5 year band dummies), parental indicators for being foreign born, mother's and father's education and occupation, indicators for non-birth father, non-birth mother, non-full sibling, indicator for living with birth father and mother at age 14, indicator for father's being unemployed for more than 6 month when respondent was growing up.